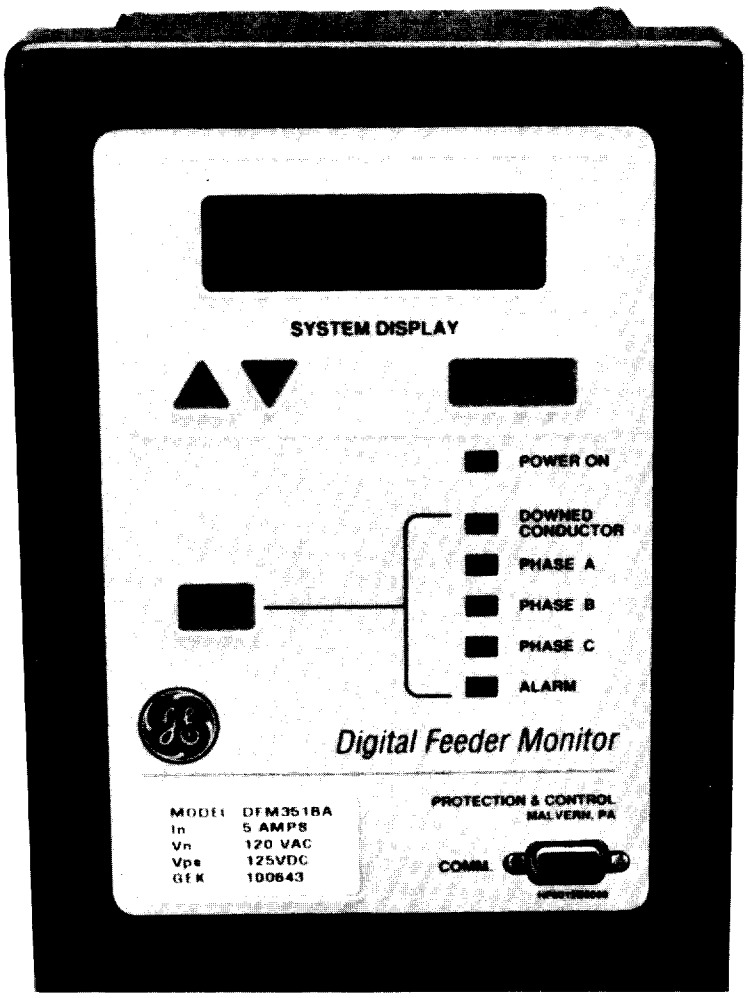
GEK-100693
DFM™
DIGITAL FEEDER MONITOR



GE Power Management

The Technology Center
205 Great Valley Parkway
Malvern, Pa. 19355,USA

These instructions do not purport to cover all details or variations in equipment nor provide for every possible contingency to be met in connection with installation, operation, or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purpose, the matter should be referred to the General Electric Company.

To the extent required the products described herein meet applicable ANSI, IEEE, and NEMA standards; but no such assurance is given with respect to local codes and ordinances because they vary greatly.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

PRODUCT DESCRIPTION

GENERAL

The DFM™ relay is an advanced microprocessor-based digital relay and monitoring system for application on distribution feeders. Conventional instantaneous and time-overcurrent protection functions are included. The DFM™ relay will also detect a high percentage of high-impedance faults on a distribution feeder. Instantaneous and RMS oscillography recording is included with all DFM™ relay models, and power-quality monitoring is available as an optional function. Conventional feeder monitoring functions are also provided. See **FUNCTIONS** and **FEATURES** in this section for detailed descriptions of the DFM™ relay's monitoring capabilities.

For the purpose of understanding the operation and performance of the DFM™ relay for high-impedance faults, it is necessary to define the high-impedance faults targeted by this device. A high-impedance fault is characterized by having an impedance sufficiently high that it is not detected by conventional overcurrent protection. A high-impedance, downed conductor fault is a high-impedance fault for which the primary conductor is no longer intact on pole top insulators, but instead is broken and in contact with earth or a grounded object. An arcing fault is any high-impedance fault which exhibits arcing.

Combinations of these types are possible. An example is an arcing, high-impedance, downed conductor fault. The intent of the DFM™ relay is to detect high-impedance faults which arc, and to differentiate those which are downed conductors from those which are not. Electrical signatures are used to identify the presence of arcing. If the arcing begins with a loss of load or with an overcurrent disturbance (as might occur when a conductor falls across another phase or a neutral conductor and then falls to the ground), the DFM™ relay assumes that a conductor is down. If neither of these conditions initiates the arcing, the DFM™ relay assumes that a conductor is still intact. In the interest of system security, the DFM™ relay considers loss of load or an overcurrent disturbance to indicate a downed conductor if and only if one of these precedes the arcing, and not if one of these occurs after the initiation of arcing. The reason for this is that, following a recloser operation, power-system load levels will often change sufficiently such that the DFM™ relay cannot distinguish between a recloser operation and a loss of load due to a broken conductor.

The DFM™ relay includes a capability for setting the sensitivities of high-impedance fault detection. By changing these settings, a user may choose greater sensitivities, which would tend to increase the percentage of faults detected, but with a corresponding degradation in security. Likewise, lesser sensitivities may be chosen, which would tend to decrease the percentage of faults detected while providing slightly enhanced security.

It is difficult to derive a definitive, statistical performance figure of merit for the DFM™ relay's high-impedance fault-detection because of the wide variety of ground and circuit conditions which may be encountered. However, based upon documented field experience and assumptions of circuit environmental conditions, it can be expected that approximately 80% of all arcing, high-impedance faults will be detected by the DFM™ relay, assuming that the ARCING SENSITIVITY setting is at 5 and the remaining high-impedance settings are at their default values.

APPLICATION

The DFM™ relay is intended for installation in a distribution substation to protect and monitor a four-wire, three-phase, overhead distribution feeder at voltages ranging from 4,160 VAC to 34,500 VAC. The elementary diagram of Figure 1-1 shows the external connections to the DFM™ relay.

Conventional Overcurrent Protection

Two instantaneous (IOC low set and IOC high set) and one time-delay (TOC) non-directional overcurrent functions are provided for each phase and ground. There are separate time and instantaneous settings for phase and ground. Refer to TABLE 2-4 in the **CALCULATION OF SETTINGS** section to determine how these functions may be configured to activate the output contacts.

High Impedance Fault Protection

When a downed conductor is detected, the DFM™ relay can be used to alarm or initiate a control action. The most apparent control action is tripping the feeder breaker. However, the user may consider whether tripping the feeder breaker and the resultant interruption of service is necessary where there is virtually no risk to person or property.

Figure 1-1 shows three voltage transformers (PTs) providing three-phase voltage to the DFM™ relay via a wye-wye connection. However, the DFM™ relay can be configured to operate without voltage connected or with various single-phase and three-phase voltage connections. The practical possibilities are:

(1) No voltage connected
(2) Single-phase to ground voltage using one PT
(3) Phase-to-phase voltage using one PT
(4) Three-phase voltage using three wye-wye connected PTs
(5) Three-phase voltage using two open-delta connected PTs

Three settings are used to configure the DFM™ relay for these different voltage connections. Refer to PT RATIO, PHASE POTENTIAL, and CONFIGURED PTs in the **CALCULATION OF SETTINGS** section.

The presence or absence of voltage inputs to the DFM™ relay has no effect on the DFM™ relay's ability to detect high-impedance faults. However, with no voltage connected, phase identification in the event of a high-impedance fault would be limited. With no voltage connected, the DFM™ relay would be unable to perform any of its "power" calculations. Included in these power calculations are WATTS, VARS, VA, and POWER FACTOR. For DFM™ relay models that provide power-quality monitoring, Total Harmonic Distortion (THD) calculations based on voltage would also be eliminated. All DFM™ relay reporting functions that include these power values would no longer include them, and no data related to the power calculations would be displayed on the DFM™ relay's local man-machine interface (MMI) or transmitted via a serial port.

With at least one phase-to-ground voltage connected, the DFM™ relay's power calculations would be performed, using the value of the connected voltage(s) for the missing phase(s). With at least one phase-to-phase voltage connected, phase-to-ground voltages are calculated within the DFM™ relay and would be used in the power calculations. Only when three-phase voltage is connected as shown in Figure 1-1 will the DFM™ relay perform all functions without degradation.

The DFM™ relay requires current to operate, but it can be configured to operate with any combination of the four current inputs. While maximum performance is achieved if all four current inputs are connected, the DFM™ relay will function at a degraded level with less than four. The neutral current should always be connected, since the DFM™ relay's high-impedance fault-detection algorithms are degraded if it is not present. Refer to the setting CONFIGURED CTs in the **CALCULATION OF SETTINGS** section.

Additional application considerations are presented under the **FUNCTIONS** and **FEATURES** headings that follow.

FUNCTIONS

The following functions are available with the DFM™ relay. The list of functions is followed by detailed descriptions of each.

Conventional Overcurrent Protection
High Impedance Fault Detection
Breaker Health Monitoring
Overcurrent Disturbance Monitoring
Power Quality Monitoring (OPTIONAL)
Present Value Monitoring

Conventional Overcurrent Protection

Two instantaneous (IOC low set and IOC high set) and one time-delay (TOC) non-directional overcurrent functions are provided for each phase and ground. There are separate time and instantaneous settings for phase and ground.

For the TOC functions, five pre-defined and up to four user-defined characteristic curves are stored in non-volatile memory. The five pre-defined curves are:

Inverse
BS142 Inverse
Very Inverse
Extremely Inverse
Definite Time

The four pre-defined inverse curves are shown in Figures 1-2 to 1-5. For each of the four settings groups, one phase TOC curve and one ground TOC curve may be selected from the nine curves stored in the DFM™ relay. The TOC reset can be selected to emulate that of an EM induction-disk TOC relay or to have a fast reset. The emulated EM reset curves for the four pre-defined inverse curves are shown in Figures 1-6 to 1-9.

A unique load-adaptive feature may be used to automatically change the TOC pickup within limits as a function of the average load current. This allows the TOC function to be more sensitive when feeder loading is light. If the Adaptive Phase TOC Averaging Period (setting #617) is set to a non-zero value, then at the end of each averaging period a candidate phase-TOC pickup will be computed by multiplying the computed average phase current by a multiple determined from the Adaptive Phase TOC Pickup Percentage (setting #618). If the candidate phase-TOC pickup exceeds an upper or lower limit, then the value of the limit that was exceeded will become the new phase-TOC pickup. Otherwise, the candidate TOC pickup becomes the new phase-TOC pickup. The same scenario occurs for the ground-TOC pickup if the Adaptive Ground TOC Averaging Period (setting # 621) is set to a non-zero value. If both settings #617 and #621 are set to zero, then the TOC functions behave like conventional fixed-pickup functions.

Special settings may be defined to prevent an unwanted trip during a cold-load-pickup condition. A cold-load-pickup condition is declared when the associated breaker has been open for three minutes. If one of the three contact converters has been configured for "52/b CONTACT", then the 52/b contact closure starts the three minute timer. If there is no 52/b input, then the 3 minute timer is started when all the phase currents are less than 4% of the CT rating (i.e., 0.20 amp for a 5-amp CT or 0.04 amp for a 1-amp CT) over a two-cycle period. Settings group #4 is reserved as the cold-load settings group. If the Cold-Load-Pickup Time Delay (setting #626) is set to a non-zero value, then settings group #4 is made the active settings group following detection of a cold-load-pickup condition, and it remains in effect for a time interval determined by setting #626. If the Cold-Load-Pickup Time Delay is set to zero, then the cold-load-pickup logic is disabled.

High Impedance Fault Detection

The DFM™ relay accomplishes high-impedance fault detection through a variety of techniques, all coordinated by an expert system. At the heart of the high-impedance fault-detection system is the identification of arcing on a feeder. If the DFM™ relay detects arcing, it then determines whether or not the arcing persists for a significant period of time. If it does, the DFM™ relay determines whether the persistent arcing is from a downed conductor or from an intact conductor and then closes the appropriate output contact to indicate either the detection of a downed conductor or the detection of arcing, respectively.

Distinction between an arcing intact conductor and an arcing downed conductor is determined by looking at patterns in the load current at the beginning of the fault. A downed conductor is indicated only when a precipitous loss of load or an overcurrent condition precedes arcing detection. Otherwise, the DFM™ relay assumes that the line is intact, even if arcing is present. In such a case, if the detected arcing can be classified as persistent, and an alarm contact is configured for the detection of arcing, the DFM™ relay will close that alarm contact.

In some cases, arcing is determined to be present, but not persistent. For example, if it is caused by tree limb contact or insulator degradation, arcing will typically be present intermittently with relatively long periods of inactivity (e.g. minutes) interspersed. In such cases, arcing may be affected by such factors as the motion of a tree limb or the moisture and contamination on an insulator. Conditions such as these, characterized by a high number of brief occurrences of arcing over an extended period of time (e.g. from a fraction of an hour to one or more hours), lead the DFM™ relay to recognize and flag an "arcing suspected" event. None of these brief occurrences of arcing, if taken individually, are sufficient to indicate detection of a downed conductor or to set off an alarm indicating that persistent arcing has been detected. When considered cumulatively, however, they do indicate a need for attention. If an alarm output contact is configured to indicate "arcing suspected", the DFM™ relay's recognition of such sporadic arcing will close that contact.

If the DFM™ relay determines that a downed conductor exists, oscillography and fault data are captured (see **Instantaneous and RMS Oscillography** and **Fault Reporting** under **FEATURES** in this section). In addition, the local MMI responds with a blinking high-impedance fault message on the top display line and the appropriate LEDs being lit (see the **INTERFACE** section).

The detection of a downed conductor or arcing condition is accomplished through the execution of the following algorithms:

Energy Algorithm
Randomness Algorithm
Expert Arc Detector Algorithm
Load Event Detector Algorithm
Load Analysis Algorithm
Load Extraction Algorithm
Arc Burst Pattern Analysis Algorithm
Spectral Analysis Algorithm
Arcing-Suspected Identifier Algorithm

Energy Algorithm -
The Energy Algorithm monitors a specific set of non-fundamental frequency component energies of phase and neutral current. After establishing an average value for a given component energy, the algorithm indicates arcing if it detects a sudden, sustained increase in the value of that component. The DFM™ relay runs the Energy Algorithm on each of the following parameters for each phase current and for the neutral: (1) even harmonics, (2) odd harmonics, and (3) non-harmonics. On a 60-Hz system, the non-harmonic component consists of a sum of the 30, 90, 150, ..., 750-Hz components, while on a 50-Hz system, it consists of a sum of the 25, 75, 125, ...,

625-Hz components. If the Energy Algorithm detects a sudden, sustained increase in one of these component energies, it reports this to the Expert Arc-Detector Algorithm, resets itself, and continues to monitor for another sudden increase.

Randomness Algorithm -
The Randomness Algorithm monitors the same set of component energies as the Energy Algorithm. However, rather than checking for a sudden, sustained increase in the value of the monitored component energy, it looks for a sudden increase in a component followed by highly erratic behavior. This type of highly random behavior is indicative of many arcing faults. Just as with the Energy Algorithm, if the Randomness Algorithm detects a suspicious event in one of its monitored components, it reports this to the Expert Arc-Detector Algorithm, resets itself, and continues to monitor for another suspicious event.

Expert Arc-Detector Algorithm -
The purpose of the Expert Arc-Detector Algorithm is to assimilate the outputs of the basic arc-detection algorithms into one "belief-in-arcing" confidence level per phase. Note that there are actually 24 independent basic arc-detection algorithms, since both the Energy Algorithm and the Randomness Algorithm are run for the even harmonics, odd harmonics, and non-harmonics for each phase current and for the neutral. The assimilation performed by the Expert Arc-Detector Algorithm, then, is accomplished by counting the number of belief-in-arcing indications determined by any one of the twenty-four algorithms over a short period of time (e.g. the last 30 seconds). Also taken into account is the number of <u>different</u> basic algorithms that indicate a belief in arcing.

The Expert Arc-Detector Algorithm's belief-in-arcing confidence level for each phase increases as the number of basic algorithms that indicate a belief in arcing increases. It also increases with increasing numbers of indications from any one basic algorithm. These confidence level increases occur because multiple, consecutive indications and multiple, independent indications are more characteristic of the presence of arcing than a single algorithm giving a single indication.

Load Event Detector Algorithm -
The Load Event Detector Algorithm examines, on a per-phase basis, one reading of RMS values per two-cycle interval for each phase current and the neutral. It then sets flags for each phase current and for the neutral based on the following events: (1) an overcurrent condition, (2) a precipitous loss of load, (3) a high rate-of-change, (4) a significant three-phase event, and (5) a breaker open condition. These flags are examined by the Load Analysis Algorithm. Their states contribute to that algorithm's differentiation between arcing downed conductors and arcing intact conductors, and inhibit the Expert Arc-Detector Algorithm from indicating the need for an arcing alarm for a limited time following an overcurrent or breaker-open condition.

Load Analysis Algorithm -
The purpose of the Load Analysis Algorithm is to differentiate between arcing downed conductors and arcing intact conductors by looking for a precipitous loss of load and/or an overcurrent disturbance at the beginning of an arcing episode. The presence of arcing on the system is determined based on the output of the Expert Arc-Detector Algorithm. If the DFM™ relay finds persistent arcing on the power system, the Load Analysis Algorithm then considers the type of incident that initiated the arcing and classifies the arcing conductor as either downed or intact. Another function of the algorithm is to provide coordination between the DFM™ relay and the power system's conventional overcurrent protection, by observing a timeout (via setting #505, OC COORD TIMEOUT) from the beginning of the arcing, before giving an indication of arcing.

If the Load Analysis Algorithm determines that a downed conductor or arcing exists, it attempts to determine the phase on which the high-impedance fault condition exists. It does this in a hierarchical manner. First, if a significant loss of load triggered the Load Analysis Algorithm, and if there was a significant loss on only one phase, that phase is identified. If there was not a single-phase loss of load, and if an overcurrent condition on only one phase triggered the algorithm, that

phase is identified. If both of these tests fail to identify the phase, the phase with a significantly higher confidence level (e.g. higher than the other two phases by at least 25%) is identified. Finally, if none of these tests provides phase identification, the result of the Arc-Burst Pattern Analysis Algorithm is checked. If that test fails, the phase is not identified.

Load Extraction Algorithm -
The Load Extraction Algorithm attempts to find a quiescent period during an arcing fault so that it can determine the background load current level. If it is successful in doing so, it then removes the load component from the total measured current, resulting in a signal which consists only of the fault component of the current. This information is then provided as input to the Arc-Burst Pattern Analysis Algorithm.

Arc-Burst Pattern Analysis Algorithm -
The Arc-Burst Pattern Analysis Algorithm attempts to provide faulted phase identification information based on a correlation between the fault component of the measured line current and the phase voltage. The fault component is received from the Load Extraction Algorithm. The result of the analysis is checked by the Load Analysis Algorithm if its other phase identification methods prove unsuccessful.

Spectral Analysis Algorithm -
The Spectral Analysis Algorithm analyzes the non-harmonic components of the current on the power system and correlates the shape of the non-harmonic components of the spectrum to an ideal arcing spectrum. A high correlation provides confirmation of the DFM™ relay's belief in arcing on the power system.

Arcing-Suspected Identifier Algorithm -
The purpose of the Arcing-Suspected Identifier Algorithm is to detect multiple, sporadic arcing events. If taken individually, such events are not sufficient to warrant an arcing alarm. When taken cumulatively, however, these events do warrant an alarm to system operators so that the cause of the arcing can be investigated.

Breaker-Health Monitoring

The DFM™ relay calculates and stores the cumulative I*t or I^2*t value, depending on setting 406 BRKR HEALTH UNITS, of each of the three phase currents in order to monitor breaker health. The I*t or I^2*t value is calculated by multiplying the average RMS value of current prior to the breaker operation by the breaker operating time, determined from setting #405 (BRKR ARC TIME). A breaker-health threshold is established by a setting (see **MONITORING SETTINGS** in the **CALCULATION OF SETTINGS** section). If this threshold is exceeded, a breaker-health alarm condition exists. If either of the alarm output contacts is configured for "breaker health", that contact is closed, the alarm LED on the local MMI is illuminated, and a message indicating a breaker-health alarm condition can be viewed on the local MMI's display. The cumulative I*t or I^2*t values, a count of breaker trips, and the breaker-health threshold value are accessible either through the local MMI or via a serial port.

Breaker operation (opening) is determined by detecting that the RMS current for each phase has fallen below 0.1 amp and that a 52/b auxiliary contact has passed through an open-to-closed transition during the previous 2 seconds. **If a contact converter has not been configured for "52/b CONTACT", then Breaker-Health Monitoring is effectively out of service.**

If a breaker that has had prior use is connected to the DFM™ relay, the DFM™ relay accepts initial cumulative values for each phase and an initial value for the total number of trips. This initialization is accomplished through a serial port. The breaker-health values can also be reset through a serial port upon completion of breaker maintenance. If the DFM™ relay is configured to allow local MMI resets, a breaker-health reset can also be accomplished through the local MMI.

Overcurrent-Disturbance Monitoring

This function is part of High Impedance Fault Detection and should not be confused with Conventional Overcurrent Protection. The DFM™ relay monitors for an overcurrent condition on the feeder by establishing overcurrent thresholds for the phases and for the neutral and then checking for a single two-cycle RMS current that exceeds those thresholds. Oscillography and fault data are captured if it is determined that an overcurrent condition exists (see **Instantaneous and RMS Oscillography** and **Fault Reporting** under **FEATURES** in this section). In addition, the DFM™ relay's local MMI responds with a blinking overcurrent message on the top display line and appropriate LEDs being lit (see the **INTERFACE** section).

Power-Quality Monitoring (OPTIONAL)

The DFM™ relay's power-quality monitoring function provides information for assessing the duration and severity of periods of poor power quality. The DFM™ relay checks the power quality by calculating the total harmonic distortion (THD) on each of the three phase currents and voltages over one-minute intervals. The THD is used, then, to define the effect of harmonics on the power-system currents and voltages. It represents the ratio of the root-mean-square of the harmonic content to the root-mean-square value of the fundamental quantity, expressed as a percent of the fundamental. Calculation of THD values requires the accumulation of the real and imaginary components of the 2nd through 13th harmonic frequencies. This accumulation is performed on the phase currents for each two-cycle sample interval. The three voltage inputs are sequentially analyzed, also using a two-cycle data window.

The THD values stored in the DFM™ relay are updated once per minute for each phase current and voltage. These values can be viewed on the local MMI or accessed through a serial port. A command may also be used to retrieve all the real and imaginary components of the thirteen multiples of the fundamental frequency for the last two-cycle interval.

The power quality data maintained in the DFM™ relay includes minimum, maximum, and average values for THD, and the minimum 2-second RMS average for each phase voltage. This data is reported for a time interval configurable to 15, 30, or 60 minutes, with 2, 4, or 8 days of storage provided, respectively, depending on the time interval selected. An extended-memory option is available that provides 35, 70, or 140 days of entries, respectively, again depending on the time interval. (The selected interval and storage capability apply to all the demand data in the DFM™ relay.)

In addition to the above data, the maximum daily THD and voltage dip values are maintained in a 35-day log. These daily maximums are based on averages of the selected demand period (15, 30, or 60 minutes). The maximum THD value since the data storage memory has been cleared (peak THD) for each current and voltage is also maintained, as well as the minimum 2-second average RMS voltage for each phase since the memory was cleared. These peak values (also based on averages of the selected demand period) can be accessed or reset from a local or remote computer connected to the DFM™ relay via a serial port. They can also be accessed through the local MMI as well, and reset through the local MMI if the DFM™ relay is configured to allow local MMI resets. All demand data entries (including daily maximums and peaks) include a time stamp to the nearest second.

Settings are provided for establishing one-minute THD thresholds for currents and for voltages. These values are percentages, ranging from 0% to 100%. If a THD threshold setting is exceeded by any one-minute THD average, a THD alarm is indicated. If either of the alarm output contacts is configured for a THD alarm, that alarm is activated, the alarm LED on the DFM™ relay local MMI is illuminated, and a message indicating a THD alarm condition can be viewed on the local MMI display.

If a THD threshold setting is exceeded, a snapshot of two cycles of instantaneous current and voltage data is captured, together with the real and imaginary components of the 2nd through 13th harmonics. The five most recent captures are maintained in the system memory. Once a power-quality capture occurs, no subsequent captures occur for a period of 15 minutes. THD monitoring is suspended during the operation of high-impedance fault discrimination.

The THD threshold settings and the demand data calculation time interval can be viewed on the DFM™ relay's local MMI display. (The local MMI label associated with the time interval is "DEMAND PERIOD".) The configuration of the output contacts can likewise be viewed on the local MMI to determine if either of the alarm output contacts is configured for a THD alarm. These settings can be changed and new settings downloaded to the DFM™ relay through a serial port.

An event is logged in the system each time any phase current or voltage THD exceeds its respective THD threshold setting, and then again when the THD value for that same phase current or voltage falls below its threshold. Each event is time stamped, and thus it is possible to monitor the duration of a period of poor power quality for individual phase currents and voltages.

Present Value Monitoring

The DFM™ relay provides typical panel meter functions by monitoring the present values of the three-phase distribution circuit. Present value data consists of the individual currents, voltages, watts, VARs, and power factors, as well as the individual total harmonic distortions (THDs) for each of the three phase currents and voltages in models that include power-quality monitoring. Three-phase values are calculated for the watts, VARs, VA, and power factors. Each present value is updated once per second.

A lagging power factor (i.e., VARs being supplied to an inductive load) is indicated by a positive (+) sign. A leading power factor (i.e., VARs being supplied to a capacitive load) is indicated by a negative (−) sign.

FEATURES

The following features are included in the DFM™ relay. The list of features is followed by detailed descriptions of each.

Breaker Control
Configurable Contact Converters
Configurable Outputs
Control Circuit Monitor
Configurable Time Interval Demand Reporting
Daily Maximum Demand Reporting
Peak Value Reporting
Event Reporting
Fault Reporting
Harmonic Spectral Analysis
Local Man-Machine Interface
Multiple Groups of Settings
Instantaneous and RMS Oscillography
Password Protection
Power-On Self-Tests
Run-Time Self-Tests
Serial Communications
Time Synchronization
Upgrade Model Number

Breaker Control

Breaker tripping and closing through the DFM™ relay is enabled or disabled by a hardware jumper located on the Input/Output circuit board (see J1 in Figure 3-8 in the **HARDWARE DESCRIPTION** section). As shipped from the factory, this jumper is physically present, and breaker control is disabled. To enable remote breaker control, the jumper must be clipped.

Two of the DFM™ relay's output contacts are designated as control contacts and are configurable for tripping a breaker. If one or both of these are configured as such, the breaker can be tripped by closing one or both of those contacts. A "close breaker" command will close a dedicated contact. It is also possible to trip and close the breaker via external contacts wired to the DFM™ relay's contact converters, by configuring one to "open breaker" and another to "close breaker".

Configurable Contact Converters

All three of the DFM™ relay's contact converters (digital inputs) are configurable. The user can select from eight possible assignments, but each contact converter (CC) may be given one and only one assignment, and no two CCs can be given the same assignment. For detailed information on the CCs, including the allowed assignments, refer to **CONTACT SETTINGS** in the **CALCULATION OF SETTINGS** section.

Configurable Outputs

To provide greater flexibility in utilization of the output contacts, five of the seven output contacts are designated as configurable. For each configurable output, the selected assignments are logically ORed together.

A Security State Machine Circuit provides a high level of output-contact security in the DFM™ relay. A very stringent procedure is required to enable the control output contacts, thus protecting against unintentional operation. Detailed information on the DFM™ relay's output contacts, including the allowed assignments, can be found in TABLE 2-4 in the **CALCULATION OF SETTINGS** section.

Control Circuit Monitor

Within the DFM™ relay the DC battery voltage across output contacts #1 and #2 may be continuously monitored to indicate if the external control or trip circuit is intact. If the monitored DC voltage falls below appoximately 30 VDC, this function produces a WARN status message MON CONTROL #1 or MON CONTROL #2. These status messages indicate that the external circuit has failed open or that the 52/a contact, normally wired in series with a typical breaker trip circuit, has opened (i.e., breaker opened manually). To avoid unwanted operation due to an open 52/a contact, a 52/b contact can be assigned to one of the contact converters. When the 52/b contact is closed (breaker open) the WARN status message is supressed.

Within the DFM™ relay a current sensor is wired in series with output contacts OUTPUT #1 and OUTPUT #2 to detect DC current flow when the associated contact closes. If an assigned DFM™ relay signal causes one these two contacts to close and the current sensor measures less than 100 milliamperes of DC current, then a "Trip circuit #1(2) energized" event message is generated. Control Circuit Monitor usage, determined by setting #309 (CNTRL CKT MONITOR), selects both of the features described above to be either in service or out of service for OUTPUT #1 or OUTPUT #2.

Configurable Time Interval Demand Reporting

Demand profiles are maintained per phase in the DFM™ relay for the currents, watts, VARs, 3-phase VA, and power factors, as well as for the minimum, maximum, and average total harmonic distortions (THDs), and minimum 2-second average RMS voltages in models that include power-quality monitoring. The demand profiles are averages that are calculated based on an interval of time known as the demand period, which is configurable to either 15, 30, or 60 minutes.

The organization of demand data maintained in the DFM™ relay depends on the model and on the demand period selected. Two different demand storage capabilities are available. In models that maintain up to 192 entries of demand data, a maximum of either 2, 4, or 8 days of data will be stored, depending on whether the demand period is configured to 15, 30, or 60 minutes, respectively. For models that provide up to 2880 entries, the number of days extends to a maximum of 35, 70, or 140, respectively.

Demand profiles can be accessed through a serial port. See the **SOFTWARE** section for a detailed description of how these profiles are organized and accessed using a PC.

Daily Maximum Demand Reporting

In addition to the demand profiles, a 35-day history of daily maximums (or minimums, depending on the data) is also maintained. Included in this history are the maximum current per phase and neutral, the maximum three-phase watts, VARs, and VA, and the minimum three-phase power factor. For DFM™ relay models that provide power-quality monitoring, the maximum THD per current and voltage phase and the minimum 2-second RMS voltage per phase are also included. Each entry is time stamped independently to the nearest second.

The 35-day log of daily maximums can be accessed through a serial port. See the **SOFTWARE** section for a detailed description of how this information is organized and accessed using a PC.

Peak Value Reporting

Peak values are maintained in the DFM™ relay that represent maximum values (or minimum, depending on the data) since the data storage memory was last cleared. Peak entries include the maximum phase and neutral currents, the maximum three-phase watts, VARs, and VA, and the minimum three-phase power factor. Peak THDs for each phase current and voltage, as well as the minimum 2-second average RMS voltages per phase are also included in models that provide power-quality monitoring.

The latest peak data can be accessed or reset via a serial port. The peaks can also be viewed on the local MMI, and can be reset through the local MMI if setting #112 (FRONT PANEL RESETS) allows local MMI resets.

Event Reporting

A log of events is maintained in the DFM™ relay that contains the last 150 power-system events. For event sequencing, events are time stamped to the nearest half-millisecond. Examples of events logged include alarms, contact operations, logins and logouts, oscillography captures, remote operations, and resets. Event data can be accessed through a serial port. See the **SOFTWARE** section for a detailed description of how event reports are organized and accessed using a PC.

Fault Reporting

When either a high-impedance fault is detected, an overcurrent disturbance is detected, or an overcurrent trip occurs, pertinent information (unit ID, date and time, operating time, pre-fault currents, fault currents and voltages, fault type, operation type, selected events) is stored in the DFM™ relay. Complete data for the most recent faults is maintained, up to a maximum number of faults. This maximum can be set to either 1, 2, 4, or 8. The fault data can be accessed through a serial port, or an abbreviated summary containing only the fault types, operation types, and dates and times can be viewed on the DFM™ relay's local MMI. A full description of this local MMI display is contained in the **INTERFACE** section. Detailed information regarding the PC presentation of fault reports is contained in the **SOFTWARE** section.

Harmonic Spectral Analysis (OPTIONAL)

Harmonic spectral analysis is performed in DFM™ relay models that provide power-quality monitoring. Harmonic data is maintained by accumulating the real and imaginary components of the 2nd through 13th harmonic frequencies for phase currents and voltages. The last two-cycle interval of these components can be retrieved through a serial port for analysis.

Local Man-Machine Interface (MMI)

A local MMI, consisting of four pushbuttons, six LEDs, and a 2-line by 20-character alphanumeric display, provides the user easy access for monitoring present values, peak demand data, contact-converter and output-contact assignments, contact converter states, and disturbance data, as well as DFM™ relay status and alarm information. In addition, via the local MMI, the user may view the current date and time, view the DFM™ relay model and EPROM version numbers, zero the peak values, initiate a self-test of the MMI, or initiate the automatic scrolling of present values on the bottom line of the display. The structure and use of the MMI is described in detail in the **INTERFACE** section.

Multiple Groups of Settings

Four separate groups of HI-Z and PROTECTION settings are stored in the DFM™ relay's nonvolatile memory, with only one group active at a given time. The currently active group number is determined by setting #108. This setting dictates which is the active group or that the active group is determined by the state of one or two contact converters. If the value of setting #108 is EXTERNAL, the contact converter(s) determines the active settings group, provided that ALT SETTINGS bit 0 or bit 1 have been assigned to a contact converter as described in TABLE 2-3 in the **CALCULATION OF SETTINGS** section.

Instantaneous and RMS Oscillography

Two sets of oscillography data are stored in memory each time the DFM™ relay detects either a high-impedance fault, or an overcurrent disturbance, or an overcurrent trip occurs, or an external contact triggers oscillography. The first set of data consists of the instantaneous voltage and current values for up to 200 cycles of data. The memory for this data can be configured for the most recent one 200-cycle, two 100-cycle, four 50-cycle, or eight 25-cycle events. The second set of data consists of the two-cycle RMS values for the voltage and current for 5400 samples (3 minutes). The configuration of this data is tied directly to the instantaneous oscillography configuration, with the one, two, four, and eight mapped to 5400-sample, 2700-sample, 1350-sample, and 675-sample events, respectively.

Note: All the instantaneous and RMS oscillography capture data is destroyed when the oscillography memory size configuration is changed.

Password Protection

Three different passwords provide remote access security when uploading and viewing stored data and settings, when performing control operations, and when changing settings. Each password has a default, which is stored in memory as shipped from the factory. These defaults must be changed when the DFM™ relay is placed in operation. The three passwords may be viewed in their encrypted form on the local MMI. They may be changed through a serial port. Refer to the **SOFTWARE** section for a description of DFM-LINK password usage.

Power-On Self-Tests

The most comprehensive testing of the DFM™ relay is performed during a power-up. Since the DFM™ relay is not performing any monitoring activities at that time, tests that would be disruptive to run-time processing may be performed. The power-on self-tests attempt to verify the DFM™ relay's hardware components (EPROM, local RAM, interrupt controller, timer chip, serial ports, DMA channels, nonvolatile memory, analog and digital I/O circuitry, MMI hardware, etc.). For a complete list of the power-on self-tests, see TABLE 6-1 in the **SERVICING** section.

In most cases, if any critical self-test failure is detected, the DFM™ relay will not continue its power-up, nor will it cause a reset. An attempt will be made to store the DFM™ relay status and to initialize the MMI and remote communications hardware/software in a reduced operation mode. At this point, the DFM™ relay self-test alarm contact is energized.

If no failures are detected, the DFM™ relay completes initialization of its hardware and software. This includes reading information from the serial nonvolatile RAM (NVRAM) in the magnetics module, stored during the manufacturing process, to determine the current rating of the magnetics in the unit (1-amp or 5-amp). The power-up procedure is completed in a matter of seconds. As the power-on diagnostics are run and the system's hardware and software are initialized, the message "INITIALIZING" appears on the top line of the local MMI display. When all DFM™ relay initialization is completed satisfactorily, a power-up self-test of the display segments and LEDs is performed for user verification. The DFM™ relay then begins acquiring and processing data, and the display enters its automatic scrolling mode, with the feeder ID displayed on the top line and present values scrolling on the bottom line.

Run-Time Self-Tests

The DFM™ relay's run-time self-test diagnostics are executed on a regular basis during online operation. These self-tests are intended to diagnose possible real-time failures due to component aging, premature component failure, etc. Tests that are run verify DFM™ relay memory cell integrity and bus connections without disturbing ongoing algorithmic and communication processes. For a complete list of the run-time self-tests, see TABLE 6-2 in the **SERVICING** section.

If any run-time self-test fails, the test is repeated. To declare a component "failed", the test of that component must fail three consecutive times. In most cases, run-time self-test failures will force a reset in an attempt to get the failed component working again. As an extension of the run-time diagnostic self-tests, the user may initiate a visual-response test of the local MMI components at any time through the local MMI. For a detailed description of this MMI self-test, refer to **Action Menu Options** in the **INTERFACE** section.

The DFM™ relay keeps a running count of warm boots that result from the detection of a run-time self-test failure. Only four resets are allowed in a one-hour period. On the fourth reset, the DFM™ relay does not perform initialization, but instead follows the same procedure as previously described when a critical self-test failure is detected on power-up.

Serial Communications

Two RS-232 serial ports are provided on the DFM™ relay, one on the local MMI and one on the rear panel. A DB-25 connector (PL-1) located on the rear of the case is provided to permit the user to communicate with the DFM™ relay from a local or remote computer or to connect the DFM™ relay to the host computer of a G-NET™ substation information and control system. A DB-9 connector located on the local MMI of the DFM™ relay permits the user to communicate with the DFM™ relay from a local or remote computer, but it cannot be used to connect the DFM™ relay to the host computer of a G-NET™ system.

When communication through a PC is desired, the PC may be connected via the proper null-modem cable, provided the cable length does not exceed 50 feet, or the PC may be connected via interposing modems when it is physically remote from the DFM™ relay. Unique PC software, DFM-LINK, is required to communicate with the DFM™ relay. The capabilities and use of DFM-LINK are described in the **SOFTWARE** section. Refer to the **INTERFACE** section (Figure IN-2) for details regarding the required cables.

When connection to the G-NET™ host computer is desired, three different physical connections are possible. Standard cables may be used for distances up to 50 feet. For longer distances, two optional external adapters are available that plug into PL-1 to provide communications between the DFM™ relay and the G-NET™ host computer. One of these adapters provides a fiber optic link, and the other is an RS-485 adapter that provides communication links for up to 31 DFM™ relay units for distances less than 4000 feet over a pair of shielded conductors. An isolated 5-volt DC supply is internally connected to pin 11 of PL-1 to power either of these external adapters.

The two RS-232 serial ports, PL-1 and the front-panel port, are implemented with a DUART (dual universal asynchronous receiver transmitter). The configuration of the DUART is such that when one serial port is active, the other is effectively disabled. For example, when PL-1 is connected to the G-NET™ host computer and the G-NET™ system is active, it is not possible to log into the DFM™ relay from the front port. If PL-1 is connected to a modem and the front port is connected to a PC using a null-modem cable, the first port that becomes active is given preference and the other port is disabled. It is permissible, however, to have cables and associated equipment connected to each port simultaneously.

Time Synchronization

The DFM™ relay includes a clock that can run freely from the internal oscillator or be synchronized from an external signal. Three different external time-synchronization signals are possible. If available, an unmodulated IRIG-B signal connected to the IRIG-B BNC connector on the DFM™ relay's back panel is used to synchronize the clock. If the DFM™ relay is connected to the host computer of a G-NET™ substation information and control system, then the DFM™ relay receives a time-synchronization pulse via pin 25 of PL-1 on the DFM™ relay's back panel. If both external time sources are available, the IRIG-B signal takes precedence. An advantage to having the G-NET™ connection, even when an IRIG-B signal is used for synchronization, is that the current year can be derived from the G-NET™ signal. For both G-NET™ and IRIG-B, the clock in a given DFM™ relay is synchronized to within plus or minus one millisecond of any other DFM™ relay clock, provided the two devices are wired to the same external synchronizing signal.

A time reference can also be supplied to the DFM™ relay from a PC. If a PC supplies a time reference while G-NET™ or IRIG-B is connected, then the time supplied by the PC will be overwritten by the G-NET™ or IRIG-B time.

Upgrade Model Number

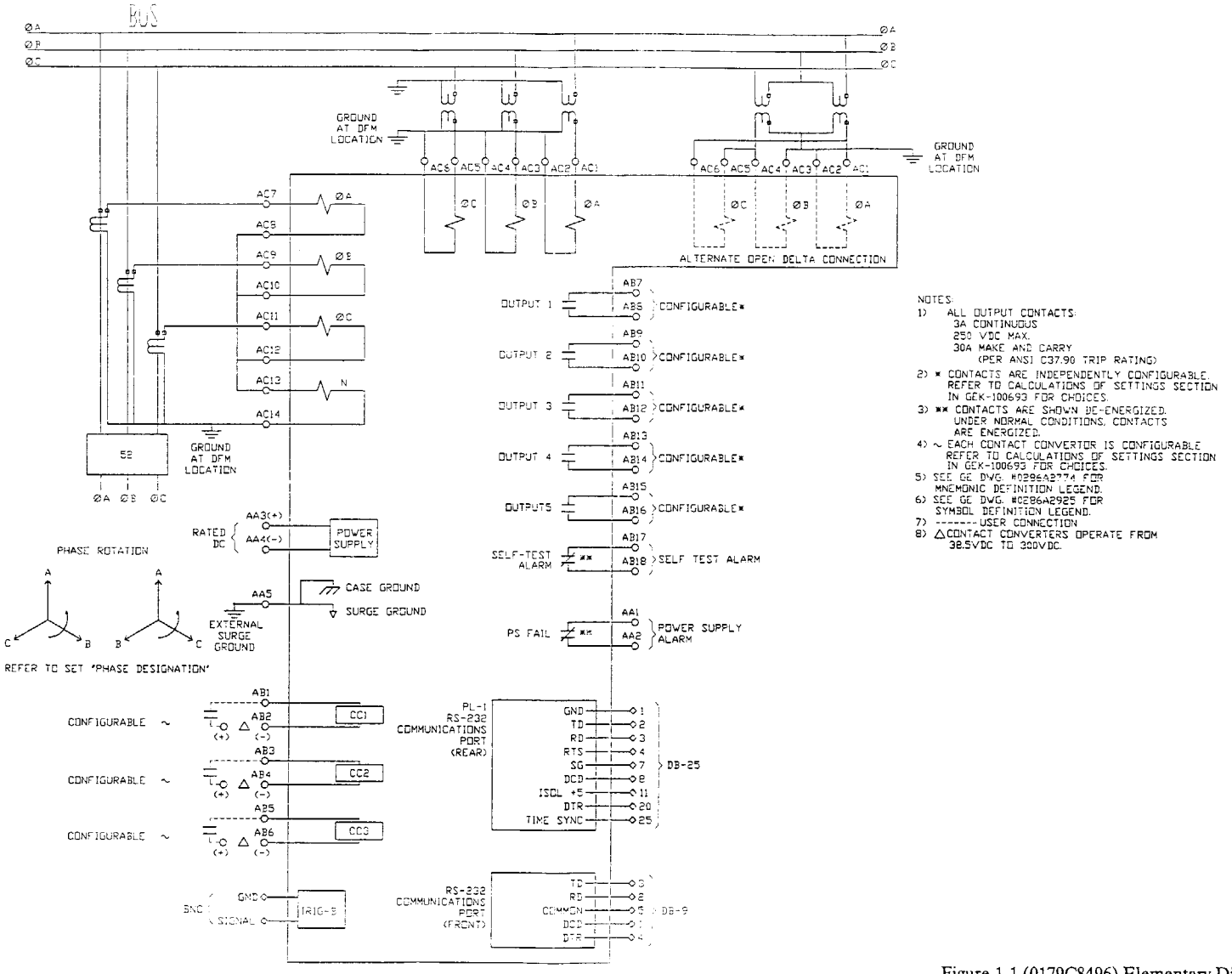
The model number breakdown in the **INTRODUCTION** section shows that the DFM™ relay may be purchased with or without:

POWER QUALITY
35 DAY DEMAND DATA
IOC/TOC OVERCURRENT FUNCTIONS

This results in eight combinations as indicated by option letters A - H associated with digit position seven in the model number.

It is possible to upgrade to POWER QUALITY and/or IOC/TOC OVERCURRENT FUNCTIONS by purchasing a file from GE that will allow "turning on" one or both of these features and changing the model number in the process. The upgrade file is encrypted and contains the serial number of the specific DFM™ relay to be upgraded. The file is supplied on a floppy disk and the upgrade is accomplished via DFM-LINK communications program (refer to the **SOFTWARE** section for details). **Note that this upgrade file can only be used to upgrade the one DFM™ relay corresponding to the unique serial number contained in the upgrade file.**

It is not possible to upgrade to 35 DAY DEMAND DATA via this process. If it is desired to upgrade to 35 DAY DEMAND DATA, it will be necessary to return the DFM™ relay to the factory.



NOTES:
1) ALL OUTPUT CONTACTS:
   3A CONTINUOUS
   250 VDC MAX.
   30A MAKE AND CARRY
   (PER ANSI C37.90 TRIP RATING)
2) * CONTACTS ARE INDEPENDENTLY CONFIGURABLE. REFER TO CALCULATIONS OF SETTINGS SECTION IN GEK-100693 FOR CHOICES.
3) ** CONTACTS ARE SHOWN DE-ENERGIZED. UNDER NORMAL CONDITIONS, CONTACTS ARE ENERGIZED.
4) ~ EACH CONTACT CONVERTOR IS CONFIGURABLE REFER TO CALCULATIONS OF SETTINGS SECTION IN GEK-100693 FOR CHOICES.
5) SEE GE DWG. #0286A2774 FOR MNEMONIC DEFINITION LEGEND.
6) SEE GE DWG. #0286A2925 FOR SYMBOL DEFINITION LEGEND.
7) ------- USER CONNECTION
8) △CONTACT CONVERTERS OPERATE FROM 38.5VDC TO 300VDC.

Figure 1-1 (0179C8496) Elementary Diagram

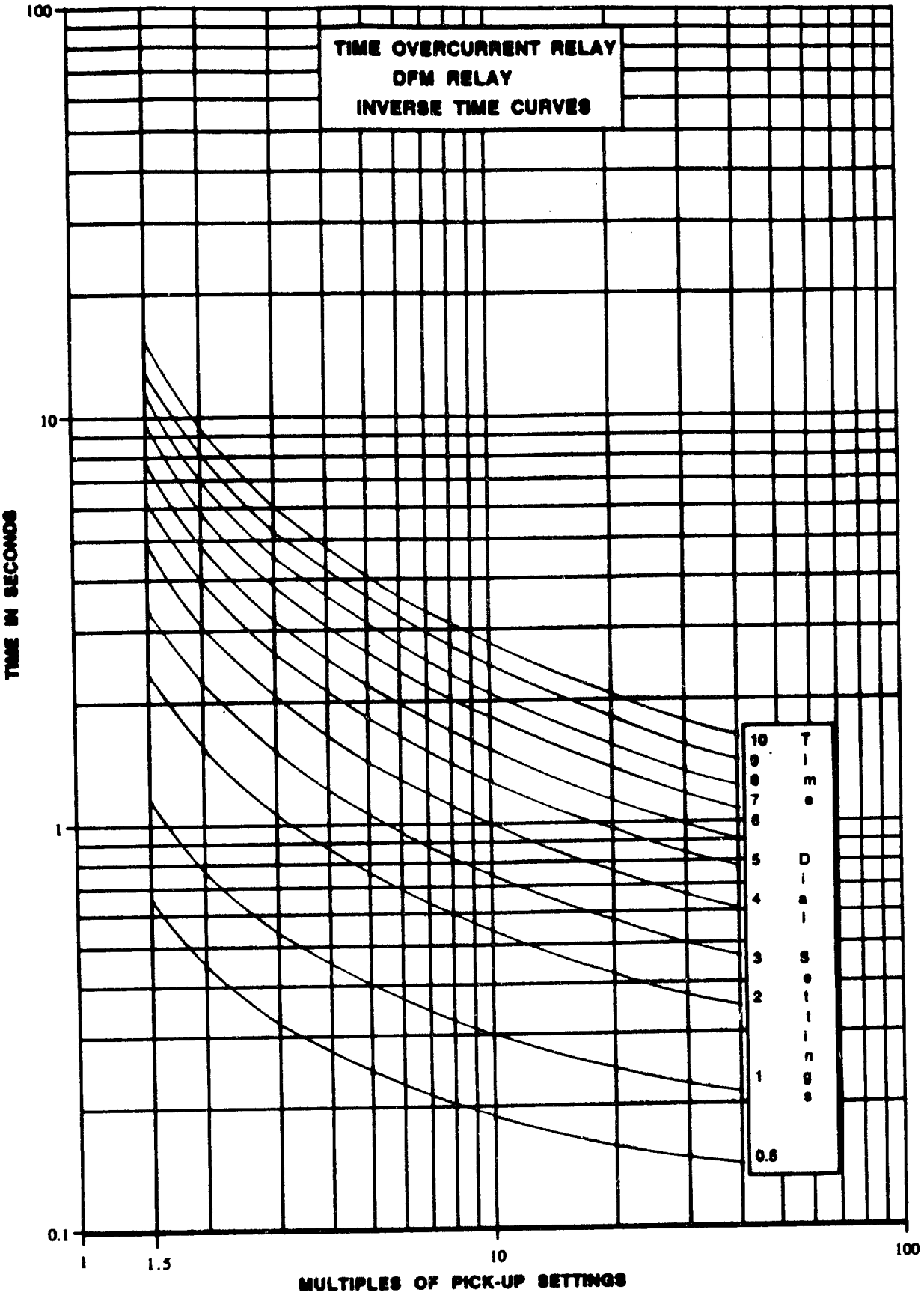


Figure 1-2 (0286A5820) Inverse Time Overcurrent Curve

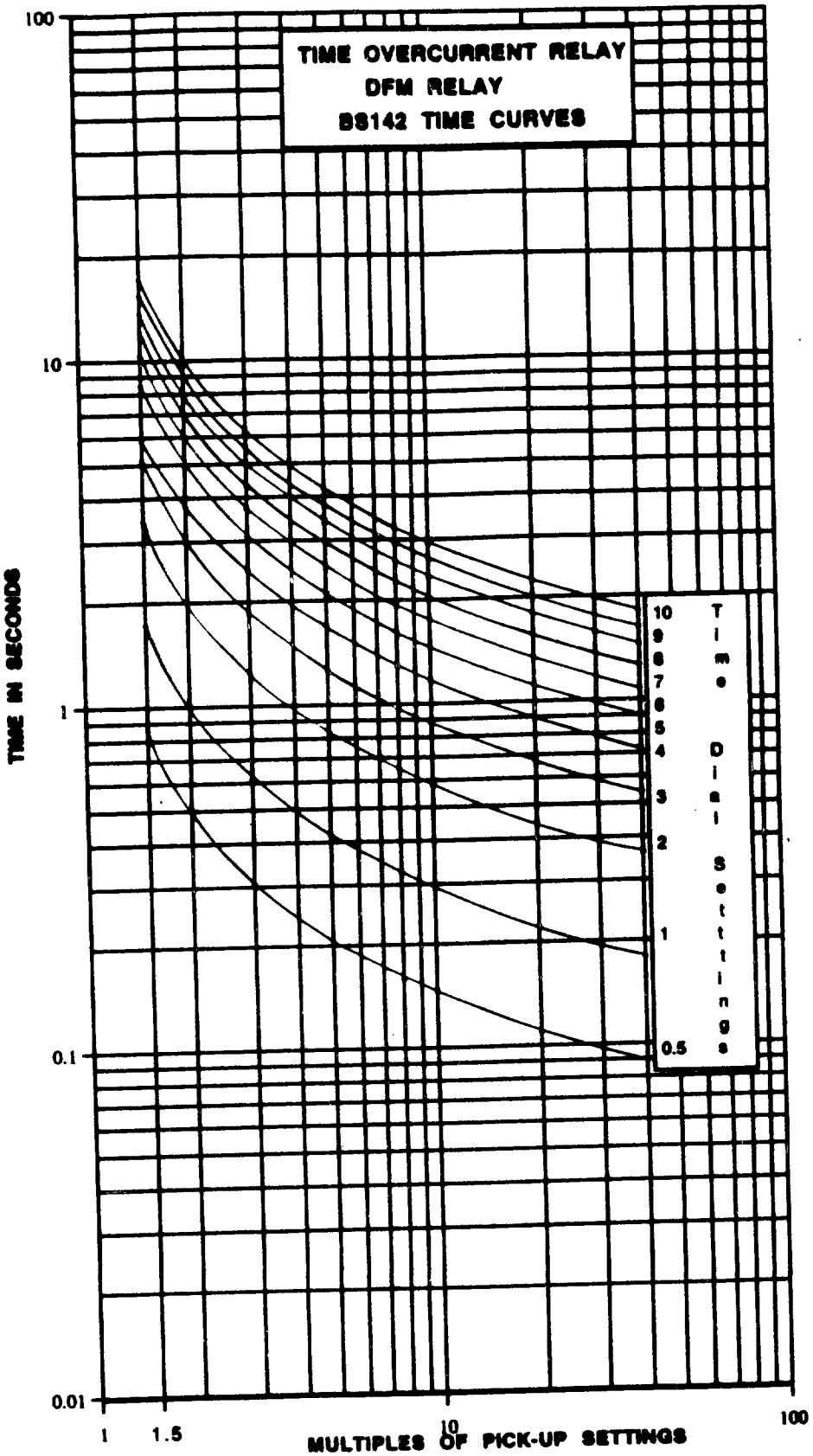


Figure 1-3 (0286A5821) BS142 Inverse Time Overcurrent Curve

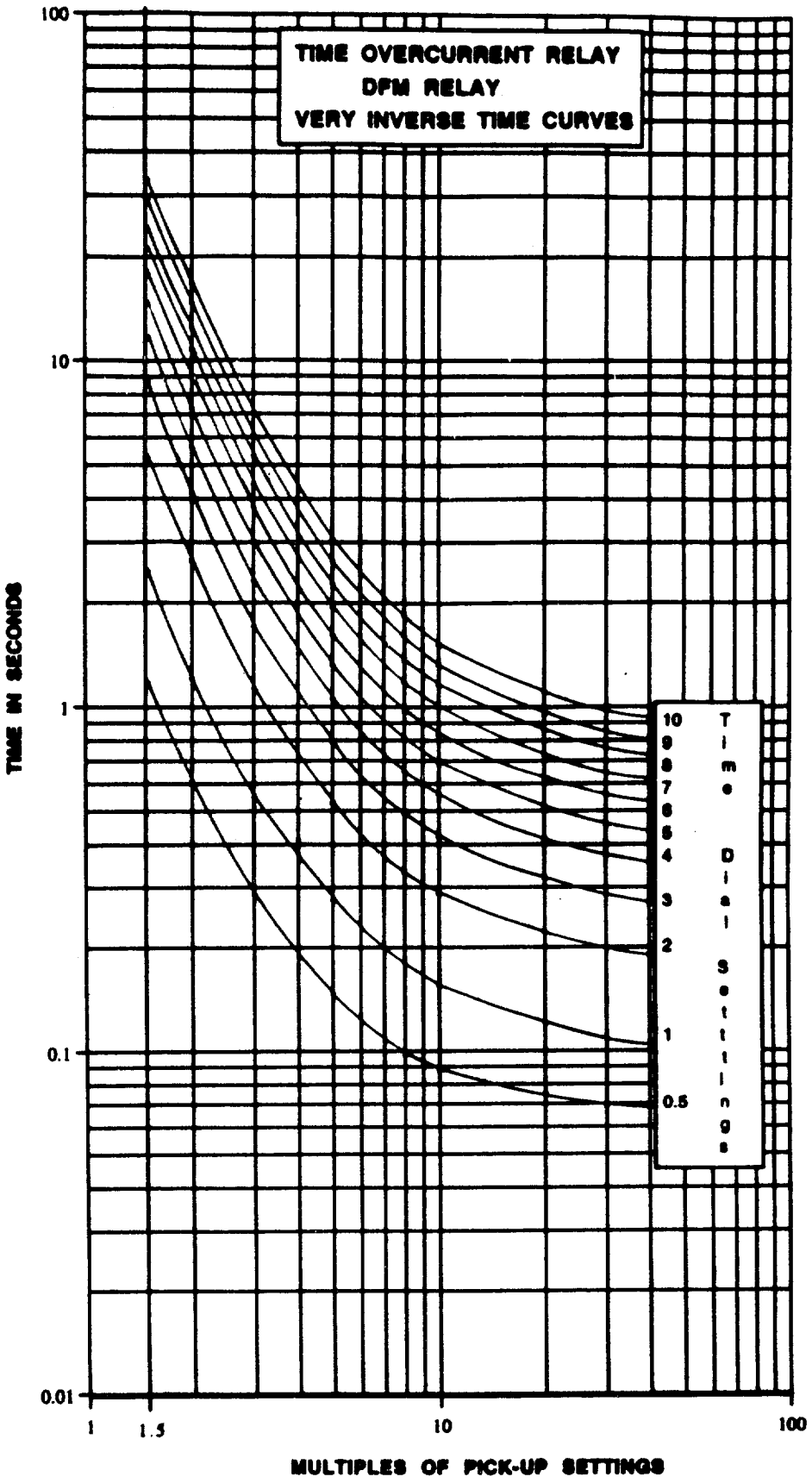


Figure 1-4 (0286A5822) Very Inverse Time Overcurrent Curve

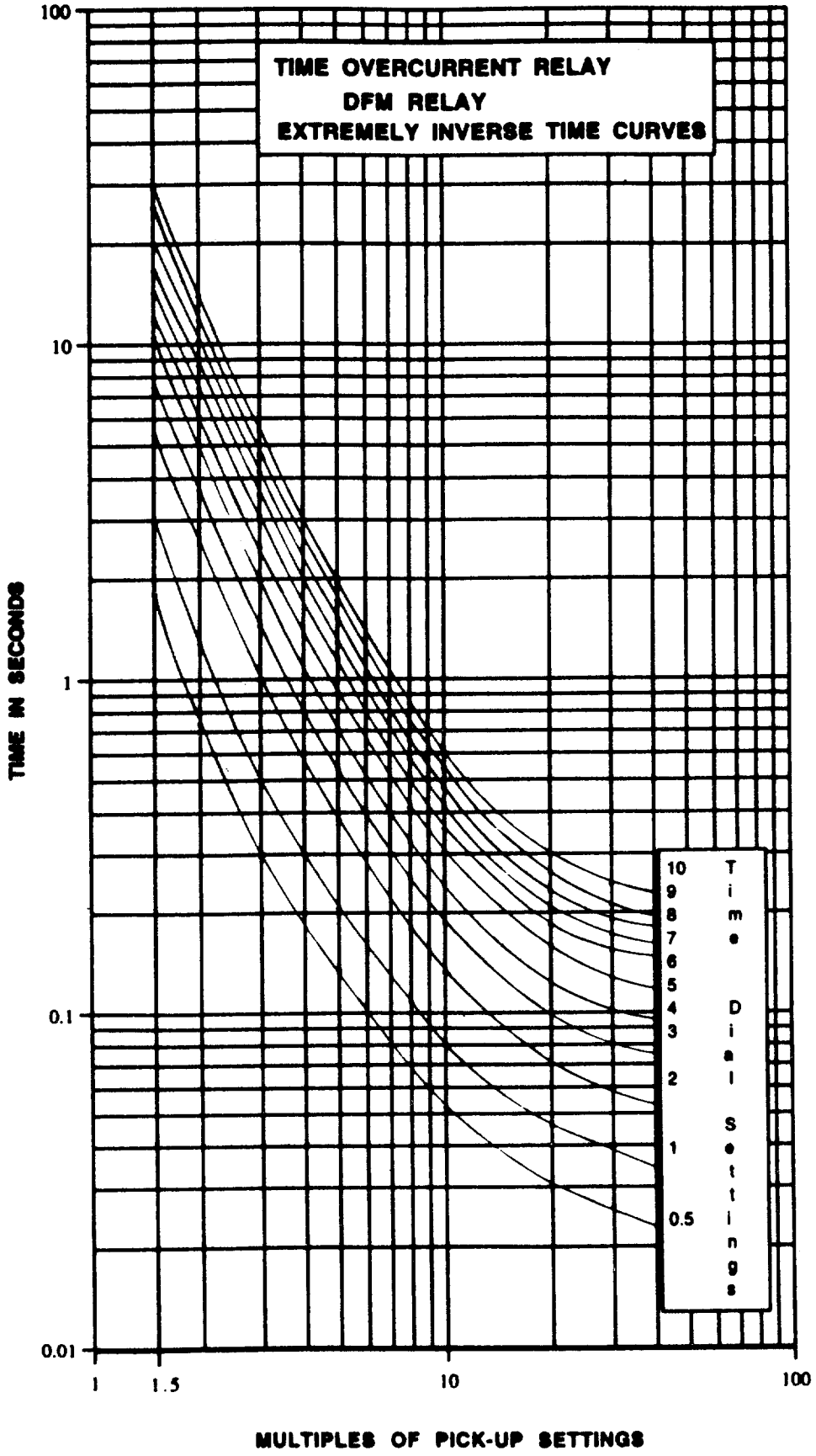


Figure 1-5 (0286A5823) Extremely Inverse Time Overcurrent Curve

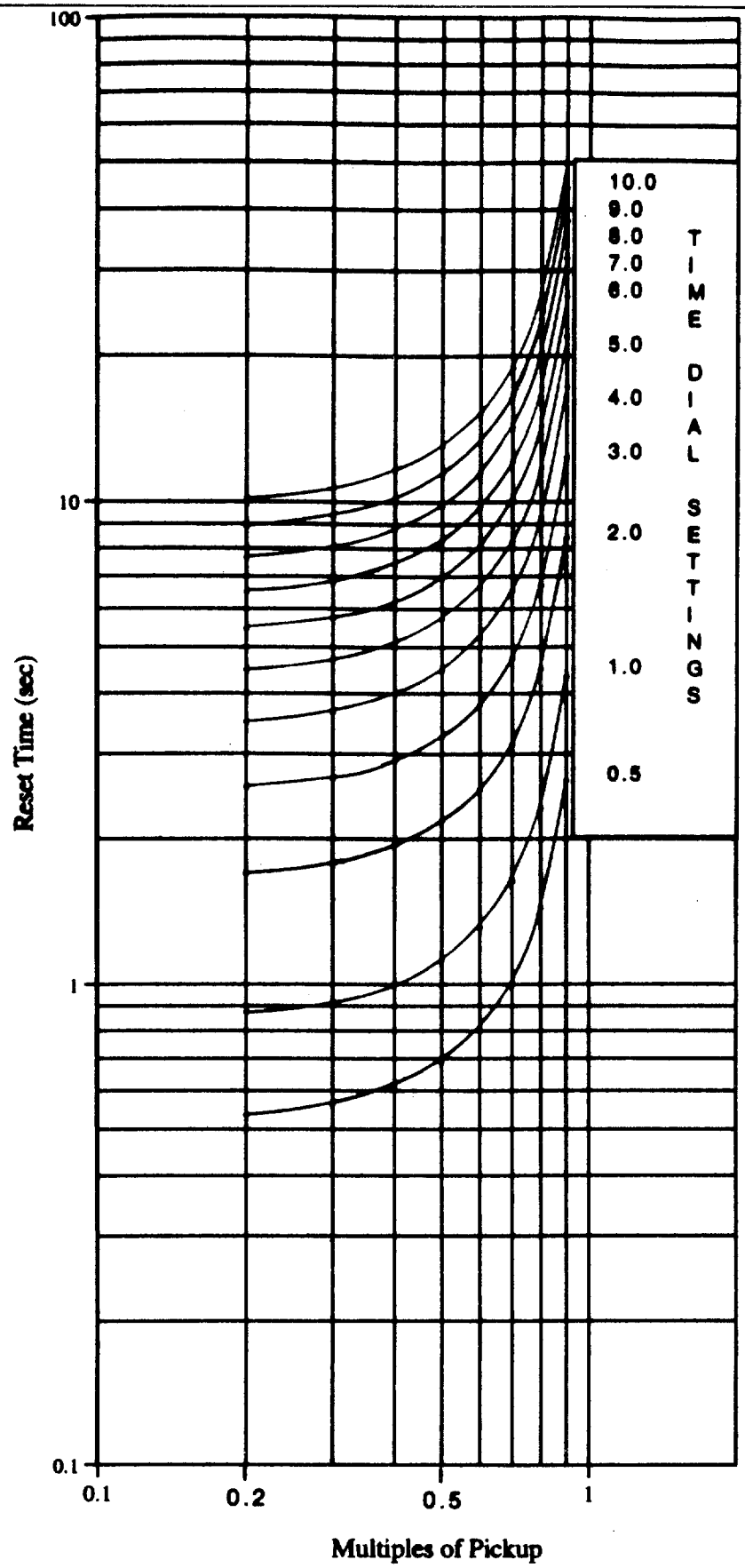


Figure 1-6 (0286A5824) Inverse Reset Curve

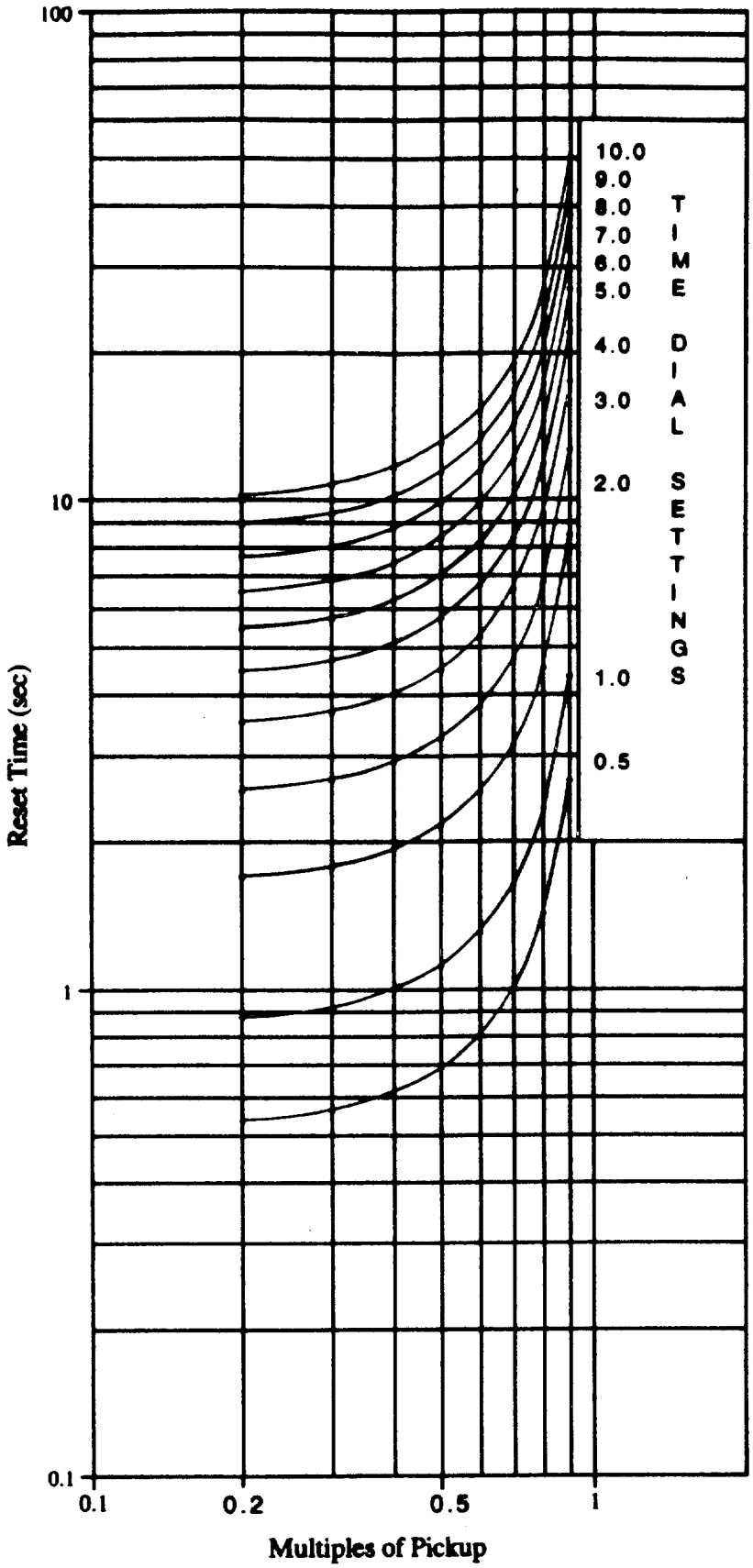


Figure 1-7 (0286A5825) BS142 Inverse Reset Curve

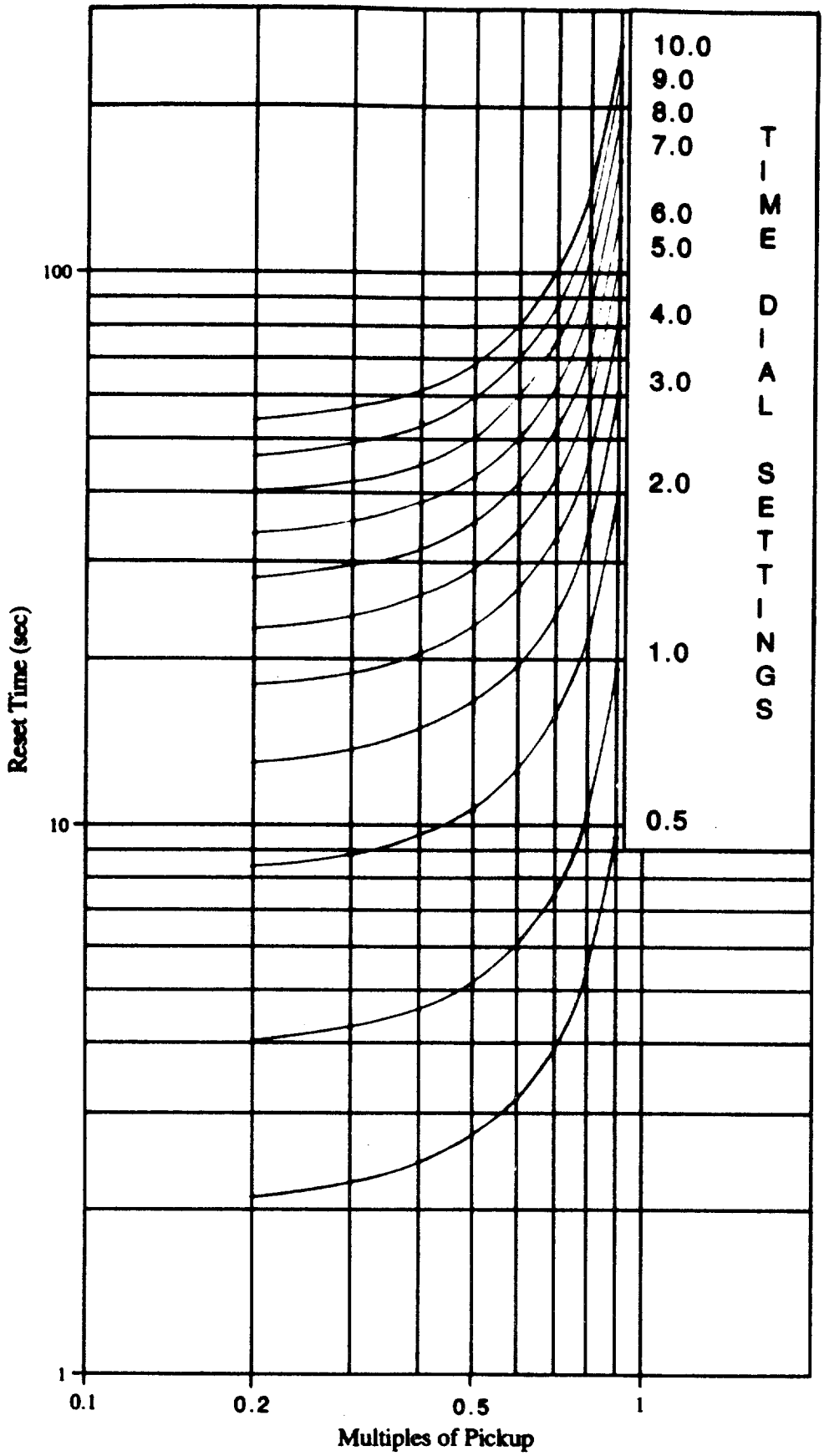


Figure 1-8 (0286A5826) Very Inverse Reset Curve

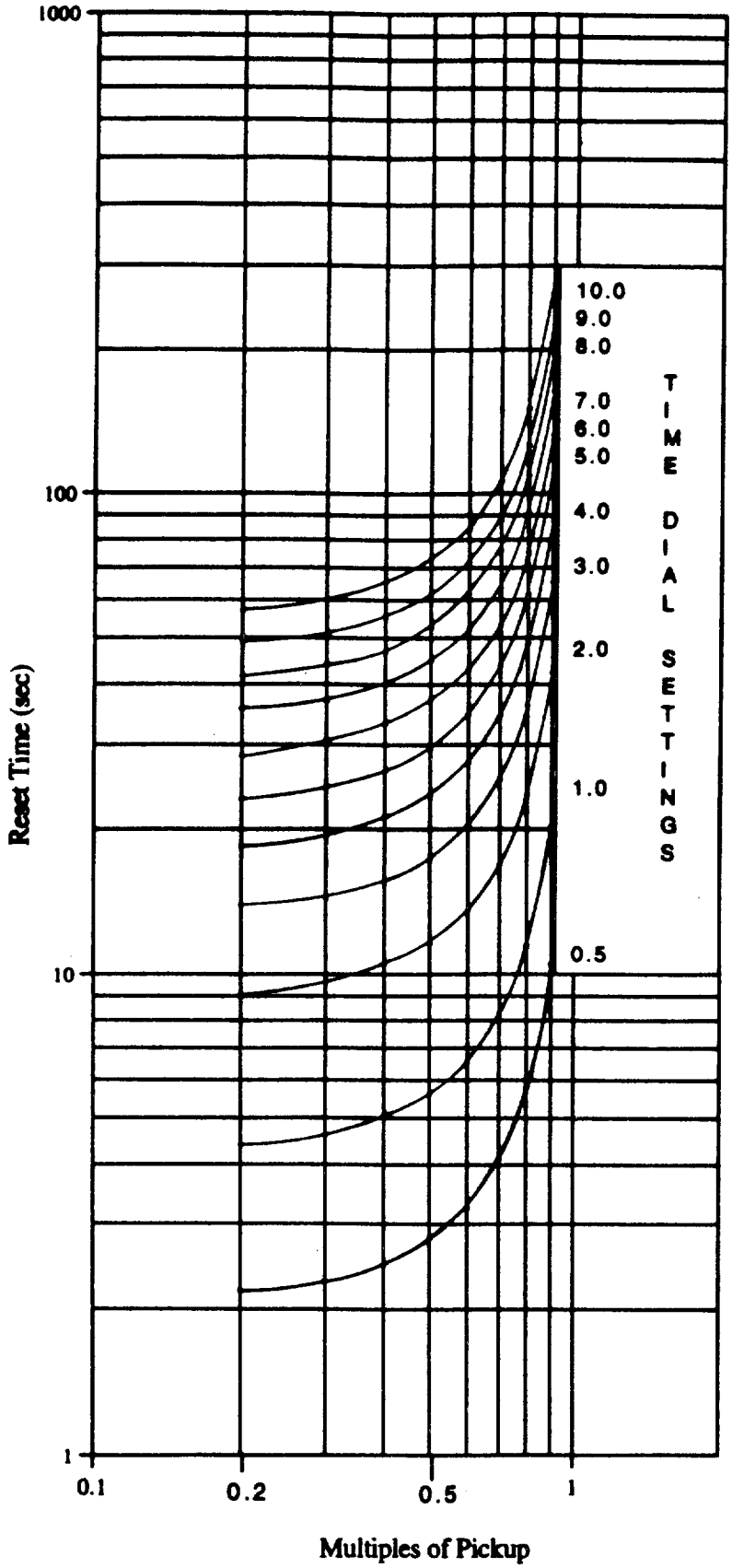


Figure 1-9 (0286A5827) Extremely Inverse Reset Curve

CALCULATION OF SETTINGS

This section provides information to assist the user in determining the required settings for the DFM™ relay. All the settings, along with corresponding ranges (and associated units of measurement, where applicable), are listed in TABLE 2-1. The column entitled **DEFAULT** indicates the DFM™ relay settings stored in memory as shipped from the factory. Both the ranges and defaults listed in the table apply to DFM™ relays designed for use with current transformers having a nominal 5-amp secondary rating. The eleven settings for which the range and default would differ for a 1-amp secondary rating are marked with a double asterisk (**) and explained at the end of the table.

The DFM™ relay settings can only be changed via DFM-LINK communications software running on a PC connected to one of the DFM™ relay's RS-232 serial ports. Settings cannot be changed via the local man-machine interface (MMI), but they may be viewed via the MMI. Refer to the INTERFACE and SOFTWARE sections of this instruction book for detailed information.

The DFM™ relay settings are divided into the following six categories:

GENERAL SETTINGS
HARDWARE SETTINGS
CONTACT SETTINGS
MONITORING SETTINGS
HI-Z SETTINGS
OVERCURRENT SETTINGS

Four separate settings groups can be defined. Within each settings group, distinct settings for the HI-Z and OVERCURRENT categories are allowed, but the settings in the remaining categories are identical from group to group. The DFM™ relay switches between groups of settings on command by the user via either DFM-LINK or an external contact(s).

TABLE 2-1 lists the DFM™ relay settings by category. Note that the THD threshold settings included under MONITORING SETTINGS assume a DFM™ relay model with power-quality monitoring. Likewise, an output contact can only be configured for a THD alarm if the model provides power-quality monitoring.

In the text descriptions of the DFM™ relay settings, a category of settings is identified by all capitals followed by its mnemonic **if different from the category name**. Individual settings under each category are listed by a descriptive name followed by its mnemonic. The mnemonic is what is displayed on the local MMI to identify a particular setting or category of settings.

TABLE 2-2 lists the items displayed on the local MMI under the main menu heading **DEVICE PARAMETERS** (see the **INTERFACE** section). Those items marked with an asterisk (*) are ASCII strings that can be changed via DFM-LINK using menu category **DEVICE PARAMETERS** (see the **SOFTWARE** section).

TABLE 2-1 DFM™ RELAY SETTINGS

SETTING #	SETTING NAME	RANGE	DEFAULT
GENERAL SETTINGS			
101	DFM UNIT ID	0 - 9999	0
102	PHASE CT RATIO	1 - 5000	120
103	GROUND CT RATIO	1 - 5000	120

TABLE 2-1 DFM™ RELAY SETTINGS (continued)

SETTING #	SETTING NAME	RANGE	DEFAULT
GENERAL SETTINGS (continued)			
104	PT RATIO	1 - 7000	110
105	FRONT PORT SETTINGS		
	Baud Rate:	xxx = 003,012,024,096,192	
	Parity:	y = 0(N-none), 1(O-odd), 2(E-even)	
	Stop Bits:	z = 1, 2	
		[xxxyz]	02401
106	REAR PORT SETTINGS		
	Baud Rate:	xxx = 003,012,024,096,192	
	Parity:	y = 0(N-none), 1(O-odd), 2(E-even)	
	Stop Bits:	z = 1, 2	
		[xxxyz]	02401
107	SYSTEM FREQUENCY	50 Hz or 60 Hz	60 Hz
108	SETTINGS FILE	0 (EXTERNAL) 1 (SETGRP 1) 2 (SETGRP 2) 3 (SETGRP 3) 4 (SETGRP 4)	1 (SETGRP 1)
109	PHASE DESIGNATION	0 (A-B-C) 1 (A-C-B)	0 (A-B-C)
110	PHASE POTENTIAL	0 (L-N) 1 (L-L)	0 (L-N)
111	DISPLAYED VALUES	0 (SECONDARY) 1 (PRIMARY)	0 (SECONDARY)
112	FRONT PANEL RESETS	0 (NOT ALLOWED) 1 (ALLOWED)	0 (NOT ALLOWED)
113	CONFIGURED CTs	0 (ABCN) 1 (ABC) 2 (ABN) 3 (AB) 4 (ACN) 5 (AC) 6 (AN) 7 (A) 8 (BCN) 9 (BC) 10 (BN) 11 (B) 12 (CN) 13 (C) 14 (N) 15 (NONE)	0 (ABCN)
114	CONFIGURED PTs	0 (ABC) 1 (AB) 2 (AC) 3 (A) 4 (BC) 5 (B) 6 (C) 7 (NONE)	0 (ABC)
115	LOGIN TIMEOUT	0 - 99 min	15 min

TABLE 2-1 DFM™ RELAY SETTINGS (continued)

SETTING #	SETTING NAME	RANGE	DEFAULT
HARDWARE SETTINGS (READ ONLY)			
201	REMOTE BREAKER OP	0 (NOT ALLOWED) 1 (ALLOWED)	0 (NOT ALLOWED)
202	REMOTE CONFIG	0 (NOT ALLOWED) 1 (ALLOWED)	0 (NOT ALLOWED)
203	CT RATING	0 (5-AMP) 1 (1-AMP)	model dependent
CONTACT SETTINGS			
301	OUTPUT #1	See TABLE 2-4	See TABLE 2-4
302	OUTPUT #2	See TABLE 2-4	See TABLE 2-4
303	OUTPUT #3	See TABLE 2-4	See TABLE 2-4
304	OUTPUT #4	See TABLE 2-4	See TABLE 2-4
305	OUTPUT #5	See TABLE 2-4	See TABLE 2-4
306	CC 1 CONFIGURATION	See TABLE 2-3	(52/b CONTACT)
307	CC 2 CONFIGURATION	See TABLE 2-3	(OSC START)
308	CC 3 CONFIGURATION	See TABLE 2-3	(TIME-TAG-STORE)
309	CNTRL CKT MONITORS	0 (NONE) 1 (OUTPUT #1) 2 (OUTPUT #2) 3 (BOTH)	0 (NONE)
MONITORING SETTINGS			
401	BRKR HEALTH THRESH	0 - 39,999,999.99 @	14400.00
402	CURRENT THD THRESH	0.0% - 100.0%	25.0%
403	VOLTAGE THD THRESH	0.0% - 100.0%	3.0%
404	# DISTURBANCE RPTS	1, 2, 4, 8	4
405	BREAKER ARC TIME	20 ms - 200 ms	100 ms
406	BRKR HEALTH UNITS	0 (AMP* SECONDS) 1 (AMP^2* SECONDS)	1 (AMP^2* SECONDS)
407	DEMAND PERIOD	15 min, 30 min, 60 min	15 min
HI-Z SETTINGS (GROUP 1)			
501	ARCING SENSITIVITY	1 - 10	*
502	PHASE EVENT COUNT	10 - 250	20
503	GROUND EVENT COUNT	10 - 500	20
504	EVENT COUNT TIME	5 min - 180 min	60 min
505	OC COORD TIMEOUT	10 sec - 200 sec	15 sec
506	PCHZ (PHASE OC) **	0.50 - 50.00 amps	7.50 amps
507	GCHZ (GROUND OC) **	0.50 - 50.00 amps	2.50 amps
508	PHASE RATE OF CHNGE **	0.01 - 10 amps/2 cycles	1.25 amps/2 cycles
509	GROUND RATE OF CHNG **	0.01 - 10 amps/2 cycles	1.25 amps/2 cycles
510	LOSS OF LOAD THRESH	5% - 100%	15%
511	3-PH EVENT THRESH **	0.01 - 10 amps	0.42 amp
512	HI-Z MONITORING	0 (OFF) 1 (ON)	1 (ON)

*** Note: An invalid value is set at the factory, which forces the user to set the initial value of ARCING SENSITIVITY**

TABLE 2-1 DFM™ RELAY SETTINGS (continued)

SETTING #	SETTING NAME	RANGE	DEFAULT
HI-Z SETTINGS (GROUP 2)			
HI-Z SETTINGS (GROUP 3)			
HI-Z SETTINGS (GROUP 4)			

The types of settings and their ranges in all four of the HI-Z settings groups are the same as shown above under GROUP 1. However, the intent is that one or more setting values will be unique in each of the four settings groups.

OVERCURRENT PROTECTION SETTINGS (GROUP 1)			
601	PHASE TOC CURVE	0 (INVERSE) 1 (VERY INVERSE) 2 (EXTREMELY INVERSE) 3 (DEFINITE TIME) 4 (BS142 INVERSE) 5 - 8 (USER DEFINED)	2 (EXTREMELY INVERSE)
602	GROUND TOC CURVE	0 (INVERSE) 1 (VERY INVERSE) 2 (EXTREMELY INVERSE) 3 (DEFINITE TIME) 4 (BS142 INVERSE) 5 - 8 (USER DEFINED)	2 (EXTREMELY INVERSE)
603	PHASE TOC PICKUP **	0.50 - 12.00 amps	5.10 amps
604	GROUND TOC PICKUP **	0.50 - 12.00 amps	1.00 amps
605	PHASE TIME DIAL	0.50 - 10.00	5.00
606	PHASE DEFINITE TIME	0.50 - 30.00 sec	5.00 sec
607	GROUND TIME DIAL	0.50 - 10.00	5.00
608	GRND DEFINITE TIME	0.50 - 30.00 sec	5.00 sec
609	IOC LOW PHASE **	0.50 - 160.00 amps	10.00 amps
610	IOC HIGH PHASE **	0.50 - 160.00 amps	10.00 amps
611	IOC LOW GROUND **	0.50 - 160.00 amps	10.00 amps
612	IOC HIGH GROUND **	0.50 - 160.00 amps	10.00 amps
613	IOC LOW PHASE DELAY	0 - 250 ms	100 ms
614	IOC HI PHASE DELAY	0 - 50 ms	10 ms
615	IOC LOW GRND DELAY	0 - 250 ms	100 ms
616	IOC HI GRND DELAY	0 - 50 ms	10 ms
617	PHASE AVERAGING PD	0 - 600 sec	60 sec
618	PHASE ADAPTIVE	110 - 300 %	150 %
619	MIN PHASE ADAPTIVE	25 - 100 %	50 %
620	MAX PHASE ADAPTIVE	100 - 200 %	150 %
621	GROUND AVERAGING PD	0 - 600 sec	60 sec
622	GROUND ADAPTIVE	110 - 300 %	150 %
623	MIN GRND ADAPTIVE	25 - 100 %	50 %
624	MAX GRND ADAPTIVE	100 - 200 %	150 %
625	TOC RESET OPTION	0 (EM RESET) 1 (FAST RESET)	0 (EM RESET)
626	COLD LOAD PICKUP	0 - 60 min	15 min
627	PH TOC PROTECTION	0 (OFF) 1 (ON)	1 (ON)

TABLE 2-1 DFM™ RELAY SETTINGS (continued)

SETTING #	SETTING NAME	RANGE	DEFAULT
OVERCURRENT PROTECTION SETTINGS (continued)			
628	PHASE LOW IOC PROT	0 (OFF) 1 (ON)	1 (ON)
629	PHASE HIGH IOC PROT	0 (OFF) 1 (ON)	1 (ON)
630	GRND TOC PROTECTION	0 (OFF) 1 (ON)	1 (ON)
631	GRND LOW IOC PROT	0 (OFF) 1 (ON)	1 (ON)
632	GRND HIGH IOC PROT	0 (OFF) 1 (ON)	1 (ON)

OVERCURRENT PROTECTION SETTINGS (GROUP 2)
OVERCURRENT PROTECTION SETTINGS (GROUP 3)
OVERCURRENT PROTECTION SETTINGS (GROUP 4)

The types of settings and their ranges in all four of the HI-Z settings groups are the same as shown above under GROUP 1. However, the intent is that one or more setting values will be unique in each of the four settings groups.

Notes:

@ The range for Breaker Health Threshold is given in terms of secondary current. DFM-LINK and the DFM™ relay's MMI display the range in terms of primary current by multiplying 39,999,999.99 by the CT ratio (setting #102) or the CT ratio squared depending on the Breaker Health Units (setting #406) selected.

**** Note: For the use of current transformers having a nominal 1-amp secondary rating, the ranges and defaults for these settings should be divided by 5. All settings are in secondary amps.**

TABLE 2-2 DEVICE PARAMETERS

DFM MODEL #
EPROM VERSION #
* VIEWING PASSWORD
* SETTING PASSWORD
* CONTROL PASSWORD
* STATION ID
* FEEDER ID
* CONTACT CONVERTR ID

* ASCII strings that can be changed via DFM-LINK using **Device parameters** in the **MONITOR FUNCTIONS** in the **SOFTWARE** section).

GENERAL SETTINGS

DFM™ Relay Unit Identification Number, DFM UNIT ID (101)

The DFM UNIT ID is a decimal number between 0 and 9999 that uniquely identifies a DFM™ relay. When the DFM™ relay is accessed via either of its serial ports, the DFM UNIT ID must be known to establish communication, thus providing a measure of security.

If the DFM™ relay is to be installed in a multi-drop communications configuration, it is recommended that the user not leave any DFM UNIT ID at the default value of zero. This is due to the fact that detection of a configuration error by the DFM™ relay's run-time self-tests would cause this setting to be reset to its default value. If such an event occurred, the failed unit and Unit '0' would be in contention, and both would be unable to perform serial communications.

Phase Current Transformer Ratio, PHASE CT RATIO (102)

The PHASE CT RATIO specifies the primary-to-secondary ratio of the phase current transformers connected to the DFM™ relay. A phase current transformer ratio of 1200/5 (primary/secondary), for example, would be entered as 240. The range allowed for the PHASE CT RATIO is from 1 to 5000.

Ground Current Transformer Ratio, GROUND CT RATIO (103)

The GROUND CT RATIO specifies the primary-to-secondary ratio for the ground current. The range allowed is the same as for the PHASE CT RATIO (1 to 5000).

Potential Transformer Ratio, PT RATIO (104)

The PT RATIO specifies the primary-to-secondary ratio of the voltage inputs to the DFM™ relay. The allowed range is from 1 to 7000.

Communications Parameters for the Front Serial Port, FRONT PORT SETTINGS (105)

FRONT PORT SETTINGS sets the baud rate, parity, and stop bits of the DFM™ relay's front-mounted RS232 serial port. The setting format is xxxyz where:

Baud Rate = xxx = 003 (300), 012 (1200), 024 (2400), 096 (9600), or 192 (19200)
Parity = y = 0 (none), 1 (odd), or 2 (even)
Stop Bits = z = 1 or 2

The baud-rate setting must match the baud rate of the modem or other serial device connected to the front serial port on the DFM™ relay. The parity and stop bits must match those selected for the serial port of the remote PC. Normally 1 stop bit is selected. However, certain modems or other communication hardware might dictate using 2 stop bits. DFM-LINK communications software can be configured to match this DFM™ relay setting for baud rate, parity, and stop bits.

Communications Parameters for the Rear Serial Port, REAR PORT SETTINGS (106)

REAR PORT SETTINGS sets the baud rate, parity, and stop bits of the DFM™ relay's rear-mounted RS232 serial port. The setting format is xxxyz where:

Baud Rate = xxx = 003 (300), 012 (1200), 024 (2400), 096 (9600), or 192 (19200)
Parity = y = 0 (none), 1 (odd), or 2 (even)
Stop Bits = z = 1 or 2

The baud-rate setting must match the baud rate of the modem or other serial device connected to the rear serial port on the DFM™ relay. The parity and stop bits must match those selected for the serial port of the remote PC. Normally 1 stop bit is selected. However, certain modems or other communication hardware might dictate using 2 stop bits. DFM-LINK communications software can be configured to match this DFM™ relay setting for baud rate, parity, and stop bits.

System Frequency, SYSTEM FREQUENCY (107)

The SYSTEM FREQUENCY can be set to either 50 Hz or 60 Hz. When this setting is changed and downloaded to the DFM™ relay, the DFM™ relay automatically reboots in order to re-initialize based on the new frequency.

Note: When this setting is changed, the DFM™ relay automatically reinitializes. However, this reinitialization is transparent to the user; DFM-LINK stays logged into the DFM™ relay.

Settings File, SETTINGS FILE (108)

SETTINGS FILE can be set to EXTERNAL, SETGRP 1, SETGRP 2, SETGRP 3, or SETGRP 4 to control which of four groups of settings is currently active. If the value for this setting is EXTERNAL, the state of one or two contact converters indicates which group is active, as described in TABLE 2-3.

Phase Designation, PHASE DESIGNATION (109)

PHASE DESIGNATION can be set to either A-B-C or A-C-B to match the positive-sequence phase rotation for the section of the power system where the DFM™ relay is installed. This setting permits the DFM™ relay to report the faulted phase or phases properly.

Note: When this setting is changed, the DFM™ relay automatically reinitializes. However, this reinitialization is transparent to the user; DFM-LINK stays logged into the DFM™ relay.

Voltage Connection, PHASE POTENTIAL (110)

PHASE POTENTIAL can be set to either L-N (Line-Neutral) or L-L (Line-Line) to match the potential transformer connections to the DFM™ relay.

Note: When this setting is changed, the DFM™ relay automatically reinitializes. However, this reinitialization is transparent to the user; DFM-LINK stays logged into the DFM™ relay.

Display Primary or Secondary Values, DISPLAYED VALUES (111)

DISPLAYED VALUES can be set to either SECONDARY or PRIMARY. This setting determines whether currents, voltages, watts, VARs, and VA will be displayed as primary or secondary values.

Allow Front Panel Resets, FRONT PANEL RESETS (112)

FRONT PANEL RESETS can be set to NOT ALLOWED or ALLOWED. If it is set to ALLOWED, the user is able to reset the peak values and the breaker-health values via the DFM™ relay front-panel menu options RESET PEAK VALUES and RESET BRKR HEALTH, respectively. If FRONT PANEL RESETS is set to NOT ALLOWED and the user attempts a reset via the front panel, a message will be displayed on the local MMI indicating to the user that local MMI resets are not allowed (see **Action Menu Options** in the **INTERFACE** section for more detail).

Configured Current Phases, CONFIGURED CTs (113)

The CONFIGURED CTs can be set to any combination of the four CT inputs represented by A, B, C, and N (e.g. ABCN, ABN, BCN, ...). While maximum performance is achieved if all four of the CT signals are connected, the DFM™ relay will be able to function, at a degraded level, with any number of CTs connected. It is strongly recommended, however, that the neutral current (N) not be the missing current, as this would result in a degraded performance of the DFM™ relay's high-impedance-fault-detection algorithms.

Note: When this setting is changed, the DFM™ relay automatically reinitializes. However, this reinitialization is transparent to the user; DFM-LINK stays logged into the DFM™ relay.

Configured Voltage Phases, CONFIGURED PTs (114)

The DFM™ relay can be configured for none, one, two, or three potential transformer (PT) secondaries. Thus, the CONFIGURED PTs can be set to either none or to any combination of the three PT signals represented by A, B, and C (e.g. NONE, ABC, AC, B, ...). The voltage rating of the DFM™ relay's auxiliary potential transformers is four times nominal line-to-neutral (67 volts).

The DFM™ relay can operate without voltage connected or with various single-phase and three-phase voltage connections. The practical possibilities are:

(1) No voltage connected
(2) Single-phase to ground voltage using one PT
(3) Phase-to-phase voltage using one PT
(4) Three-phase voltage using three wye-wye connected PTs
(5) Three-phase voltage using two open-delta connected PTs

The presence or absence of voltage inputs to the DFM™ relay has no effect on the DFM™ relay's ability to detect high-impedance faults. However, with no voltage connected, phase identification in the event of a high-impedance fault would be limited. With no voltage connected the DFM™ relay would be unable to perform any of its "power" calculations. Included in these power calculations are WATTS, VARS, VA, and POWER FACTOR. For DFM™ relays that provide power-quality monitoring, Total Harmonic Distortion (THD) calculations based on voltage would also be eliminated. All DFM™ relay reporting functions that include these power values would no longer include them, and no data related to the power calculations would be displayed on the DFM™ relay's local man-machine interface (MMI) or transmitted via a serial port.

With at least one phase-to-ground voltage connected, the DFM™ relay's power calculations would be performed using the value of the connected voltage(s) for the missing phase(s). With at least one phase-to-phase voltage connected, phase-to-ground voltages are calculated within the DFM™ relay and would be used in the power calculations. Only when three-phase voltage is connected as shown in Figure 1-1 will the DFM™ relay perform all functions without degradation.

Note: When this setting is changed, the DFM™ relay automatically reinitializes. However, this reinitialization is transparent to the user; DFM-LINK stays logged into the DFM™ relay.

Login Timeout, LOGIN TIMEOUT (115)

When logged into the DFM™ relay via DFM-LINK software, the DFM™ relay will automatically logout if there is no serial link activity for the time interval determined by LOGIN TIMEOUT. The setting range is 0 - 99 minutes. A setting of "0" prevents the DFM™ relay from initiating an automatic logout (i.e., the DFM™ relay will stay logged in until a logout command is sent from DFM-LINK).

HARDWARE SETTINGS (***Read Only***)

Remote Breaker Operation, REMOTE BREAKER OP (201)

REMOTE BREAKER OP is set to either NOT ALLOWED or ALLOWED as determined by the position of a hardware jumper (J1 in Figure 3-8) specifically intended to enable or disable breaker control via the rear serial port. If the jumper is in place, breaker operation is disabled; if the jumper is removed, it is enabled. As shipped from the factory, the hardware jumper is in place. If the hardware jumper is removed after the DFM™ relay has been placed in operation, the DFM™ relay must reboot in order to re-initialize based on the new hardware configuration.

This setting does not affect the front serial port. Breaker control is possible via the front serial port regardless of the position of jumper J1.

Remote Configuration, REMOTE CONFIG (202)

REMOTE CONFIG is set to either NOT ALLOWED or ALLOWED as determined by the position of a hardware jumper (J2 in Figure 3-8) specifically intended to enable or disable the ability to change settings via the rear serial port. If the jumper is in place, remote setting capability is disabled; if the jumper is removed, it is enabled. As shipped from the factory, the hardware jumper is in place. If the hardware jumper is removed after the DFM™ relay has been placed in operation, the DFM™ relay must reboot in order to re-initialize based on the new hardware configuration.

This setting does not affect the front serial port. Setting changes can be made via the front serial port regardless of the position of jumper J2.

Magnetics Module Rated Current, CT RATING (203)

The CT RATING is either 1-AMP or 5-AMP, indicating whether the DFM™ relay is designed for use with current transformers having a nominal 1-amp secondary rating or a nominal 5-amp secondary rating, respectively. This setting is read from the serial EEPROM on the magnetics module.

Note: The HARDWARE SETTINGS category is provided in the DFM™ relay for informational purposes only. These settings cannot be changed using DFM-LINK.

CONTACT SETTINGS

Output Contact Configurations,
OUTPUT #1 (301)
OUTPUT #2 (302)
OUTPUT #3 (303)
OUTPUT #4 (304)
OUTPUT #5 (305)

These five settings determine how the respective output contacts are used. There are twelve possible assignments for each output contact. For each configurable output, the selected assignments are logically ORed together.

Possible assignments for the configurable output contacts are listed in TABLE 2-4. The assignment mnemonic, listed under the **NAME** column, is what is displayed on the local MMI to identify the existing configuration. A more detailed explanation of the output-contact activation characteristics is presented in TABLE 2-5. This table includes descriptions for the two non-configurable output contacts as well as for the five that are configurable.

TABLE 2-4 lists DWELL TIME as one of the output-contact assignments. As explained in TABLE 2-4, DWELL TIME is not an actuating signal but rather a modifier of output-contact operation.

Contact Converter Configurations,
CC 1 CONFIGURATION (305)
CC 2 CONFIGURATION (306)
CC 3 CONFIGURATION (307)

CC 1 CONFIGURATION, CC 2 CONFIGURATION, and CC 3 CONFIGURATION determine how the three contact converters CC1, CC2, and CC3, are used. There are eight allowable contact converter assignments. Each CC may be given one and only one assignment at a time, and no two CCs can have the same assignment.

A contact converter is an isolated interface that converts the DC battery voltage applied when an external contact closes to a "logic 1" signal level within the DFM™ relay. The terms "contact converter" and "digital input" are synonymous.

The contact converter assignments are presented in TABLE 2-3. The assignment mnemonic, listed under the **NAME** column, is what is displayed on the local MMI to identify the existing configuration.

Output Contact Circuit Monitor, CNTRL CKT MONITORS (308)

CNTRL CKT MONITORS determines which output contact is monitored by checking DC battery voltage across the open contact. If the monitored DC voltage becomes virtually zero, then the **external circuit** has failed open. When the external circuit is a breaker trip circuit, absence of DC voltage indicates that either the trip circuit has failed open or the breaker 52/a contact, which is normally wired in series with the trip coil, has opened. To prevent nuisance alarms that would otherwise occur if the breaker was tripped manually, this monitor function checks the status of the 52/b contact provided that one of the contact converters has been configured to "52/b CONTACT" (see TABLE 2-3). Closure of the 52/b contact (i.e., breaker open) disables the monitor function.

CNTRL CKT MONITORS can be set to either NONE, CONTROL OUTPUT #1, CONTROL OUTPUT #2, or BOTH, to designate which, if either, of the OUTPUT #1 or OUTPUT #2 output contacts is to be monitored. Two of the possible configurations for the output contacts are CNTRL OUTPT #1 FAIL and CNTRL OUTPT #2 FAIL. If a monitor function operates, and an output contact is configured for the failure of that monitored contact, an alarm condition is indicated. The alarm condition causes the DFM™ relay's alarm LED to be illuminated, and an output-contact failure message is listed on the local MMI display when the ALARM DATA main menu option is selected.

MONITORING SETTINGS

Breaker Health Alarm Threshold, BRKR HEALTH THRESH (401)

The BRKR HEALTH THRESH represents an I*t or I^2*t accumulated value used in determining whether or not a breaker-health-alarm condition exists. The range for this threshold is from 0 to 39,999,999.99 I*t or I^2*t. There is an accumulated value for each phase current. If any of the three phase values exceeds 80% of the BRKR HEALTH THRESH, a breaker-health alarm is indicated. If one of the output-contact assignments is 'breaker health', this condition will illuminate the DFM™ relay's alarm LED, and a breaker-health-alarm message is listed on the local MMI display when the ALARM DATA main menu option is selected.

Total Harmonic Distortion Thresholds, CURRENT THD THRESH (402) VOLTAGE THD THRESH (403)

The CURRENT THD THRESH and VOLTAGE THD THRESH represent THD values for currents and voltages, respectively, that trigger a THD power-quality snapshot capture and indicate a THD alarm condition. These thresholds range from 0% to 100%. The CURRENT THD THRESH and VOLTAGE THD THRESH settings are only applicable to DFM™ relays that provide power-quality monitoring.

Number of Oscillography Captures, # DISTURBANCE RPTS (404)

Each time the DFM™ relay detects an overcurrent or high-impedance disturbance, or in the event of an oscillography request through the serial communications, an oscillography capture of instantaneous voltage and current values is triggered. At the same time, the 2-cycle RMS values for the voltages and currents are also captured. Data from the most recent captures is stored in the DFM™ relay. The number and size of the captures is determined by # DISTURBANCE RPTS, which can be set to either 1, 2, 4, or 8. Depending on the configuration, a capture of either one 200-cycle event, two 100-cycle events, four 50-cycle events, or eight 25-cycle events of instantaneous oscillography is stored; at the same time, a capture of either one 5400-sample, two 2700-sample, four 1350-sample, or eight 675-sample events of 2-cycle RMS oscillography data is also stored.

After the number of oscillography captures has reached its maximum (# DISTURBANCE RPTS), the trigger of a new oscillography capture causes the data for the oldest stored capture to be overwritten. **It is important for the user to note that if the # DISTURBANCE RPTS setting is changed, all oscillography capture data is destroyed.**

Breaker Arc Time, BREAKER ARC TIME (405)

One of the functions of the DFM™ relay (breaker-health monitoring) requires the calculation of the amperes squared multiplied by seconds (I^2*t) or amperes multiplied by seconds (I*t),

depending on the existing settings. This calculation is performed for each phase of the feeder breaker, starting from the time the DFM™ relay orders a trip. BREAKER ARC TIME determines the time interval for the calculation. The setting value is the average breaker-opening time, and the range for this setting is from 20 to 200 milliseconds.

Breaker Health Units, BRKR HEALTH UNITS (406)

The DFM™ relay updates its breaker-health accumulations each time a breaker open operation is detected. These breaker-health accumulations can be expressed as either AMP* SECONDS or AMP SQUARED* SECONDS, as established by the BRKR HEALTH UNITS setting. The more common, abbreviated forms of these measurement units are I* t and I^2* t, respectively.

Time Interval for Demand Data, DEMAND PERIOD (407)

Demand profiles for the average currents, voltages, watts, VARs, and power factors are maintained for a specified interval of time. This configurable interval of time is the DEMAND PERIOD, which may be set to either 15, 30, or 60 minutes. The average 3-phase watts, 3-phase VARs, and 3-phase VA are also maintained for each demand period, as well as the average minimum 3-phase power factor. In DFM™ relays that provide power-quality monitoring, the minimum, maximum, and average THD per phase current and voltage and the minimum 2-second RMS voltage average per phase is also recorded for each period.

Note: When this setting is changed, the DFM™ relay automatically reinitializes. However, this reinitialization is transparent to the user; DFM-LINK stays logged into the DFM™ relay.

HIGH IMPEDANCE SETTINGS, HI-Z SETTINGS

Arcing Sensitivity, ARCING SENSITIVITY (501)

This one setting establishes both the belief-in-arcing confidence level at which the DFM™ relay will recognize arcing on the power system, and sets the arc-detection thresholds in the basic arc-detection algorithms. The range for this setting is from 1 to 10 where 10 is the most sensitive setting and 1 is the least sensitive setting.

Each belief-in-arcing confidence level that is derived by the system's Expert Arc Detector Algorithm is compared to this **ARCING SENSITIVITY** setting before concluding that arcing is present (see **High Impedance Fault Detection** in the **PRODUCT DESCRIPTION** section). Increasing this setting results in the DFM™ relay recognizing arcing at a lower belief-in-arcing level; conversely, decreasing this setting results in recognition at a higher level.

A higher **ARCING SENSITIVITY** setting causes the arc-detection thresholds in the basic arc-detection algorithms to be lower. A higher setting would be suitable for a very quiet, well-behaved power system. However, it would give the basic algorithms a higher propensity for the indication of arcing on a normal system transient. An initial setting of 5 is suggested if the user has no previous experience with the DFM™ relay.

Note: An invalid value is set at the factory, which forces the user to set the initial value of ARCING SENSITIVITY. When the DFM™ relay is first powered up, the message *SET HI-Z SENSITIVITY SETTING* will appear on the local MMI display after the completion of the power-up self-test. Pressing the UP pushbutton will result in the display *SENSITIVITY SETTING: 1*. The UP and DN pushbuttons can then be used to scroll through the possible sensitivity settings, **which are the integers 1 through 10. When the desired setting is displayed, pressing the ENTER**

pushbutton results in the display of a confirmation message asking the user to verify the desired setting. If the ENTER pushbutton is pressed in response to this confirmation message, the setting value selected is saved, and the DFM™ relay reboots. If either the UP or DN pushbutton is pressed instead, the next possible sensitivity setting in the sequence is displayed. This sequence occurs only at initial power-up. After a valid setting is selected, it can be changed by the user at any time via DFM-LINK, but not via the MMI.

Arcing-Suspected Identifier Counts,
PHASE EVENT COUNT (502)
GROUND EVENT COUNT (503)

The PHASE EVENT COUNT and GROUND EVENT COUNT settings allow the user to specify how many individual belief-in-arcing indications for a phase current or the residual current, respectively, must be counted in a specified period of time before it is determined that an arcing-suspected event exists. The indications of arcing are detected by the DFM™ relay's basic arc-detection algorithms (Energy Algorithm and Randomness Algorithm) for a specific set of non-fundamental frequency component energies of a phase or residual current. The range for PHASE EVENT COUNT is 10-250. The range for GROUND EVENT COUNT is 10 to 500.

Arcing-Suspected Identifier Time Period, EVENT COUNT TIME (504)

The EVENT COUNT TIME setting allows the user to specify the length of time (in minutes) over which the DFM™ relay monitors long term, sporadic, arcing events for determination of an arcing-suspected event. The belief-in-arcing confidence level of the DFM™ relay increases as the number of arcing indications during this time period increases. The range for this setting is from 5 to 180 minutes.

Conventional Protection Timeout, OC COORD TIMEOUT (505)

The DFM™ relay's high-impedance algorithms use the OC COORD TIMEOUT in providing coordination between the DFM™ relay and the feeder's conventional overcurrent protection. The DFM™ relay will not indicate detection of a downed conductor or an arcing, intact conductor before the expiration of this timeout, which begins when the DFM™ relay detects a trigger condition (loss of load, high rate of change, overcurrent, breaker open, or high belief-in-arcing confidence).

The value of this setting should be such that a feeder's conventional protection is given adequate opportunity to operate before the timeout expires. The range for the setting is 10 to 200 seconds. In choosing a value for this setting, however, the user should keep in mind that the arcing activity of many downed lines diminishes as time passes due to drying of soil, burning through of the conductor, etc. When this occurs, the arcing becomes more difficult, or even impossible, to detect. Therefore, it is recommended that this timeout value not exceed 30 seconds. Note that at least one additional arc burst must occur after the timeout has expired in order for the DFM™ relay to proceed with its high-impedance analysis.

Overcurrent Thresholds,
PCHZ (PHASE OC) (506)
GCHZ (GROUND OC) (507)

PUPH (PHASE OC) and PUGR (GROUND OC) indicate the levels at which the DFM™ relay considers a phase current and residual current, respectively, to be an overcurrent. The DFM™ high-impedance-fault-detection algorithms will ignore all data as long as an overcurrent condition exists on the system, because it is assumed that the power system's conventional protection will

clear an overcurrent fault. The range for these settings is 0.50 to 50.00 amps. It is recommended that PCHZ be set above the maximum load current and that GCHZ be set above the maximum $3I_0$ (residual) current due to unbalanced loading.

If the DFM™ relay determines that an overcurrent condition is present, an oscillography capture is triggered and a blinking disturbance message appears on the top line of the display. In addition, if one of the output contacts is configured for '2-cycle RMS overcurrent', that contact closes and the alarm LED on the DFM™ relay's front panel is illuminated.

Rate-of-Change Thresholds,
PHASE RATE OF CHNGE (508)
GROUND RATE OF CHNG (509)

The PHASE RATE OF CHNGE and GROUND RATE OF CHNG settings establish thresholds for determining when a high rate-of-change event occurs on either a phase RMS current or residual RMS current, respectively, of a distribution feeder. While high-impedance fault current exhibits a great deal of randomness, varying considerably from one half-cycle to the next, an extremely high rate of change is not characteristic of most high-impedance faults. It is, in fact, more indicative of a breaker closing, causing associated inrush. Since this type of inrush current causes substantial variations in the harmonics used by the high-impedance algorithms, these algorithms ignore all data for several seconds following a high rate-of-change event that exceeds the associated rate-of-change threshold, in order to give the power system a chance to stabilize.

The basic unit of measurement for RMS currents in the DFM™ relay's high-impedance algorithms is two fundamental frequency cycles, and the DFM™ relay internally calculates the rate of change as the difference between two consecutive 2-cycle RMS readings. The range for these settings is from 0.01 to 10 amps per 2 cycles. The recommended setting is:

$$\frac{150}{\text{CT RATIO}} \text{ amps / 2cycles}$$

Significant Loss of Load Threshold, LOSS OF LOAD THRESH (510)

One way that the DFM™ relay checks for a downed conductor is by looking for a precipitous loss of load. The level at which the DFM™ relay considers a loss of load to be significant is determined by the LOSS OF LOAD THRESH, which is expressed as a percentage of the feeder's loading. A loss of load is indicated by the DFM™ relay if the high-impedance algorithms detect a percentage drop in phase current between two successive readings (each of which represents a 2-cycle RMS current) that meets or exceeds the LOSS OF LOAD THRESH.

Depending on this setting, if a conductor breaks very near the end of the line, the DFM™ relay will not be able to detect the loss of load. Thus, while it may be able to detect an arcing condition and set an arcing alarm, it will not classify the event as a downed conductor, even though there may be one, simply because the expected loss of load could not be verified. The range for this setting is 5% to 100%, 5% being the most sensitive.

Three-Phase Event Threshold, 3-PH EVENT THRESH (511)

Starting a very large load on a feeder often has many of the same effects as the closing of a breaker, only on a smaller scale. Starting a large motor, for example, involves inrush that the DFM™ relay will see, and this inrush typically will be rich in certain harmonics. However, this type of large load should be three-phase in nature, not single phase. The high-impedance-fault-detection algorithms in the DFM™ relay ignore the data generated by a large three-phase event.

The 3-PH EVENT THRESH determines the level at which the DFM™ relay will characterize a sudden three-phase current increase as a three-phase event. The range for this setting is from 0.01 to 10 amps. The recommended setting is:

$$\frac{50}{\text{CT RATIO}} \text{ amps}$$

OVERCURRENT PROTECTION SETTINGS, OC SETTINGS

Phase TOC Curve Shape Selection, PHASE TOC CURVE (601)

This setting determines whether one of five pre-defined curve shapes or a user-defined curve shape is active for the phase TOC functions. Curve shape selection allows for easier coordination with down-stream overcurrent devices. Normally a curve shape identical or similar to that of the down-stream device(s) is chosen.

Ground TOC Curve Shape Selection, GROUND TOC CURVE (602)

This setting determines whether one of five pre-defined curve shapes or a user-defined curve shape is active for the ground TOC function. Curve shape selection allows for easier coordination with down-stream overcurrent devices. Normally a curve shape identical or similar to that of the down-stream device(s) is chosen.

Phase TOC Pickup Setting, PHASE TOC PICKUP (603)

PHASE TOC PICKUP can be set from 0.50 - 12.00 amps for DFM™ relays designed for use with current transformers whose secondaries are rated at 5 amps nominal, and from 0.01 - 2.40 amps for DFM™ relays designed for use with current transformers whose secondaries are rated at 1 amp nominal. The resolution is 0.01 amp. This one setting establishes the pickup level of the Phase TOC function on each of the three phases. The pickup setting is generally determined by a detailed study to assure coordination with down-stream overcurrent devices, and it should be set low enough to ensure that the minimum fault current is at least 1.5 times the pickup value.

Ground TOC Pickup Setting, GROUND TOC PICKUP (604)

GROUND TOC PICKUP can be set from 0.50 - 12.00 amps for DFM™ relays designed for use with current transformers whose secondaries are rated at 5 amps nominal, and from 0.01 - 2.40 amps for DFM™ relays designed for use with current transformers whose secondaries are rated at 1 amp nominal. The resolution is 0.01 amp. This setting establishes the level of $3I_0$ (residual) secondary current required to pick up the function.

If the distribution feeder three-phase load is balanced, normal ground (residual) current is near zero and the ground function could have a sensitive setting. However, distribution feeder loads are typically unbalanced, requiring the ground TOC function to be set above the $3I_0$ value resulting from maximum unbalance. The pickup setting is generally determined by a detailed study to assure coordination with down-stream overcurrent devices, and it should be set low enough to ensure that the minimum ground fault current is at least 1.5 times the pickup value.

Phase TOC Time Dial Setting, PHASE TIME DIAL (605)

PHASE TIME DIAL can be set from 0.50 to 10.00 with a resolution of 0.01. The time-dial value moves the TOC curves up and down on the time scale as shown in Figures 1-2 to 1-5, and it is selected based on providing selectivity with other down-stream phase overcurrent devices consistent with an overall coordination study. This setting has no effect if PHASE TOC CURVE = 3 (DEFINITE TIME).

Phase Definite Time Delay Setting, PHASE DEFINITE TIME (606)

PHASE DEFINITE TIME can be set from 0.50 to 30.00 seconds with a resolution of 0.01. This setting has an effect only if PHASE TOC CURVE = 3 (DEFINITE TIME), in which case it establishes the definite time delay.

Ground TOC Time Dial Setting, GROUND TIME DIAL (607)

GROUND TIME DIAL can be set from 0.50 to 10.00 with a resolution of 0.01. The time-dial value moves the TOC curves up and down on the time scale as shown in Figures 1-2 to 1-5, and it is selected based on providing selectivity with other down-stream ground overcurrent devices consistent with an overall coordination study. This setting has no effect if GROUND TOC CURVE = 3 (DEFINITE TIME).

Ground Definite Time Delay Setting, GRND DEFINITE TIME (608)

GROUND DEFINITE TIME can be set from 0.50 to 30.00 seconds with a resolution of 0.01. This setting has an effect only if GROUND TOC CURVE = 3 (DEFINITE TIME), in which case it establishes the definite time delay.

Phase Low-Set IOC Pickup Setting, IOC LOW PHASE (609)
Phase High-Set IOC Pickup Setting, IOC HIGH PHASE (610)

IOC LOW PHASE and IOC HIGH PHASE can be set from 0.50 - 160.00 amps for DFM™ relays designed for use with current transformers whose secondaries are rated at 5 amps nominal, and from 0.01 - 32.00 amps for DFM™ relays designed for use with current transformers whose secondaries are rated at 1 amp nominal. The resolution is 0.01 amp.

The phase IOC function is normally set not to overreach any other protective device. This is not always the case; for example, in a "fuse saving" scheme, the phase IOC might be set to overreach branch fuses up to the first recloser. The actual setting should be selected based on providing the desired selectivity with other down-stream devices consistent with an overall coordination study.

Ground Low-Set IOC Pickup Setting, IOC LOW GROUND (611)
Ground High-Set IOC Pickup Setting, IOC HIGH GROUND (612)

IOC LOW GROUND and IOC HIGH GROUND can be set from 0.50 - 160.00 amps for DFM™ relays designed for use with current transformers whose secondaries are rated at 5 amps nominal, and from 0.01 - 32.00 amps for DFM™ relays designed for use with current transformers whose secondaries are rated at 1 amp nominal. The resolution is 0.01 amp.

The ground IOC function is normally set not to overreach any other protective device. This is not always the case; for example, in a "fuse saving" scheme, the ground IOC might be set to overreach branch fuses up to the first recloser. The actual setting should be selected based on providing the desired selectivity with other down-stream devices consistent with an overall coordination study.

Phase Low-Set IOC Time Delay, IOC LOW PHASE DELAY (613)
Ground Low-Set IOC Time Delay, IOC LOW GRND DELAY (615)

IOC LOW PHASE DELAY and IOC LOW GRND DELAY can be set from 0 to 250 milliseconds, and are used to add time delay to the Phase Low-Set IOC and Ground Low-Set IOC respectively.

Phase High-Set IOC Time Delay, IOC HI PHASE DELAY (614)
Ground High-Set IOC Time Delay, IOC HI GRND DELAY (616)

IOC HI PHASE DELAY and IOC HI GRND DELAY can be set from 0 to 50 milliseconds, and are used to add time delay to the Phase High-Set IOC and Ground High-Set IOC respectively.

Adaptive Phase TOC Averaging Period, PHASE AVERAGING PD (617)
Adaptive Ground TOC Averaging Period, GROUND AVERAGING PD (621)

PHASE AVERAGING PD and GROUND AVERAGING PD can be set from 0 to 600 seconds. If a zero "0" value is selected, then the respective TOC load-adaptive feature is disabled. If a non-zero value is selected, then this value is the time period at the end of which an adaptive TOC pickup value is computed. The adaptive TOC pickup is:

$$\text{ADAPTIVE TOC PU (amps)} = \frac{(\text{I-AVG.})(\text{ADAPTIVE \%})}{100} \qquad (1)$$

where: I-AVG. = a computed average value of phase or ground current over the time period determined from PHASE AVERAGING PD or GROUND AVERAGING PD.

ADAPTIVE % = percentage determined from setting #618 (PHASE ADAPTIVE) or setting #622 (GROUND ADAPTIVE) described below.

Adaptive Phase TOC Pickup Percentage, PHASE ADAPTIVE (618)
Adaptive Ground TOC Pickup Percentage, GROUND ADAPTIVE (622)

PHASE ADAPTIVE and GROUND ADAPTIVE can be set from 110% to 300%, and determines the value for ADAPTIVE % in equation (1) above.

Minimum Phase Adaptive Pickup, MIN PHASE ADAPTIVE (619)
Minimum Ground Adaptive Pickup, MIN GRND ADAPTIVE (623)

MIN PHASE ADAPTIVE and MIN GRND ADAPTIVE can be set from 25% to 100%. A minimum adaptive pickup is computed as:

$$\text{I-MIN (amps)} = \frac{(\text{PU SETTING})(\text{MIN ADAPTIVE \%})}{100} \qquad (2)$$

where: PU SETTING = either setting #603 (PHASE TOC PICKUP) or setting #604 (GROUND TOC PICKUP).

MIN ADAPTIVE % = either setting #619 (MIN PHASE ADAPTIVE) or setting #623 (MIN GRND ADAPTIVE).

After the DFM™ relay calculates ADAPTIVE TOC PU using equation (1), its value is compared against I-MIN from equation (2). If ADAPTIVE TOC PU is greater than I-MIN, then the new TOC pickup value becomes equal to ADAPTIVE TOC PU. If ADAPTIVE TOC PU is less than I-MIN ADAPTIVE, then the new TOC pickup value becomes equal to I-MIN.

Maximum Phase Adaptive Pickup, MAX PHASE ADAPTIVE (620)
Maximum Ground Adaptive Pickup, MAX GRND ADAPTIVE (624)

MAX PHASE ADAPTIVE and MAX GRND ADAPTIVE can be set from 110% to 300%. A maximum adaptive pickup is computed as:

$$\text{I-MAX (amps)} = \frac{(\text{PU SETTING})(\text{MAX ADAPTIVE \%})}{100} \quad (3)$$

where: PU SETTING = either setting #603 PHASE TOC PICKUP or setting #604 GROUND TOC PICKUP.

MAX ADAPTIVE % = either setting #620 MAX PHASE ADAPTIVE or setting #624 MAX GRND ADAPTIVE.

After the DFM™ relay calculates ADAPTIVE TOC PU using equation (1), its value is compared against I-MAX from equation (3). If ADAPTIVE TOC PU is less than I-MAX, then the new TOC pickup value becomes equal to ADAPTIVE TOC PU. If ADAPTIVE TOC PU is greater than I-MAX, then the new TOC pickup value becomes equal to I-MAX.

TOC Reset Characteristic Selection, TOC RESET OPTION (625)

TOC RESET OPTION can be set to 0 (EM RESET) or 1 (FAST RESET). If the protective devices down-stream from the DFM™ relay are electro-mechanical (EM) induction-disk TOC relays, then it may be easier to obtain coordination if the DFM™ relay's TOC functions emulate the slow reset of the EM relays. With TOC RESET OPTION = 0, the DFM™ relay's TOC reset characteristics are as shown in Figures 1-6 to 1-9.

Cold Load Pickup Time Delay, COLD LOAD PICKUP (626)

COLD LOAD PICKUP can be set from 0 to 60 minutes. If set to zero "0", then the "cold-load pickup" logic is disabled. If set to a non-zero value, then the "cold-load pickup" logic is enabled and the COLD LOAD PICKUP setting is the time interval that the "cold-load settings group" will remain in effect after being activated.

Phase TOC Enable/Disable, PH TOC PROTECTION (627)
Phase High-Set IOC Enable/Disable, PHASE LOW IOC PROT (628)
Phase Low-Set IOC Enable/Disable, PHASE HIGH IOC PROT (629)
Ground TOC Enable/Disable, GRND TOC PROTECTION (630)
Ground High-Set IOC Enable/Disable, GRND LOW IOC PROT (631)
Ground Low-Set IOC Enable/Disable, GRND HIGH IOC PROT (632)

All of these six settings can be set to either 0 (OFF) or 1 (ON). An OFF setting disables the function. An ON setting enables the function.

TABLE 2-3 POSSIBLE CONTACT CONVERTER (CC) ASSIGNMENTS

NAME	DESCRIPTION
ALT SETTINGS bit 0	**Select Settings File** If ALT SETTINGS bit 1 is NOT selected: With the contact open, bit 0 is set to 0 and settings group 1 is the active group. When the contact closes, bit 0 is set to 1 and settings group 2 becomes the active group. If ALT SETTINGS bit 1 IS selected: Bit 0 and bit 1 select the active settings group as shown below: binary # — active settings group 00 — 1 01 — 2 10 — 3 11 — 4
ALT SETTINGS bit 1	**Select Settings File** If ALT SETTINGS bit 0 is NOT selected: With the contact open, bit 1 is set to 0 and settings group 1 is the active group. When the contact closes, bit 1 is set to 1 and settings group 3 becomes the active group. If ALT SETTINGS bit 0 IS selected: Bit 0 and bit 1 select the active settings group as shown above under ALT SETTINGS bit 0.

NOTE: The external contacts associated with ALT SETTINGS bit 0 or bit 1 are ignored unless setting #108 is selected to be 0 (i.e., SETTINGS FILE = 0 (EXTERNAL)

CLOSE BREAKER	**Close Breaker Via Control Command** When the contact closes, the output contact assigned to CLOSE BREAKER is closed.
DISABLE DFM	**Disable DFM Control** If the contact is closed, no output contacts are allowed to operate.
52/b CONTACT	**52/b Circuit Breaker Auxiliary Contact** When the contact closes, an indication is present that the breaker's main contacts are open. Note that this configuration is required for output-contact monitoring and breaker-health calculations.
OSC START	**Oscillography Start** When the contact closes, an oscillography capture is triggered.
TARGET RESET	**Target and Latched Alarm Reset** When the contact closes, any disturbance data is reset and any latched alarms are cleared.
TIME-TAG-STORE	**Time-Tag-Store Substation Event** When the contact closes, the substation event associated with this configuration is logged. Note that the name given to the associated substation event is itself a user-configurable string (see CONTACT CONVERTER ID in TABLE 2-2).
OPEN BREAKER	**Open Breaker Via Control Command** When the contact closes, any assigned output contact closes.

TABLE 2-4
POSSIBLE OUTPUT CONTACT ASSIGNMENTS AND DEFAULT VALUES FOR CONFIGURABLE OUTPUTS #1 - #5

OUTPUT ASSIGNMENTS
OPEN BREAKER
DOWNED COND DETECTED
ARCING DETECTED
BREAKER HEALTH
THD ALARM
ARCING SUSPECTED
2-CYCLE RMS OC
CNTRL OUTPT #1 FAIL
CNTRL OUTPT #2 FAIL
NON-CRIT DFM FAILURE
LOGIN FAILURE
CLOSE BREAKER
PHASE HIGH SET IOC
GROUND HIGH SET IOC
PHASE LOW SET IOC
GROUND LOW SET IOC
PHASE TOC
GROUND TOC
DWELL TIME *

* DWELL TIME is not a signal that drives an output. When it is selected, the time the associated output contact stays closed differs from that listed in the ACTIVATION DURATION column in TABLE 2-5. DWELL TIME causes the output contact to stay closed for 2 seconds or, assuming a contact converter has been assigned as "52/b CONTACT" (see TABLE 2-3), until the 52/b contact closes. With DWELL TIME selected, the output contact may stay closed for 2 seconds, but never longer than 2 seconds regardless of the ACTIVATION DURATION listed in TABLE 2-5.

CAUTION: If DWELL TIME is selected, the initiating OUTPUT ASSIGNMENT signal must reset before the associated contact can be closed subsequent to its opening.

CONTACT	FACTORY DEFAULT ASSIGNMENT
OUTPUT #1	DOWNED COND DETECTED
OUTPUT #2	DOWNED COND DETECTED
OUTPUT #3	CLOSE BREAKER
OUTPUT #4	ARCING DETECTED
	BREAKER HEALTH
	THD ALARM
	ARCING SUSPECTED
OUTPUT #5	ARCING DETECTED

NOTE: Any number of the listed conditions or responses for each contact can be assigned to operate the contact. The THD ALARM configuration applies only to DFM™ relays with power-quality monitoring. The Control Circuit Monitor function is only available on OUTPUT #1 and OUTPUT #2 (reference setting #309 in TABLE 2-1).

TABLE 2-5 OUTPUT CONTACT ACTIVATION CHARACTERISTICS

OUTPUT ASSIGNMENT	ACTIVATION STIMULUS	ACTIVATION DURATION	PHYSICAL CONTACT
OPEN BREAKER	Serial communications or contact converter	While activation condition is present	Assignable to OUTPUT #1 - #5
CLOSE BREAKER	Serial communications or contact converter	While activation condition is present	Assignable to OUTPUT #1 - #5
DOWNED COND DETECTED	Instantaneous overcurrent or significant loss of load combined with arcing	While activation condition is present	Assignable to OUTPUT #1 - #5
ARCING DETECTED	High impedance algorithms detect persistent arcing	5 minutes	Assignable to OUTPUT #1 - #5
BREAKER HEALTH	Calculated I^2t or It exceeds 80% of user-configurable setting	Until accumulators are reset	Assignable to OUTPUT #1 - #5
THD ALARM	Measured distortion on current or voltage exceeds user-configurable setting	While activation condition is present	Assignable to OUTPUT #1 - #5
ARCING SUSPECTED	High impedance algorithms detect sporadic arcing	5 minutes	Assignable to OUTPUT #1 - #5
2-CYCLE RMS OC	Calculated RMS value for the previous two cycles exceeds user-configurable setting	Until targets are reset, either through front panel, serial communications, or configured CC	Assignable to OUTPUT #1 - #5
CNTRL OUTPUT #1 or #2 FAIL (2 separate assignments)	DC control voltage not measured across open contact and 52/b is configured and open (i.e., breaker closed)	While activation condition is present	Assignable to OUTPUT #1 & #2 only
NON-CRIT DFM FAILURE	Non-critical hardware failure condition exists	While activation condition is present	Assignable to OUTPUT #1 - #5
LOGIN FAILURE	Three consecutive login attempts with invalid password	Until successful login or target/ alarm reset	Assignable to OUTPUT #1 - #5

TABLE 2-5 OUTPUT CONTACT ACTIVATION CHARACTERISTICS (CONTINUED)

OUTPUT ASSIGNMENT	ACTIVATION STIMULUS	ACTIVATION DURATION	PHYSICAL CONTACT
PHASE HIGH SET IOC	Phase High Set IOC picked up	While activation condition is present	Assignable to OUTPUT #1 - #5
GROUND HIGH SET IOC	Ground High Set IOC picked up	While activation condition is present	Assignable to OUTPUT #1 - #5
PHASE LOW SET IOC	Phase Low Set IOC picked up	While activation condition is present	Assignable to OUTPUT #1 - #5
GROUND LOW SET IOC	Ground Low Set IOC picked up	Wile activation condition is present	Assignable to OUTPUT #1 - #5
PHASE TOC	Phase TOC picked up	While activation condition is present	Assignable to OUTPUT #1 - #5
GROUND TOC	Ground TOC picked up	While activation condition is present	Assignable to OUTPUT #1 - #5
Critical DFM Failure	Critical hardware failure condition exists	Until power reset	Self-Test Alarm Contact
DC Power Supply Failure	DC voltage removed or power-supply output out of regulation	Until DC voltage re-applied or power supply repaired	Power Supply Alarm Contact

HARDWARE DESCRIPTION

***** CAUTION *****

The DFM™ relay contains electronic components that could be damaged by electrostatic discharge currents if those currents flow through certain terminals of the components. The main source of electrostatic discharge currents is the human body, and the conditions of low humidity, carpeted floors , and isolating shoes are conducive to the generation of electrostatic discharge currents. Where these conditions exist, care should be exercised when removing and handling the DFM™ relay's internal components. The persons handling the components should make sure that their body charge has been discharged, by touching some surface at ground potential, before touching any of the components.

CASE ASSEMBLY

Case Construction

The components of the DFM™ relay are mounted in a steel case. The exposed front panel is constructed of molded plastic. Since the case is not of the 'draw-out' construction, external provisions may be made if it is desired to isolate the DFM™ relay from the current and voltage signal connections.

Front and rear views of the DFM™ relay's case are presented in Figure 3-1 and Figure 3-2, respectively.

Electrical Connections and Internal Construction

All field wiring connections to the DFM™ relay are made through three terminal blocks, a BNC connector, and a DB-25 connector, all of which are located on the rear panel of the case.

The internal circuitry of the DFM™ relay is functionally divided into four printed-circuit boards (PCBs), as follows: (1) Processor Board (PRC), (2) Analog Input Board (ANI), (3) Input/Output Board (I/O), and (4) Power Supply Board. The circuit boards are mounted into card guides and interconnect via ribbon cables. The current transformers (CTs) and potential transformers (PTs) are located on a Magnetics Module, which connects to the ANI board. Certain sections of the circuit are electromagnetically isolated in order to maximize system immunity from EMI/RFI conditions.

Access to all PCBs is obtained by removing the DFM™ relay's front panel. Each PCB has it own name and identification number printed on it, but these are visible only when the board is removed from the DFM™ relay's case.

The block diagram of the DFM™ relay presented in Figure 3-3 illustrates the functional interaction among the DFM™ relay's printed-circuit boards (PRC, ANI, or I/O), magnetics module, and power-supply board. Individual block diagrams for the DFM™ relay's Magnetics Module, ANI board, PRC board, and I/O board are presented in Figure 3-4, Figure 3-5, Figure 3-6, and Figure 3-7, respectively. Figure 3-8 is a layout drawing of the I/O board showing the location of jumpers J1 and J2. Figure 3-9 is a cut-away view into the front of a DFM™ relay. The circuit-board line-up and interconnecting cables inside the DFM™ relay are visible in this diagram.

Identification

The model number label is located in the bottom left corner of the front panel of the DFM™ relay (see Figure 3-1). The method of interpreting a DFM™ relay model number is explained in the **INTRODUCTION** section.

The three terminal blocks located on the rear panel of the DFM™ relay are uniquely identified by a two-letter code found directly above each terminal block. The terminals on each block are labeled individually to the right of the terminal, according to their intended use (e.g. CC1, CC3, ALARM 2, VA, IN, etc.) Pin 1 of each terminal block is always located at the top of the block.

Female DB-9 and DB-25 connectors for serial communications (RS232) are located at the bottom of the DFM™ relay's front panel and rear panel, respectively. The front port connector is labeled "COMM", and the rear port connector is labeled both "PL-1" and "COMM". A BNC connector labeled "IRIG-B" is located at the top of the rear panel for connection to an IRIG-B time-synchronization signal. See Figure 3-2 for an illustration of the DFM™ relay's rear panel.

THEORY OF OPERATION

The monitoring capability of the DFM™ relay is accomplished through hardware that digitizes the appropriate parameters from feeder current and potential transformers, performs digital computations on the required data, logs significant information, activates control contacts, and provides an interface to the utility engineer for reviewing information.

The DFM™ relay's hardware shown in Figure 3-3 can be divided into six sections, as listed below. A functional description of each of these sections follows the list.

Front Cover
Magnetics Module
Analog Board
Processor Board
Input/Output Board
Power Supply Board

Front Cover

The DFM™ relay's case incorporates an exposed, front-panel 'man-machine interface' consisting of a vacuum fluorescent alphanumeric display, status LEDs, control pushbuttons, and a serial-port-interface connector (see Figure 3-1). The display is a separate component, connected to the DFM™ relay's Processor Board but visible through a window on the front panel. Similarly, the LEDs are actually located on the Input/Output Board, but are also visible through windows on the front panel. The control pushbuttons are membrane switches located on the outer cover of the front panel. A ribbon cable between the front cover and the Input/Output Board provides the circuitry for processing the pushbuttons.

Magnetics Module

The Magnetics Module (see Figure 3-4) has two important functions: (1) high-potential isolation and surge suppression, and (2) input scaling (PT) and current-to-voltage conversion (CT). The PT scales down the input voltage. The CT steps down the input current and passes it through a resistor, converting the input current (on the primary winding) to an output voltage (across a shunt on the secondary winding). Each CT and PT must be linear throughout the measurement range, and must have a frequency response of at least the sampling rate of the DFM™ relay (1600/

1920-Hz) so as to have minimal effect on the DFM™ relay's frequency response. Because of manufacturing variations, each magnetics module contains a serial EEPROM that stores a scaling factor for each CT and PT. Calibration consists of measuring the conversion ratio for each CT and PT and writing a scaling factor to the serial EEPROM. The serial EEPROM also contains a byte that indicates whether the magnetics module contains 5-amp or 1-amp CTs. The voltage outputs of the Magnetics Module are applied to the Analog Input Board.

Analog Input Board

Each current signal from the Magnetics Module passes through three parallel analog processing paths. These three paths provide filtering and amplification for what are illustrated in Figure 3-5 as the Overcurrent Range, Normal Range, and Notch Range. Each voltage signal from the Magnetics Module passes through a single analog processing path.

The Normal Range and Notch Range share a common front end consisting of a Preamplifier, Analog Switch, and Low-pass Filter. The preamp is used to amplify the input signal to a high enough level so that the switched-capacitor filters have a negligible effect on the signal-to-noise ratio. Following the preamp, an analog switch allows a test signal to be switched into the path for diagnostics. From this point, a fifth-order switched-capacitor low-pass filter with a cutoff frequency of 768 Hz and a roll-off of about 30 dB per octave is used to provide adequate anti-aliasing for either a 1600-Hz or a 1920-Hz sampling rate (used for 50-Hz or 60-Hz systems, respectively). From here, the Normal Range is obtained by applying enough gain so that the overall level for the path is 2.9 per unit current, or 14.5 amps RMS full scale.

On the other hand, the Notch Range is obtained by passing the low-pass filter output through a notch filter and amplifying the output by a factor of 12.2 times the normal range. The notch filter is a fourth-order elliptic band-reject filter based on switched-capacitor techniques. The notch frequency for this filter is set to 50 Hz or 60 Hz by setting the appropriate output frequency on a digital counter/timer dedicated to the notch filter.

The Overcurrent Range is obtained in a manner similar to the Normal Range, but the amplification for this path is reduced such that 230 amps RMS is full scale for the Analog-to-digital converter (ADC), which corresponds to 46 per-unit current, or 16 times the Normal Range. To produce the Voltage Range outputs, a circuit similar to that for the Overcurrent Range is employed. Rather than using CT isolation transformers on the front end, PT isolation transformers are used, and a different gain is applied so that 252 volts RMS is full scale for the ADC.

The eight outputs from the Overcurrent and Normal Range circuits simultaneously pass through a sample-and-hold (S/H) circuit at the sampling rate of either 1600 Hz or 1920 Hz. This S/H circuit is needed to maintain phase accuracy when calculating present values such as watts, VARs, and VA. For these calculations, the current and voltage quantities must be acquired at the same point in time. The outputs from the sample-and-hold circuit are multiplexed, along with the Notch Range outputs, the Voltage outputs, and the Test Signal, to a single 16-bit ADC with an on-chip sample-and-hold. The timing control for the sample-and-hold, multiplexer, and ADC are controlled by a state machine that initiates 16 conversions for each sample clock period and submits a DMA request to the processor when each conversion is finished. Although the voltage signals are not simultaneously sampled, they are all converted within 15 microseconds of the current sampling time.

Processor Board

The DFM™ relay's Processor Board (see Figure 3-6) is responsible for the data processing, data storage, and control for the DFM™ relay. At the heart of this section lies a 25-MHz 80960CA (i960) reduced instruction set (RISC) processor. Variables, buffers, and stack space reside in 32-bit-wide, burst-mode, address-pipelined, fast static RAM. A 32-bit-wide bank of EPROMs

holds the program code, while EEPROM is used for configuration data and calibration constants. The oscillography files, peak demand records, and other long-term storage fields are placed in 48-hour capacitor-backed RAM.

The Security State Machine Circuit is used to reset the Watchdog Timer, to reset the Lockout Counter, and to clock in data to the final stage of the Relay Output Circuit. It provides a high level of security against unintentionally performing any of these functions. In general, when this circuit recognizes one of its three special sequences of addresses, it performs the associated operation.

A Watchdog Timer and Power-Supply Monitor Circuit are used to monitor the power supply and microprocessor operation, among other basic functions. If the watchdog input to this circuit is not strobed by the Security State Machine within the watchdog timeout period (1-second minimum), a hardware reset is generated. If the unregulated power-supply voltage dips below a pre-determined threshold, a non-maskable interrupt (NMI) is issued to the microprocessor. Finally, this circuit has an input for both regulated 5 VDC and a capacitor voltage. If the 5 VDC input falls below the capacitor voltage, the internal circuitry switches over the capacitor voltage to the capacitor-backed RAM and the real-time clock so that their power supply is uninterrupted.

A Reset Lockout Counter is provided, which counts the number of hardware resets within a one-hour period. On the fourth warm boot after a power-up or a software-controlled reset of the lockout counter, a lockout occurs and the DFM™ relay's processor remains in the reset state until the power is cycled off and then on again. The lockout counter is normally reset once per hour if a warm boot has occurred within the hour. The DFM™ relay's design also includes a software counter that, under normal circumstances, puts the DFM™ relay in a reduced operational mode one reset before the lockout state is reached.

The DFM™ relay's Real-Time Clock is used to keep track of the date and low-resolution time. When the processor is operating, a 16-bit timer provides a high-resolution time base that, in turn, provides time synchronization and a millisecond timer for time-tagging events. If external time synchronization is used, the Real-Time Clock and timer are synchronized to either a pulse received on the rear RS-232 port based on a coded message received on that port's receive line, or to an externally supplied IRIG-B signal.

Input/Output Board

The I/O Board (see Figure 3-7) interfaces the processor to the front panel, the serial ports, the DFM™ relay's contact-sensing inputs, and the output contacts. The DFM™ relay has a serial port on both the front and back panel. The serial ports are handled by the Serial Communications Controller Circuit, which contains a dual universal asynchronous receiver transmitter (DUART).

The Relay Output Circuit, along with the Security State Machine on the Processor Board, provides a high level of security against erratic processor behavior accidentally opening or closing any of the six output contacts. The Control Contact Monitor Circuit is provided to monitor the integrity of the two control-contact outputs. This circuit looks for a minimum voltage across the contacts when the contacts are supposed to be open, and also looks for a minimum current through the contacts when those contacts are closed.

The Contact Input Isolation Circuit accommodates three externally-wetted contact inputs for external control of the DFM™ relay. Essentially the circuit checks for the presence or absence of the wetting voltage at the inputs. If a voltage is present at the input, the contact is assumed closed; otherwise, it is assumed open. This circuit is also responsible for providing isolation between the contact inputs and processor circuitry.

The Man-Machine Interface (MMI) circuitry controls the LEDs for indicating a downed conductor, an overcurrent disturbance, an alarm condition, and power applied. A target reset

button allows the latched alarms and disturbance targets to be cleared. Up, Down, and Enter pushbuttons control an alphanumeric display, which is connected directly to the DFM™ relay's Processor Board.

Power Supply Board

The power-supply circuitry provides a ± 12 VDC output for the analog circuitry, a + 12 VDC relay output to drive relay coils, a +5 VDC output for the digital circuitry, and an isolated +5 VDC output for the RS-232 serial ports.

RECEIVING, HANDLING AND STORAGE

Immediately upon receipt, the DFM™ relay should be unpacked and examined for any damage sustained in transit. If damage resulting from rough handling is evident, a damage claim should be filed at once with the transportation company, and the nearest GE sales office should be promptly notified.

If the equipment is not to be installed immediately, it should be returned to its original carton and stored indoors in a location that is dry and protected from dust, metallic chips, and severe atmospheric conditions.

INSTALLATION

Environment

Installation of the DFM™ relay should be in a clean, dry location that is free from dust. The area should be well lighted to facilitate inspection and testing.

Mounting

The DFM™ relay should be securely mounted on a vertical surface that provides accessibility to both the front and rear panels of the unit. Side access is not required. Mounting can be either the standard semi-flush style or, optionally, the projection (surface) mount style. The projection (surface) mount installation requires additional hardware, which is available by ordering part number 0286A4889 G1.

The outline and panel drilling dimensions for the DFM™ relay are provided in Figure 3-10.

External Connections

External connections are made according to the elementary diagram presented in Figure 1-1 in the **PRODUCT DESCRIPTION** section.

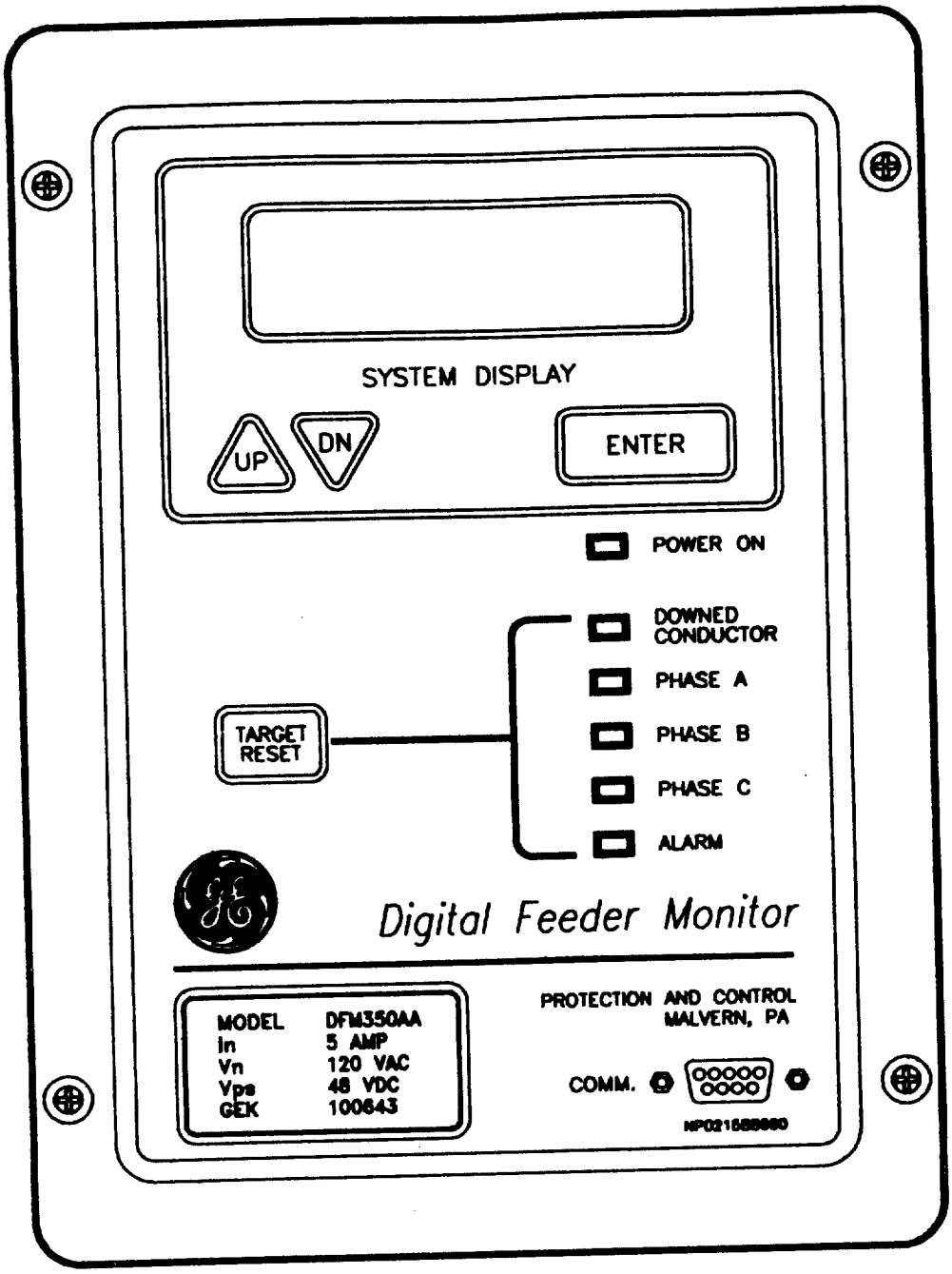


Figure 3-1 (0286A5405) DFM™ Relay Front View

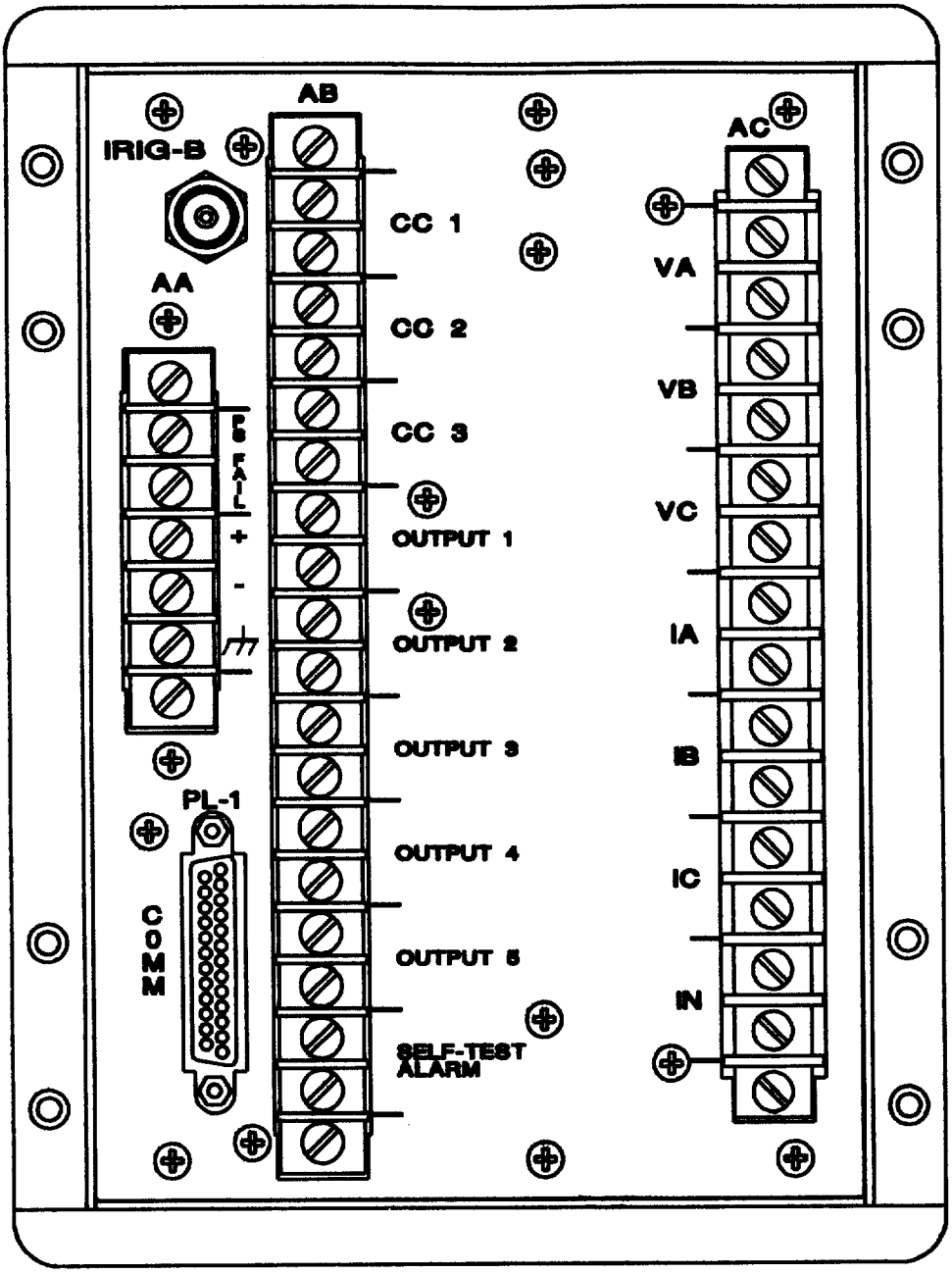


Figure 3-2 (0286A5810) DFM™ Relay Rear View

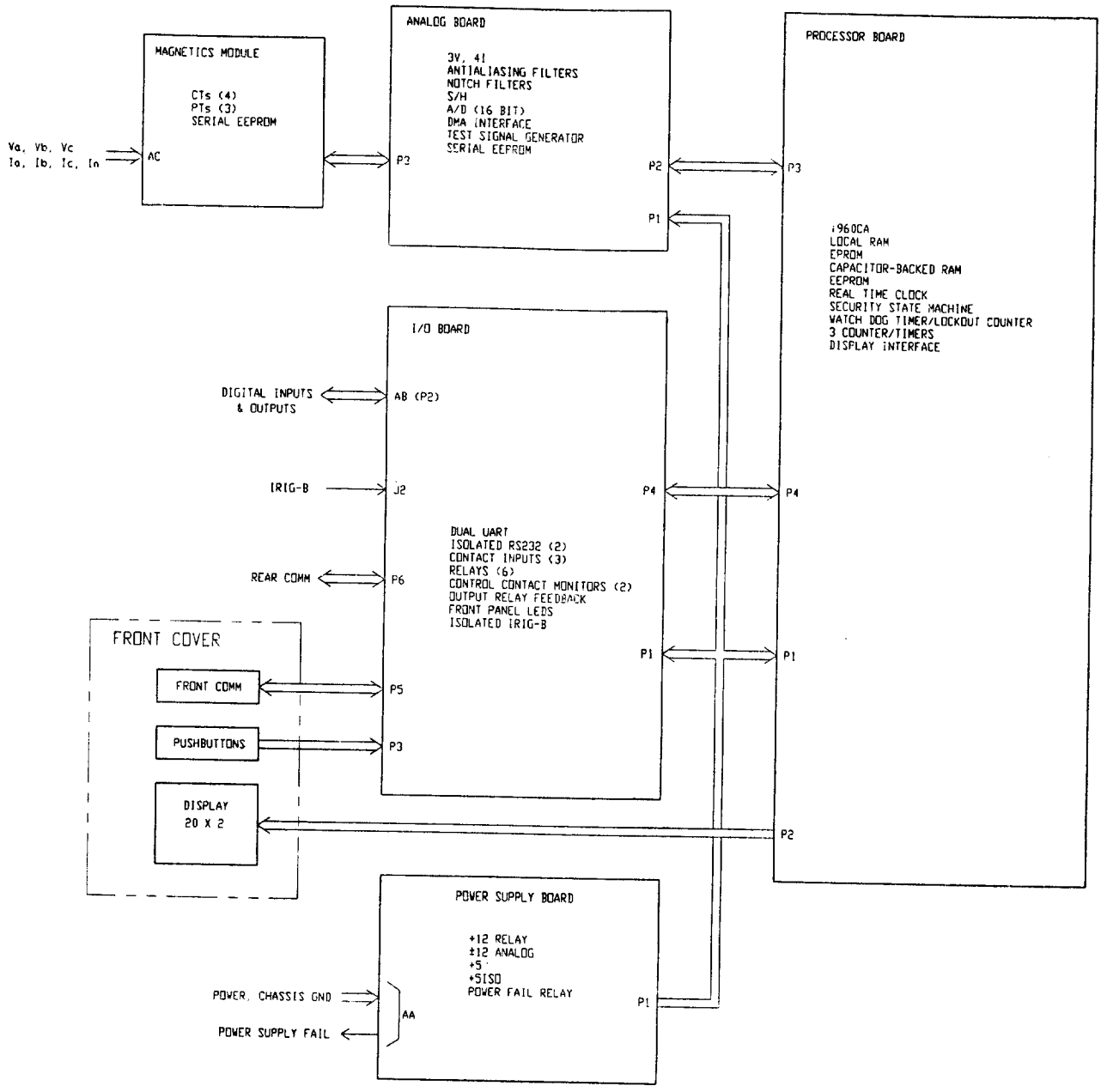


Figure 3-3 (0179C8562) DFM™ Relay Block Diagram

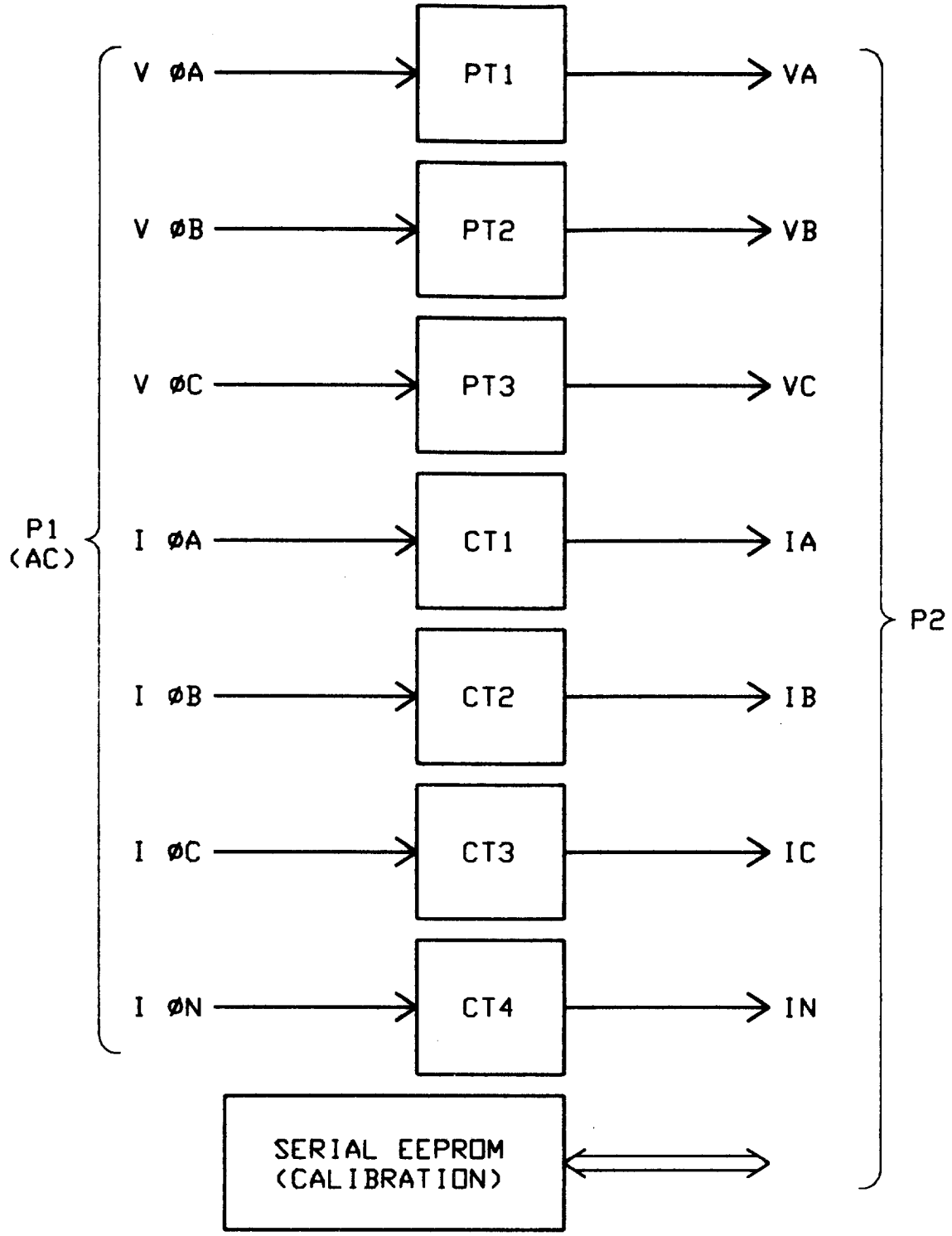


Figure 3-4 (0286A4891) DFM™ Relay Magnetics-Module Block Diagram

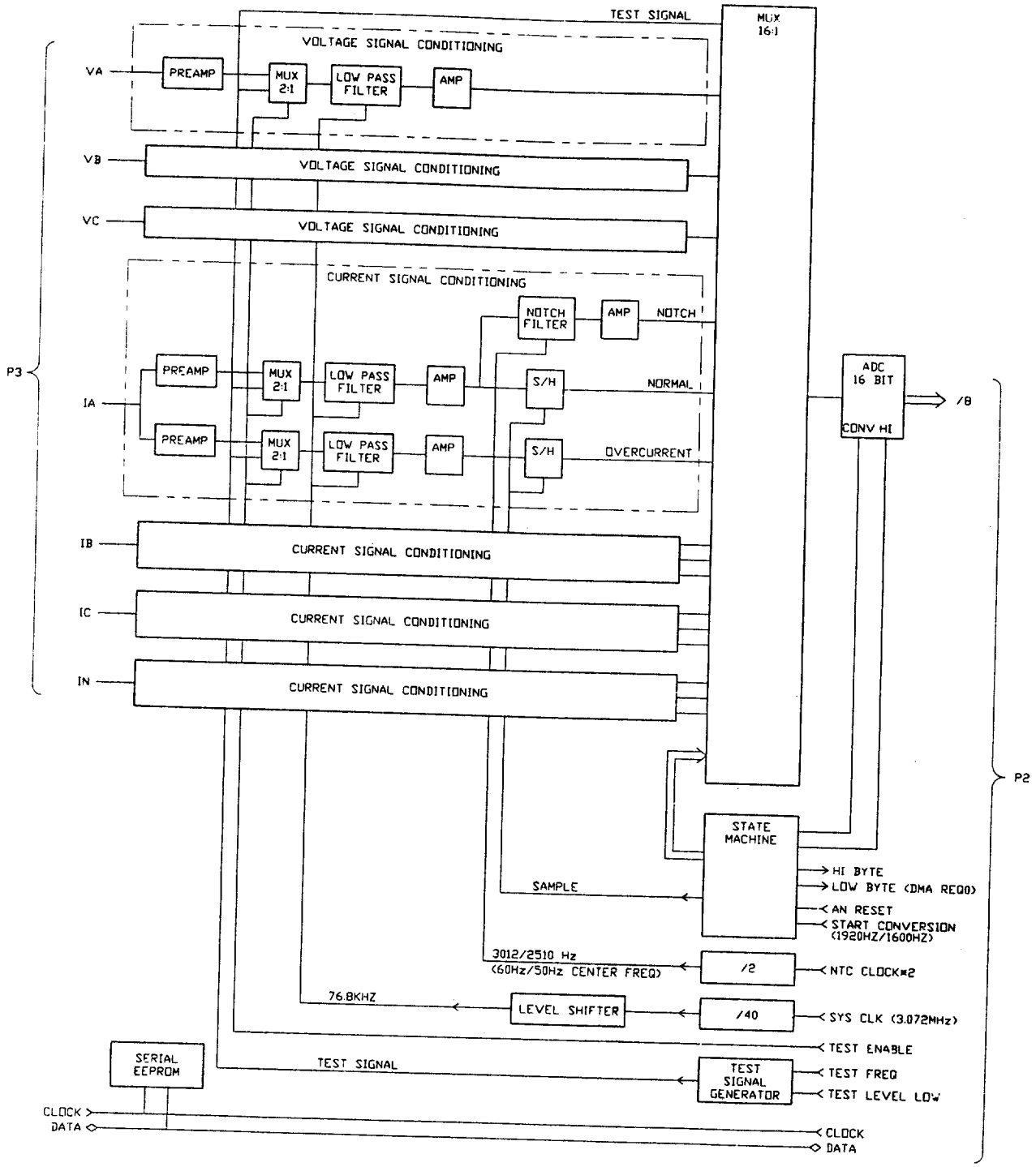


Figure 3-5 (0179C8559) DFM™ Relay Analog Input Board (ANI) Block Diagram

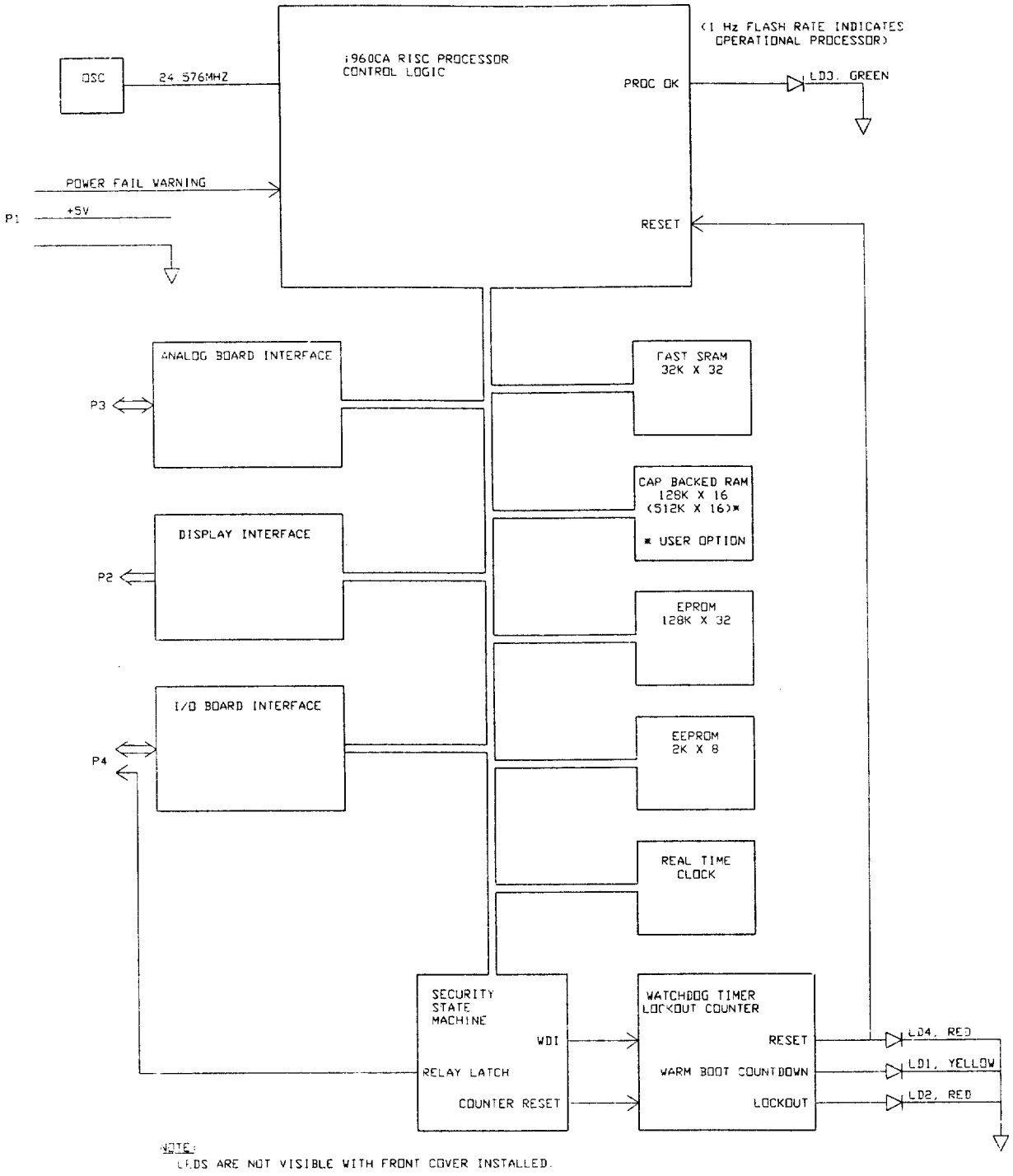


Figure 3-6 (0179C8561) DFM™ Relay Processor Board (PRC) Block Diagram

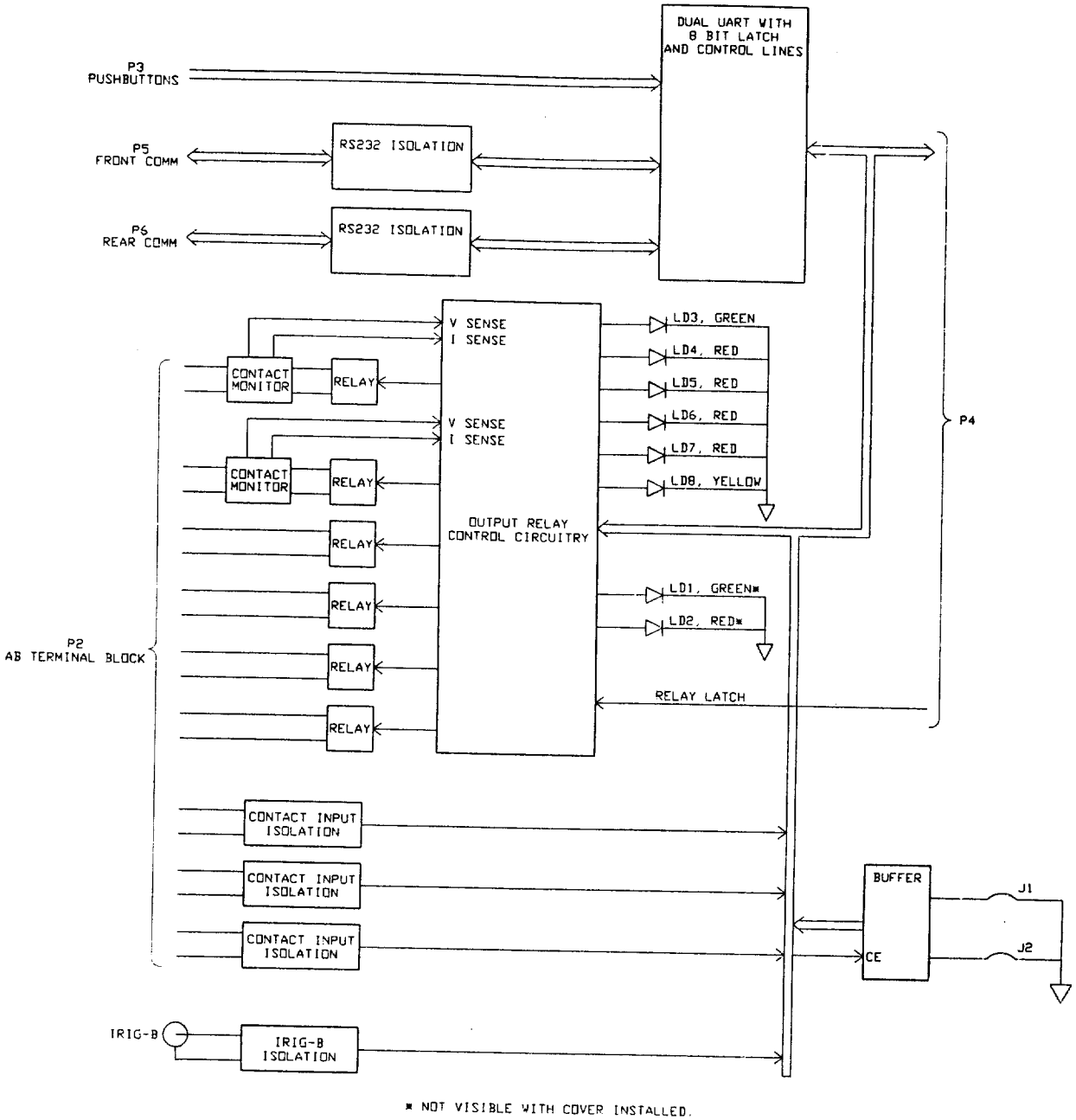


Figure 3-7 (0179C8560) DFM™ Relay I/O Board Block Diagram

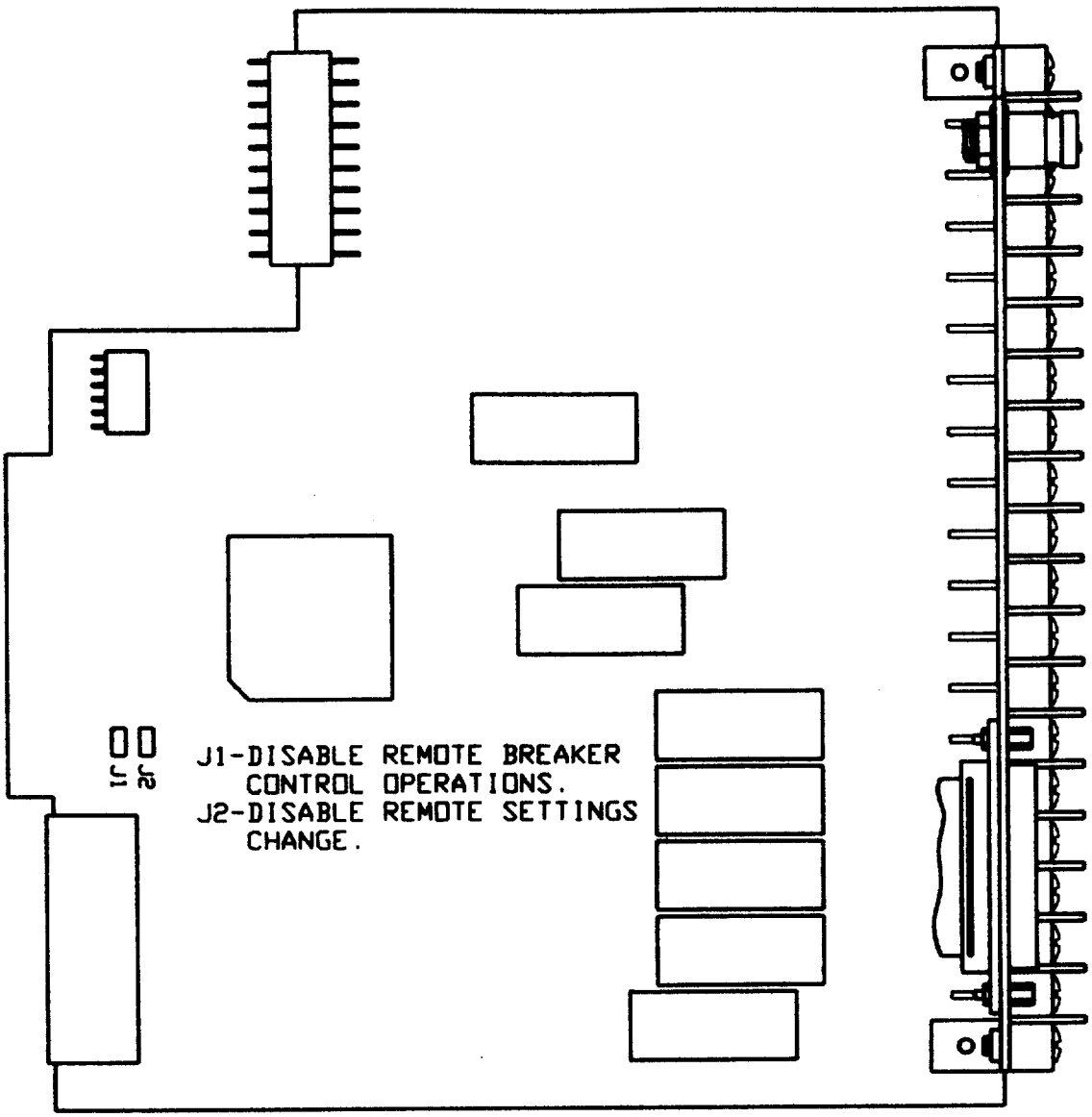


Figure 3-8 (0286A5409) DFM™ Relay I/O Board Layout

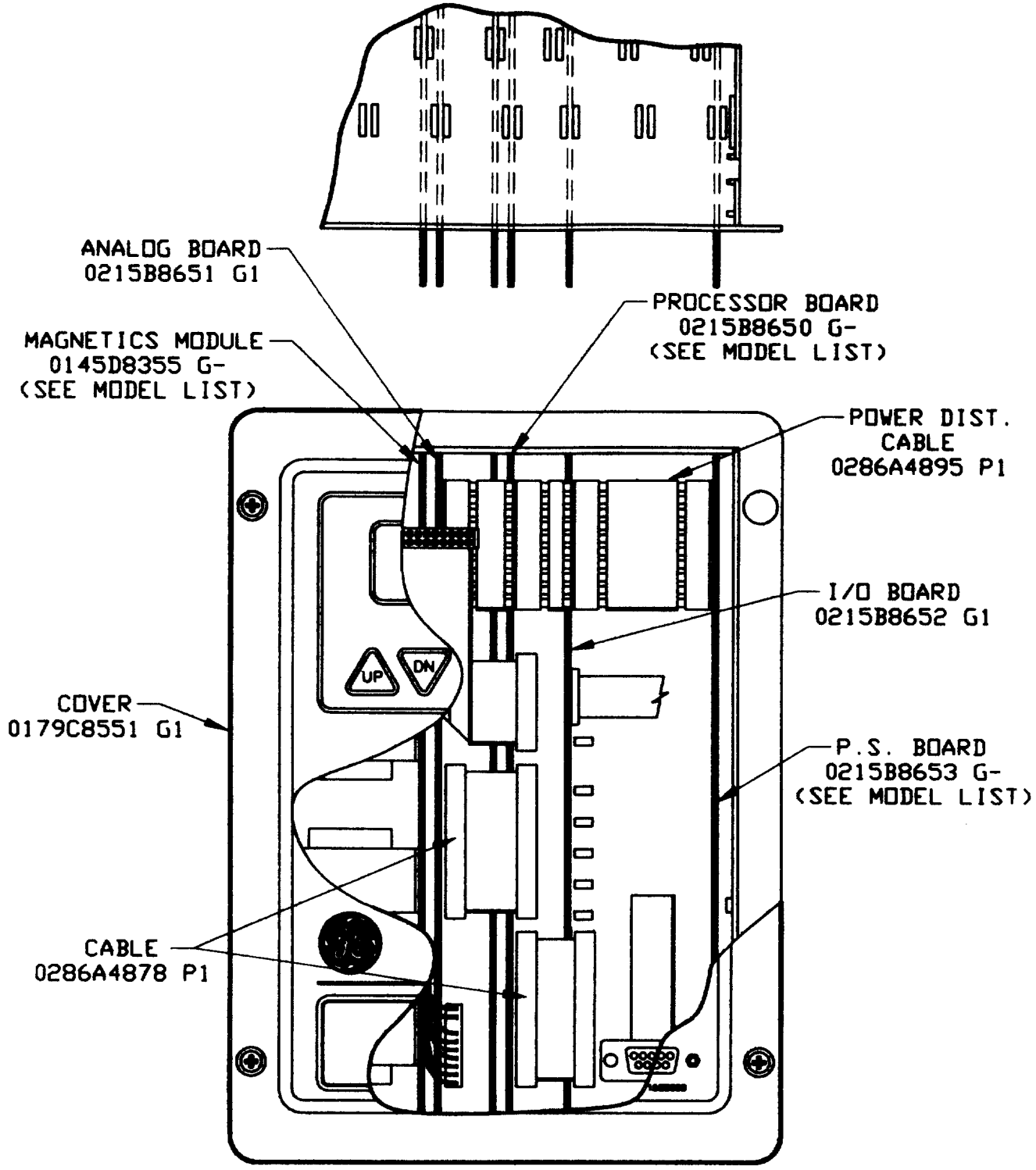


Figure 3-9 (0286A5410) DFM™ Relay Unit Line-Up

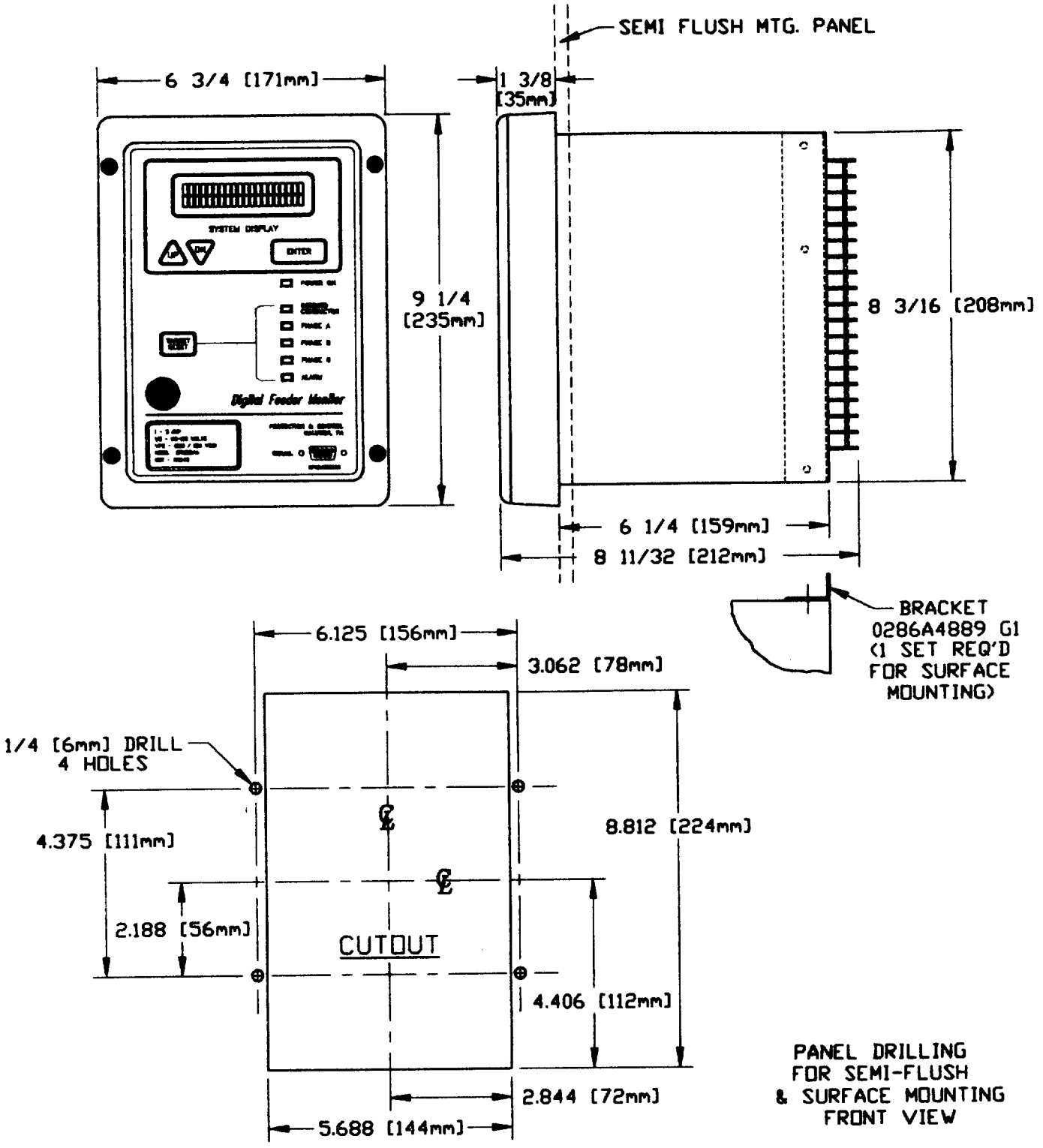


Figure 3-10 (0286A4883 [1]) DFM™ Relay Outline and Panel-Drilling Dimensions

ACCEPTANCE TESTS

***** WARNING *****
POWER DOWN THE DFM™ RELAY BEFORE REMOVING OR INSERTING BOARDS. FAILURE TO DO SO CAN PERMANENTLY DAMAGE THE DFM™ RELAY AND CAUSE SERIOUS BODILY INJURY.

GENERAL

This section is a guide for testing the DFM™ relay. The unit has been tested at the factory with automated test equipment. The DFM™ relay is a digital device that incorporates "self-test" software. If a system failure is detected, it is reported through the local MMI. Thus, it is not necessary that the following tests be performed. However, performance of these tests will aid the user in becoming familiar with the DFM™ relay and will also provide further testing of the unit before it is actually placed in operation.

General Tests

T1 Status Test
T2 DFM-Initiated MMI Test
T3 PC-Initiated Display and LED Test
T4 Digital Input and Output Test
T5 AC System Input Test
T6 2-Cycle RMS Overcurrent Test
T7 Current Channel Test for Overcurrent Range*
T8 Breaker-Health Test
T9 THD Test

* refer to the **Analog Input Board** section under **HARDWARE DESCRIPTION** for an explanation of Overcurrent Range.

Overcurrent Tests

T10 Instantaneous Overcurrent (IOC) Test
T11 Time Overcurrent (TOC) Test
T12 Adaptive TOC Test
T13 Cold Load Pickup Test

TEST EQUIPMENT

1. Three-phase source of voltage and current at rated frequency
2. DC control voltage source
3. Three AC voltmeters
4. Three AC ammeters
5. A continuity tester or ohm meter
6. A timer (oscilloscope or other device to measure elapsed time from test current application until output contact closure)
7. An IBM-compatible computer with a serial port and mouse
8. An RS-232 null-modem cable to connect the PC to the DFM™ relay
9. DFM-LINK software

Specific requirements of the equipment are given in the text and associated diagrams for the acceptance tests described in this section.

The AC test voltage and/or current must be balanced and un-distorted (i.e., sinusoidal). Similarly, the rated DC control power should have less than 5% ripple. As an alternative, a three-phase electronic test source may be used. In many cases, such a device enables the test circuits to be simplified greatly.

*** NOTE ***

Field re-verification of the operation of the high-impedance detection algorithms in the DFM™ relay requires sophisticated testing equipment that may not be available at most electric utility substations. However, the integrity of the hardware components that make up the DFM™ relay and the operation of all monitoring functions can be verified by the tests presented in this section.

DRAWINGS AND REFERENCES

The Elementary Diagram for the DFM™ relay (Figure 1-1 in the **PRODUCT DESCRIPTION** section) should be used for reference during testing. Text references include the entire **SPECIFICATIONS, INTERFACE**, and **SOFTWARE** sections of this manual and the DFM™ Relay Settings Table (TABLE 2-1) in the **CALCULATION OF SETTINGS** section.

EQUIPMENT GROUNDING

All equipment used in testing the DFM™ relay should be connected to a common grounding point to provide noise immunity. This includes the voltage and current sources, as well as the DFM™ relay itself. The case ground and surge ground are tied together internally in the DFM™ relay and are brought out through terminal AA-5.

REQUIRED SETTINGS

Most tests utilize the factory default settings. If the settings have been changed, they should be returned to the default values (see TABLE 2-1) before beginning this set of tests.

If a test requires settings different from the default values, they are listed prior to the test procedure. For periodic testing purposes, see the **PERIODIC TESTS** section of this manual for details on testing the DFM™ relay with user-specific settings.

GENERAL INSTRUCTIONS

1. In some of the acceptance tests, the DFM™ relay is tested using its "test mode" capability. The test mode selects and isolates various monitoring functions, and, when appropriate, routes their status to the OUTPUT #4 contact. Target information is displayed for tests that cause tripping.

*** CAUTION ***

The OUTPUT #4 contact will chatter when the unit under test is near its threshold. A single contact closure is enough to determine that the unit picked up. Do not prolong the test signal at the alarm threshold.

A continuity tester with high-input impedance, such as a digital ohmmeter, should be used to monitor the OUTPUT #4 contact during the testing of the DFM™ relay.

NOTE: NO OTHER OUTPUT CONTACTS EXCEPT OUTPUT #4 WILL OPERATE WHEN IN TEST MODE.

2. Where appropriate, current levels are defined with two numbers as: *xx*(*yy*), where *xx* is the value to be used for units rated at 5 amperes and (*yy*) is the value to be used for 1-ampere units.

3. During certain tests, one or more of the electronic current sources may not be required. If the source is not used, it must be set to zero (0) in addition to being disabled. Also, the currents should always be set at or near zero (0) whenever a current source is powered on or off.

4. The phase angles of the test sources are shown relative to Phase A voltage. A positive (+) phase angle refers to the referenced quantity lagging Phase A voltage.

5. All test voltages are phase-to-ground measurements unless otherwise specified.

6. Pressing a button on the local MMI or on a PC is shown as ["BUTTON"] where "BUTTON" is the alphanumeric label of the button to be pressed (UP, DN, ENTER, or TARGET RESET on the local MMI; TAB or ENTER on a PC).

7. For tests that require a setting change, the setting number is shown in parentheses next to the setting to facilitate direct access to the setting.

At the end of testing, make sure that all settings are returned to initial values. It is suggested that these settings be verified by a printout, or by scrolling through them on the DFM™ relay's local MMI display both before and after testing.

DFM™ RELAY TESTING

The following information is intended to give a step-by-step procedure to test the DFM™ relay, from setting up communications to the application of the voltages and current inputs. It is necessary to be familiar with the DFM-LINK software, since DFM-LINK is required to establish communications, change the password, change settings for the tests, and place the unit into test mode. Refer to the **SOFTWARE** section of this manual for detailed information on how to use DFM-LINK.

Hardware Setup

The hardware, specifically the cable to connect a PC to the DFM™ relay, depends on the connection the PC requires and the serial ports on the DFM™ relay. The DFM™ relay's rear serial port (PL-1) accepts a 25-pin male D-connector. The front serial port (COMM) accepts a 9-pin male D-connector. The PC used may require a 9-pin or a 25-pin connector. Null-modem cables for connecting to the DFM™ relay with a 9-pin-to-9-pin, and 25-pin-to-25-pin setup are shown in Figure 8-2 in the **INTERFACE** section.

1. Connect the PC to the DFM™ relay's front serial port with the appropriate null-modem connector.

2. See Figure 8-2 in the **INTERFACE** section for cable diagrams.

PC Software Setup

The software setup consists of loading the DFM-LINK software into the PC, starting the program, and configuring the program to the port settings of the PC and DFM™ relay.

LOAD AND START DFM-LINK

Use the **INSTALLATION** guide in the **SOFTWARE** section of this manual for directions to load DFM-LINK onto your PC.

1. Change directories to the location of the DFM-LINK program.

2. Start the program by typing "DFM-LINK" at the DOS prompt.

SET THE LOCAL (PC) CONFIGURATION

When you start DFM-LINK, the Main Menu is displayed. Refer to the **SOFTWARE** section for information on how to select items using the keyboard or a mouse.

1. Select the **SETUP** heading. The **SETUP** menu will now be displayed.

2. Select **Communication port number**. The default communications port will be displayed.

3. Type in the port number that matches the PC port connected to the DFM™ relay.

4. If Port 3 or 4 is selected, the IRQ number must also be selected.

5. Select "OK" when the port is configured.

SET UP A TEST UNIT DESCRIPTION

The next step is to create a new unit description that matches the DFM™ relay's baud rate, parity, number of stop bits, phone number, and switch code.

1. Select the **Add monitor to list** heading from the **SETUP** menu.

2. When prompted for the NEW MONITOR DESCRIPTION, type "TEST" and press [ENTER].

3. Select "OK".

A new unit description called "TEST" is created and must now have parameters set for it. The VIEW/CHANGE PARAMETERS dialog box appears with spaces for PHONE NUMBER, SWITCH CODE, BAUD RATE, STOP BITS, and PARITY.

4. At the PHONE NUMBER prompt, press [TAB]. (This is the default used when there is no phone.)

5. At the SWITCH CODE prompt, press [TAB]. (This is the default used for no switch.)
6. For BAUD RATE, select "2400" and press [TAB].
7. For STOP BITS, select "1" and press [TAB].
8. For PARITY, select "None" and press [TAB]. The unit description for "TEST" is now complete.
9. Select "OK".
10. Select "Cancel" to return to the **SETUP** menu.

DFM™ Monitor Setup

Before shipment, the DFM™ relay is set with factory default settings. Among these are the unit ID, the communications port settings, and the factory passwords. The default communications parameters are:

SETTING	DEFAULT FROM THE FACTORY
DFM UNIT ID	0
VIEWING PASSWORD *	DFM VIEW!
SETTING PASSWORD *	DFM SETT!
CONTROL PASSWORD *	DFM CONTROL!
FRONT PORT SETTINGS	2400 NONE 1 (Baud rate = 2400, Parity = None, Stop Bits = 1)
REAR PORT SETTINGS	2400 NONE 1 (Baud rate = 2400, Parity = None, Stop Bits = 1)

*** note: passwords are case (upper/lower) sensitive!**

If this is the first login to the DFM™ relay, the **passwords must be changed** before any functions except **change Password** or **lOgout** can be used.

INITIAL LOGIN TO THE DFM™ RELAY

1. Apply rated DC power to the DFM™ relay and wait for initialization to complete, as indicated by the feeder ID appearing on the top display line and the start of present values auto-scrolling on the bottom line.

Note: An invalid value is set at the factory, that forces the user to set the initial value of ARCING SENSITIVITY. When the DFM™ relay is first powered up, the message *SET HI-Z SENSITIVITY SETTING* will appear on the local MMI display after the completion of the power-up self-test. Pressing the UP pushbutton will result in the display *SENSITIVITY SETTING: 1.* The UP and DN pushbuttons can then be used to scroll through the possible sensitivity settings, that are the integers 1 through 10. When the desired setting is displayed, pressing the ENTER pushbutton results in the display of a confirmation message asking the user to verify the desired setting. If the ENTER pushbutton is pressed in response to this confirmation message, the setting value selected is saved and the DFM™ relay reboots. If either the UP or DN pushbutton is pressed instead, the next possible sensitivity setting in the sequence is displayed. This sequence occurs only at initial power-up. After a valid setting is selected, it can be changed by the user at any time via DFM-LINK.

2. Using DFM-LINK, select **Login** from the **MONITOR FUNCTIONS** menu.
3. Select the unit named "TEST" that was just created and press [ENTER].
4. DFM-LINK will prompt for a password. Type in the default viewing password and press [ENTER].
5. DFM-LINK will prompt for the unit ID. Type in "0" and press [ENTER].
6. Select "OK".

DFM-LINK will respond by re-displaying the **MONITOR FUNCTIONS** menu with the LOGOUT and **Device parameters** options now available for selection. If this is an initial login, the user must change the password via the **Device parameters** option, log out, and log in again in order to get a complete display of all the DFM™ relay's menus.

7. Select **Device parameters** from the **MONITOR FUNCTIONS** menu.
8. Select **change Password.**
9. Type in the default viewing password and press [ENTER].
10. Type in a new password and press [ENTER].
11. Re-enter the new password and press [ENTER].
12. Select "OK".
13. Select LOGOUT from the **MONITOR FUNCTIONS** menu and select "OK".
14. Repeat Steps 2 through 13 to change the default setting password, and again to change the control password.

SUBSEQUENT LOGIN TO THE DFM™ RELAY

Refer to the **SOFTWARE** section of this manual for details of the procedures involved in logging in to the DFM™ relay.

SETTING CHANGES

Setting changes required for a particular test are listed before the test. Settings are changed by using the **view/change Category of settings** option from the **Settings** menu. The sample setting change that follows outlines the steps involved in changing the PT RATIO in the DFM™ relay to 100.

1. Login to the DFM™ relay with the setting password.
2. Select **Settings** from the **MONITOR FUNCTIONS** menu.
3. Select **Upload settings** from the **Settings** menu and select "OK". Another dialog box will be displayed to confirm that settings are to be uploaded.
4. Select "OK" to upload settings from the DFM™ relay.
5. Select **view/change Category of settings** from the **Settings** menu.

A list box will be displayed containing the category names. Select GENERAL SETTINGS. A dialog box will be displayed containing a field for entering a setting number, a list box containing all the settings for this category, a field for entering a new setting value for a selected setting, and an informational field with the valid range for the setting value. Each of the different items can be selected by pressing [TAB] or by clicking on the item with the left mouse button.

6. Press [TAB] to enter the setting list box containing all the settings in this category.
7. Using the down arrow key, scroll through the list box until you get to PT RATIO.
8. Press [ENTER].
9. Enter "100" and press [ENTER]. The word "Changed" will be displayed in the list box next to PT RATIO to indicate that this setting value has been changed.
10. Select "OK" to save the setting change.

If the access level were not Settings, none of the options to download settings would be available at this point. Since the access level is Settings, the next step in completing a setting change is to download to the DFM™ relay.

11. Select **Download changed settings** from the **MONITOR FUNCTIONS Settings** menu. A dialog box will be displayed, containing the changed setting and providing an option to end setting changes automatically.
12. Select the option to end setting changes automatically.
13. Select the "OK" button to indicate that setting changes are to be downloaded to the DFM™ relay. Another dialog box will be displayed to confirm that settings are to be downloaded.
14. Select the "OK" button to download the setting change to the DFM™ relay. (If the CANCEL button is selected, no settings are sent and the **Download changed settings** dialog box is displayed again.)
15. Select "Cancel" to return to the settings menu.

Since the option for automatically ending setting changes was selected, this is the end of the setting changes. If the automatic option had not been selected, **End setting changes** would have to be selected from the **Settings** menu in order to end the setting changes.

It is important to remember either to select the option to end setting changes automatically, or to select **End setting changes** from the **Settings** menu after all settings changes for a particular test have been completed. This is necessary because settings are stored in a buffer so that they can all be downloaded at once. Ending the setting changes, either via the automatic option or via **End setting changes**, actually changes the settings in the DFM™ relay itself. Refer to the **SOFTWARE** section of this manual for further details on making setting changes.

INITIAL TEST SETUP

Before beginning the tests in this section, the DFM™ relay's settings should be printed for reference and verification. The factory setting values are listed in TABLE 2-1 in the **CALCULATION OF SETTINGS** section. If no printer is available, scroll through each category of settings on the local MMI and make sure each setting value matches the default setting listed in TABLE 2-1.

Once uploaded, the present DFM™ relay's settings can be saved to a disk file so that they can be reloaded into the DFM™ relay when testing is completed. Use the **Save settings to file** command in the **Settings** menu. DFM-LINK will prompt you for a name for the file, after that a valid MS-DOS file name should be entered. More information on how to use this command can be found in the **SOFTWARE** section of this manual.

GENERAL TESTS

T1 - Status Test

The DFM™ relay's status is reported through the local MMI display, the alarm LED on the local MMI, the alarm output contacts, and the DFM™ relay's self-test alarm contact. If a system failure inhibits the DFM™ relay's monitoring functions, the self-test alarm contact closes and a *FAIL* message is displayed on the local MMI. A failure that does not interrupt all of the DFM™ relay's monitoring functions results in the display of a *WARN* message on the local MMI. In addition, if one of the DFM™ relay's alarm output contacts is configured to operate in the event of a non-critical DFM™ relay failure, that contact closes.

This status test will demonstrate the use of the local MMI to check the DFM™ relay's status. See the **SERVICING** section of this manual for further information regarding DFM™ relay status.

1. If the display on the local MMI is blank at this point, press any pushbutton to exit the idle mode.

2. Press the [UP] button to stop the auto-scrolling of present values on the bottom line of the local MMI display. The first main-menu option (DATE/TIME) will appear.

3. Press the [UP] button twice more to reach the STATUS menu option.

4. Press the [ENTER] button. The display should be as follows:

   STATUS:
   OK

   The "OK" indicates that the DFM™ relay is operating properly and monitoring the line, and that there are no failure conditions present.

5. Press the [ENTER] button to return to the main menu.

If a non-critical or critical DFM™ relay failure is present, if the DFM™ relay's outputs are disabled, or if the DFM™ relay is presently in test mode, descriptive status messages will appear upon selection of the STATUS menu option, instead of the message "OK". See **Message List Menu Options** in the **INTERFACE** section for a detailed explanation of the STATUS option.

T2 - DFM-Initiated MMI Test

An MMI test is built into the DFM™ relay's software. It allows the user to test the local MMI display, LEDs, and TARGET RESET button. No specific test of the UP, DN, and ENTER pushbuttons is incorporated into the built-in MMI test because those buttons are tested on a continuous basis any time the user interacts with the local MMI. However, as part of this acceptance test, specific instructions are included to ensure that those three pushbuttons operate properly.

1. Press the [DN] button repeatedly until the main-menu option TEST MMI is displayed.

2. Press the [ENTER] button. The display should be two rows of twenty fully-lit rectangles that stay illuminated for a period of four seconds. The prompt *PRESS TARGET RESET BUTTON* is then displayed.

3. Press the [TARGET RESET] button. The message on the display will change to

   LEDs SHOULD BLINK
   **** CHECK PLEASE ***.*

   All LEDs on the local MMI except the POWER ON LED will blink on and off for a period of four seconds. When the LEDs stop blinking, the message *SELF-TEST OF MMI COMPLETE* will be displayed momentarily, and then the display reverts to the feeder ID on the top and the TEST MMI menu option on the bottom.

4. Press the [UP] button. The menu option RETURN TO SCROLL should appear on the bottom display line. (This step is added simply to verify the correct operation of the [UP] button.)

T3 - PC-Initiated Display and LED Test

This is a test of the local MMI display and LEDs that can be initiated from a local PC connected to the DFM™ relay through a serial port.

1. Using DFM-LINK, select **Change access level** from the **MONITOR FUNCTIONS** menu.

2. Enter the control password. If the password is not known, see the **INTERFACE** section for information on how it can be viewed. When the password is accepted, "Control Access" will appear at the bottom of the screen.

3. Select **Actions** from the **MONITOR FUNCTIONS** menu, then select **monitoR test**. The Test Mode list box will appear.

4. Select **Front Panel Display and LEDs** from the **monitoR test** list box and select "OK".

5. Select "OK" when prompted with "Perform test?".

The display will change to two rows of twenty fully-lit rectangles. The LEDs, beginning with the downed-conductor LED and progressing downward to the alarm LED, will illuminate for one second and then clear, one at a time. The display will remain fully lit and the LEDs will continue to illuminate and clear one at a time in a circular sequence until the test mode is exited.

6. End the test mode by selecting END OF MONITOR TEST from the TEST MODE list box and then selecting "OK".

7. Select "OK" when prompted with "End test mode?".

8. Select "Cancel" to return to the **Actions** menu.

T4 - Digital Input and Output Test

This test is used to check all inputs and outputs of the DFM™ relay. It verifies proper system connections without having to apply currents and voltages to simulate faults, or having to configure any contacts to particular states for operation.

1. Select **digital Output test** from the **Actions** menu. The **digital Output test** list box will appear.

2. Connect the Continuity Tester to OUTPUT #1 (see Figure 4-1) and verify that the contact is open.
3. Select OUTPUT #1 from the **digital Output test** list box and select "OK".
4. Select "OK" when prompted with "Perform test?".
5. Use the Continuity Tester to verify that the OUTPUT #1 contact closes.
6. Repeat Steps 3 through 5 for each of the five remaining outputs.
7. Select END OF TEST MODE from the **digital Output test** list box and select "OK".
8. Select "OK" when prompted with "End test mode?".
9. Select "Cancel" to return to the **Actions** menu.
10. Select **monitoR test** from the **Actions** menu. The **monitoR test** list box will appear.
11. Connect the Continuity Tester to the OUTPUT #4 contact.
12. Select **Contact Input #1** from the **monitoR test** list box and select "OK".
13. Select "OK" when prompted with "Perform test?".
14. Verify that the OUTPUT #4 contact is open and then apply rated DC across CC1.
15. Use the Continuity Tester to verify that the OUTPUT #4 contact closes.
16. Remove rated DC from CC1.
17. Repeat Steps 12 through 16 for CC2 (CONTACT INPUT #2) and CC3 (CONTACT INPUT #3).
18. End the test mode by selecting **End of Monitor Test** from the **monitoR test** list box and then selecting "OK".
19. Select "OK" when prompted with "End test mode?".
20. Select "Cancel" to return to the **Actions** menu.

T5 - AC System Input Test

This initial test uses the PRESENT VALUES main-menu option on the local MMI to verify that the voltages and currents are applied to the proper connections on the terminal strip.

1. Connect the DFM™ relay as shown in Figure 4-2.
2. Set VA = 67 volts RMS 0°, VB = 57 volts RMS +120°, and VC = 47 volts RMS +240°.
3. Press the [UP] button repeatedly until the main-menu option PRESENT VALUES is displayed.
4. Press the [ENTER] button.

5. Using the [UP] button, scroll to PHASE A VOLTAGE, PHASE B VOLTAGE, and PHASE C VOLTAGE, verifying that each voltage is within ±2 volts of its respective voltage source setting.

6. Set Iop = 1.0 amp RMS 45° lagging for phase A as shown by the "Y" connection point in Figure 4-2.

7. Using the [DN] button, scroll backward through the present values to the current value for the phase under test.

8. Verify that the current reading is between 0.97 and 1.03 amps RMS.

9. Using the [UP] button, scroll forward through the present values to the watts and VARs values for the phase under test, and then to the 3-phase VA value.

10. Verify that the watts, VARs, and VA readings fall within the proper range according to the phase under test, as follows:

	WATTS and VARS			3-PHASE VA		
Phase A	44.5	-	50.3	63.0	-	71.1
Phase B	37.7	-	43.0	53.3	-	60.8
Phase C	30.8	-	35.7	43.6	-	50.5

11. Repeat Steps 6 through 10 for phases B and C at 165° lagging and 285° lagging, respectively.

12. Repeat Steps 6 through 8 for Iop at 0° applied to the neutral (N) connection.

13. Press the [ENTER] button to return to the main menu.

T6 - 2-Cycle RMS Overcurrent Test

This test verifies the overcurrent disturbance monitoring function of the DFM™ relay.

1. Connect the DFM™ relay as shown in Figure 4-2.

2. Make the following setting changes:

(0108) SETTINGS FILE = 1 (SETGRP 1)
(0305) OUTPUT #5 = 2-CYCLE RMS OC ("set") [all others should be "not set"]
(0627) PH TOC PROTECTION = 0 (OFF)
(0628) PHASE LOW IOC PROT = 0 (OFF)
(0629) PHASE HIGH IOC PROT = 0 (OFF)
(0630) GRND TOC PROTECTION = 0 (OFF)
(0631) GRND LOW IOC PROT = 0 (OFF)
(0632) GRND HIGH IOC PROT = 0 (OFF)

3. Set Iop = 6.75(1.35) amps RMS for phase A, as shown by the "Y" connection point in Figure 4-2. This value is 90% of the PCHZ (PHASE OC) setting.

4. Slowly increase Iop until the OUTPUT #5 contact (AB15 - AB16) closes.

5. Reduce Iop to zero (0).

6. Verify that the pickup current is between 7.42(1.48) and 7.58(1.52) amps, that is ±1% of the PCHZ (PHASE OC) setting value of 7.5(1.5).

7. Verify that the top line of the DFM™ relay's local MMI display is blinking *TRG OC A xx/xx/xx*, where *xx/xx/xx* is the current date.

8. Verify that the alarm LED and the phase-under-test LED on the local MMI are illuminated.

9. Press the [DN] button repeatedly until the ALARM DATA menu option is displayed.

10. Press the [ENTER] button.

11. Verify that there is an alarm message as follows:

    ALARM DATA: 1of1
    2-CYCLE RMS OC

12. Press the [ENTER] button to return to the ALARM DATA option.

13. Press the [TARGET RESET] button to clear the blinking message on the top line and open the OUTPUT #5 contact.

14. Wait for one minute, and then press the [UP] button repeatedly until the DISTURBANCE DATA menu option is displayed.

15. Press the [ENTER] button.

16. Verify that there is a disturbance message as follows:

    DISTURBANCE 1:
    OC A *xx/xx xx:xx*

    The number on the top line represents the number of the disturbance, with 1 being the most recent. Depending on the DFM™ relay's present configuration, there may be from one to eight disturbance reports. The last two variable fields represent the month/day and hour:minute of the disturbance.

17. Press the [ENTER] button to return to the main menu.

18. Repeat Steps 3 through 17 for phases B and C.

19. Set Iop = 2.25(0.45) amps RMS for phase N, as shown by the "Y" connection point in Figure 4-2. This value is 90% of the GCHZ (GROUND OC) default setting.

20. Slowly increase Iop until the OUTPUT #5 contact (AB15 - AB16) closes.

21. Reduce Iop to zero (0).

22. Verify that the pickup current is between 2.47(0.49) and 2.53(0.51) amps RMS, that is ± 1% of the GCHZ (GROUND OC) default setting value of 2.5(0.5).

23. Verify that the top line of the DFM™ relay's local MMI display is blinking *TRG OC N xx/xx/xx*, where *xx/xx/xx* is the current date.

T7 - Current Channel Test for Overcurrent Range

This test is used to verify the RMS calculations when the overcurrent channel is involved.

1. Connect the DFM™ relay as shown in Figure 4-2.
2. Verify that DFM-LINK is logged in to the DFM™ relay at the control access level.
3. Select **Actions** from the **MONITOR FUNCTIONS** menu.
4. Select **monitoR test** from the **Actions** menu. The Test Mode list box will appear.
5. Select **Use OC Channel for RMS Calc** from the Test Mode list box and select "OK".
6. Select "OK" when prompted with "Perform test?".
7. Set Iop = 11.0(2.2) amps RMS for phase A as shown by the "Y" connection point in Figure 4-2.
8. If the PRESENT VALUES menu option is displayed on the bottom line of the MMI, press the [ENTER] button. Otherwise, press the [UP] button repeatedly until the PRESENT VALUES option is displayed, and then press the [ENTER] button.
9. Using the [UP] button, scroll to the current value that corresponds to the phase-under-test.
10. Verify that the current reading is between 10.6(2.12) and 11.4(2.28) amps RMS.
11. Reduce Iop to zero (0).
12. Press the [ENTER] button to return to the main menu.
13. Press the [TARGET RESET] button to clear the blinking overcurrent fault message.
14. Repeat Steps 7 through 13 for phases B, C, and N.
15. End the test mode by selecting **End of Monitor Test** from the **monitoR test** list box and then selecting "OK".
16. Select "OK" when prompted with "End test mode?".
17. Select "Cancel" to return to the **Actions** menu.

T8 - Breaker-Health Test

This test verifies the breaker-health monitoring function of the DFM™ relay.

1. Connect the DFM™ relay as shown in Figure 4-3.
2. Verify that DFM-LINK is logged in to the DFM™ relay at the settings access level, and then make the following setting changes:

   (0102) PHASE CT RATIO = 100
   (0103) GROUND CT RATIO = 100
   (0112) FRONT PANEL RESETS = ALLOWED
   (0304) OUTPUT #4 = BREAKER HEALTH ("set") [all others should be "not set"]
   (0401) BRKR HEALTH THRESH = 20000
   (0507) GCHZ (GROUND OC) = 10.00

3. Press the [DN] button repeatedly until the RESET BREAKER HEALTH menu option is displayed.

4. Press the [ENTER] button.
5. Press the [UP] or [DOWN] button to display the message *RESET BRKR HEALTH: YES?*.
6. Press the [ENTER] button to reset the breaker-health values.
7. Set Iop to 5.0(1.0) amps RMS.
8. Close switch S1 and immediately remove the current input, to simulate the breaker opening.
9. Use the Continuity Tester to verify that the OUTPUT #4 contact closes.
10. Verify that the alarm LED on the local MMI is illuminated.
11. Press the [UP] button repeatedly until the ALARM DATA menu option is displayed.
12. Verify that there is an alarm message as follows:

    ALARM DATA: 1of1
    BREAKER HEALTH

13. Press the [ENTER] button to return to the ALARM DATA option.
14. Press the [UP] button twice to get to the BREAKER HEALTH menu option.
15. Press the [ENTER] button.
16. Use the [UP] button to scroll through the breaker-health accumulators and verify that they are all between 22,500 and 27,500 I^2t.
17. Press the [UP] button to display the total number of breaker trips and verify that it is 1.

T9 - THD Test

This test verifies the total harmonic distortion (THD) calculations in the DFM™ relay. Two variations of the test are presented. The first test variation is to be used if available test equipment includes a test source with 180-Hz outputs. The second test variation uses three diodes to half-wave rectify the single-phase current and voltage inputs, and it is to be used if a test source with 180-Hz outputs is not available.

THD TEST USING 180-HZ SOURCE

1. Connect the DFM™ relay as shown in Figure 4-4.
2. Set V1 = 70 volts RMS @ 60 Hz and V2 = 3.5 volts RMS @ 180 Hz for VA as shown by the "X" connection point in Figure 4-4. Set I1 = 3.0 amps RMS @ 60 Hz and I2 = 0.15 amp RMS @ 180 Hz for phase A as shown by the "Y" connection point in Figure 4-4.
3. Wait up to 2 minutes for a THD alarm condition.
4. If the PRESENT VALUES menu option is already displayed on the bottom line, press the [ENTER] button. Otherwise, press the [UP] button repeatedly until the PRESENT VALUES option is displayed, and then press the [ENTER] button.

5. Using the [DN] button, scroll to the PHASE A VOLTAGE THD value and then to the PHASE A CURRENT THD value and verify that they are both between 4.6% and 5.4%.
6. Press the [ENTER] button to return to the PRESENT VALUES menu option.
7. Repeat Steps 2 through 6 for phase B, and then for phase C.

THD TEST WITHOUT USING 180-HZ SOURCE

1. Connect the DFM™ relay as shown in Figure 4-5.
2. Set V = 30 volts RMS for VA and Iop = 1.0(0.2) amp RMS for phase A as shown by the "X" and "Y" connection points, respectively, in Figure 4-5.
3. Wait up to 2 minutes for a THD alarm condition.
4. If the PRESENT VALUES menu option is already displayed on the bottom line, press the [ENTER] button. Otherwise, press the [UP] button repeatedly until the PRESENT VALUES option is displayed, and then press the [ENTER] button.
5. Using the [DN] button, scroll to the PHASE A VOLTAGE THD value and then to the PHASE A CURRENT THD value and verify that they are both between 42% and 46%.
6. Press the [ENTER] button to return to the PRESENT VALUES menu option.
7. Repeat Steps 2 through 6 for phase B, and then for phase C.

OVERCURRENT TESTS

Perform the following tests only if the DFM™ relay includes overcurrent protection functions.

T10 - Instantaneous OC Test

PHASE INSTANTANEOUS LOW SET

1. Make the following setting changes in group #1:

(0108) SETTINGS FILE = 1 (SETGRP 1)
(0301) OUTPUT #1 = PHASE LOW SET IOC ("set") [all others should be "not set"]
(0609) IOC LOW PHASE = 1.00(0.20)
(0610) IOC HIGH PHASE = 20.00(4.00)
(0613) IOC LOW PHASE DELAY = 0
(0617) PHASE AVERAGING PD = 0
(0621) GROUND AVERAGING PD = 0
(0625) TOC RESET OPTION = 1 (FAST RESET)
(0626) COLD LOAD PICKUP = 0
(0627) PH TOC PROTECTION = 0 (OFF)
(0628) PHASE LOW IOC PROT = 1 (ON)
(0629) PHASE HIGH IOC PROT = 0 (OFF)
(0630) GRND TOC PROTECTION = 0 (OFF)
(0631) GRND LOW IOC PROT = 0 (OFF)
(0632) GRND HIGH IOC PROT = 0 (OFF)

2. Connect the DFM™ relay as shown in Figure 4-6.

3. Select phase A by wiring "Y" to the appropriate terminal point, and set Iop to 1.5(0.3) amps RMS.
4. Verify that OUTPUT #1 closes within 25 - 35 milliseconds after the current is applied.
5. Verify that the top line of the front panel display reads: TRIP IOCL A
6. Remove the current.
7. Set Iop to 10.0(2.0) amps RMS.
8. Verify that OUTPUT #1 closes within 12 - 20 milliseconds after the current is applied.
9. Verify that the top line of the front panel display reads: TRIP IOCL A
10. Remove the current.

GROUND INSTANTANEOUS HIGH SET

1. Make the following setting changes in group #1:

   (0301) OUTPUT #1 = PHASE LOW SET IOC ("not set")
   (0302) OUTPUT #2 = GROUND HIGH SET IOC ("set") [all others should be "not set"]
   (0611) LOW IOC GROUND = 20.00(4.00)
   (0612) HIGH IOC GROUND = 2.00(0.40)
   (0616) IOC HI GRND DELAY = 0
   (0628) PHASE LOW IOC PROT = 0 (OFF)
   (0632) GROUND HIGH IOC PROT = 1 (ON)

2. Connect the DFM™ relay as shown in Figure 4-6.
3. Select phase B by wiring "Y" to the appropriate terminal point, and set Iop to 3.0(0.6) amps RMS.
4. Verify that OUTPUT #2 closes within 25 - 35 milliseconds after the current is applied.
5. Verify that the top line of the front panel display reads: TRIP IOCH N
6. Remove the current.
7. Set Iop to 20.0(4.0) amps RMS.
8. Verify that OUTPUT #2 closes within 12 - 20 milliseconds after the current is applied.
9. Verify that the top line of the front panel display reads: TRIP IOCH N
10. Remove the current.

T11 - Time OC Test

PHASE OVERCURRENT

1. Make the following setting changes in group #1:

   (0302) OUTPUT #2 = GROUND HIGH SET IOC (not set)

(0303) OUTPUT #3 = PHASE TOC ("set") [all others should be "not set"]
(0601) PHASE TOC CURVE = 0 (INVERSE)
(0602) GROUND TOC CURVE = 1 (VERY INVERSE)
(0603) PHASE TOC PICKUP = 0.50(0.10)
(0604) GROUND TOC PICKUP = 0.50(0.10)
(0605) PHASE TIME DIAL = 0.50
(0607) GROUND TIME DIAL = 0.50
(0627) PH TOC PROTECTION = 1 (ON)
(0632) GRND HIGH IOC PROT = 0 (OFF)

2. Connect the DFM™ relay as shown in Figure 4-6.
3. Select phase C by wiring "Y" to the appropriate terminal point, and set Iop to 0.75(0.15) amps RMS.
4. Verify that OUTPUT #3 closes within 627 - 721 milliseconds after the current is applied.
5. Verify that the top line of the front panel display reads: TRIP TOC C
6. Remove the current.
7. Set Iop to 5.0(1.0) amps RMS.
8. Verify that OUTPUT #3 closes within 175 - 200 milliseconds after the current is applied.
9. Verify that the top line of the front panel display reads: TRIP TOC C
10. Remove the current.
11. Set Iop to 20.0(4.0) amps RMS.
12. Verify that OUTPUT #3 closes within 129 - 149 milliseconds after the current is applied.
13. Verify that the top line of the front panel display reads: TRIP TOC C
14. Remove the current.

GROUND OVERCURRENT

1. Make the following setting changes in group #1:

(0303) OUTPUT #3 = PHASE TOC (not set)
(0304) OUTPUT #4 = GROUND TOC ("set") [all others should be "not set"]
(0627) PH TOC PROTECTION = 0 (OFF)
(0630) GRND TOC PROTECTION = 1 (ON)

2. Connect the DFM™ relay as shown in Figure 4-6.
3. Select phase C by wiring "Y" to the appropriate terminal point, and set Iop to 1.5(0.3) amps RMS.
4. Verify that OUTPUT #4 closes within 275 - 316 milliseconds after the current is applied.
5. Verify that the top line of the front panel display reads: TRIP TOC N
6. Remove the current.

7. Set Iop to 5.0(1.0) amps RMS.
8. Verify that OUTPUT #4 closes within 87 - 100 milliseconds after the current is applied.
9. Verify that the top line of the front panel display reads: TRIP TOC N
10. Remove the current.
11. Set Iop to 20.0(4.0) amps RMS.
12. Verify that OUTPUT #4 closes within 64 - 74 milliseconds after the current is applied.
13. Verify that the top line of the front panel display reads: TRIP TOC N
14. Remove the current.

T12 - Adaptive Time OC Test

1. Make the following setting changes in group #1:

   (0603) PHASE TOC PICKUP = 1.00(0.20)
   (0617) PHASE AVERAGING PD = 60
   (0618) PHASE ADAPTIVE = 200
   (0619) MIN PHASE ADAPTIVE = 75
   (0620) MAX PHASE ADAPTIVE = 100
   (0627) PH TOC PROTECTION = 1 (ON)
   (0630) GRND TOC PROTECTION = 0 (OFF)

2. Connect the DFM™ relay as shown in Figure 4-6.
3. Select phase C by wiring "Y" to the appropriate terminal point, and set Iop to 0.9(0.18) amps RMS and wait for 60 seconds.
4. Using PRESENT VALUES on the front panel MMI, verify that PHASE A TOC PICKUP and PHASE B TOC PICKUP are 0.75(0.15), PHASE C TOC PICKUP is 1.00(0.20), and GROUND TOC PICKUP is 0.50(0.10).
5. Remove the current.
6. Make the following setting changes in group #1:

   (0620) MAX PHASE ADAPTIVE = 200

7. Set Iop to 0.9(0.18) amps RMS and wait for 2 minutes.
8. Using PRESENT VALUES on the front panel MMI, verify that PHASE A TOC PICKUP and PHASE B TOC PICKUP are 0.75(0.15), PHASE C TOC PICKUP is 1.71(0.34) - 1.89(0.38), and GROUND TOC PICKUP is 0.50(0.10).
9. Remove the current.

T13 - Cold Load Pickup Test

1. Make the following setting changes in group #1:

(0304) OUTPUT #4 = PHASE TOC ("set") [all others should be "not set"]
(0306) CC 1 CONFIGURATION = TARGET RESET
(0617) PHASE AVERAGING PD = 0
(0621) GROUND AVERAGING PD = 0
(0626) COLD LOAD PICKUP = 2

2. Make the following setting changes in group #4:

(0603) PHASE TOC PICKUP = 5.10(1.02)
(0604) GROUND TOC PICKUP = 1.00(0.20)
(0605) PHASE TIME DIAL = 5
(0617) PHASE AVERAGING PD = 0
(0621) GROUND AVERAGING PD = 0
(0625) TOC RESET OPTION = 1 (FAST RESET)
(0626) COLD LOAD PICKUP = 0
(0627) PH TOC PROTECTION = 1 (ON)
(0630) GRND TOC PROTECTION = 1 (ON)

3. Connect the DFM™ relay as shown in Figure 4-6.

4. Select phase C by wiring "Y" to the appropriate terminal point, and set Iop to 0 (no current applied) and wait 3 minutes.

5. Using PRESENT VALUES on the front panel MMI, verify that PHASE A TOC PICKUP, PHASE B TOC PICKUP, and PHASE C TOC PICKUP are 5.10(1.02) and GROUND TOC PICKUP is 1.00(0.20).

6. Set Iop to 0.5(0.1) amp RMS and wait 2 minutes.

7. Using PRESENT VALUES on the front panel MMI, verify that PHASE A TOC PICKUP, PHASE B TOC PICKUP, and PHASE C TOC PICKUP are 1.00(0.20) and GROUND TOC PICKUP is 0.50(0.10).

8. Make the following setting changes in group #4:

(0630) GRND TOC PROTECTION = 0 (OFF)

9. Wait 3 minutes with no current applied (Iop = 0). Set Iop to 15.3(3.06) amps RMS.

10. Verify that OUTPUT #4 closes within 2.4 - 2.8 seconds after the current is applied.

11. Verify that the top line of the front panel display reads: TRIP TOC C

12. Remove the current.

END OF TEST

Make sure that the DFM™ relay is no longer in test mode, by selecting **End of monitor test** from the Test mode list box under **monitoR test**. Print out all the settings. If no printer is available, scroll through all the settings on the local MMI display. Compare each setting to the initial settings of the DFM™ relay, and make all necessary changes to return all the settings to their initial values. If the initial settings were saved to a disk file before testing with DFM-LINK, download that file to the DFM™ relay. All three privilege levels are required to perform the DFM™ relay's acceptance tests. After testing has been completed, it is necessary for security purposes that the setting and control passwords be changed. New passwords must be established so that only authorized personnel have future access to change Settings or perform Control operations in the DFM™ relay.

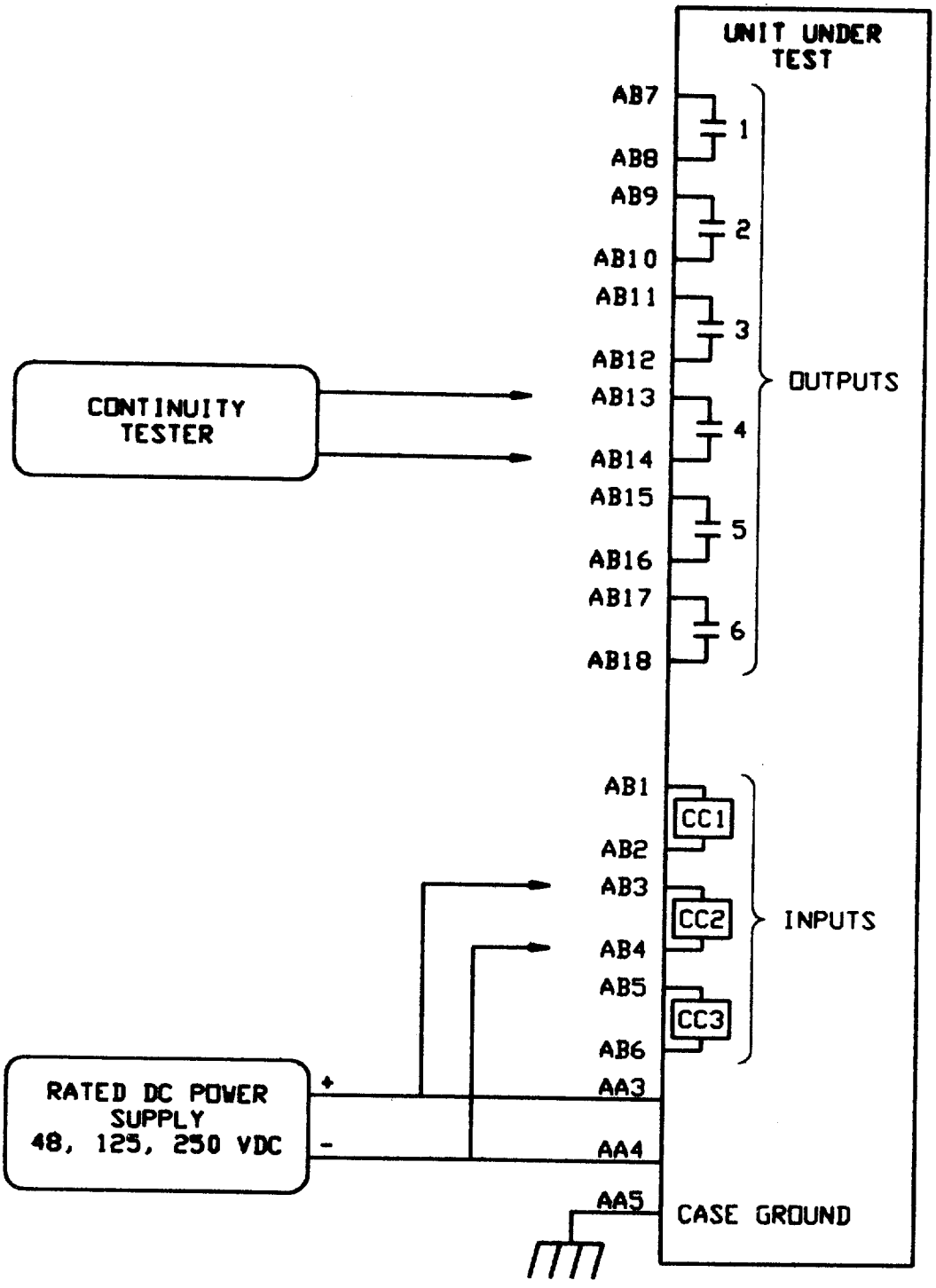
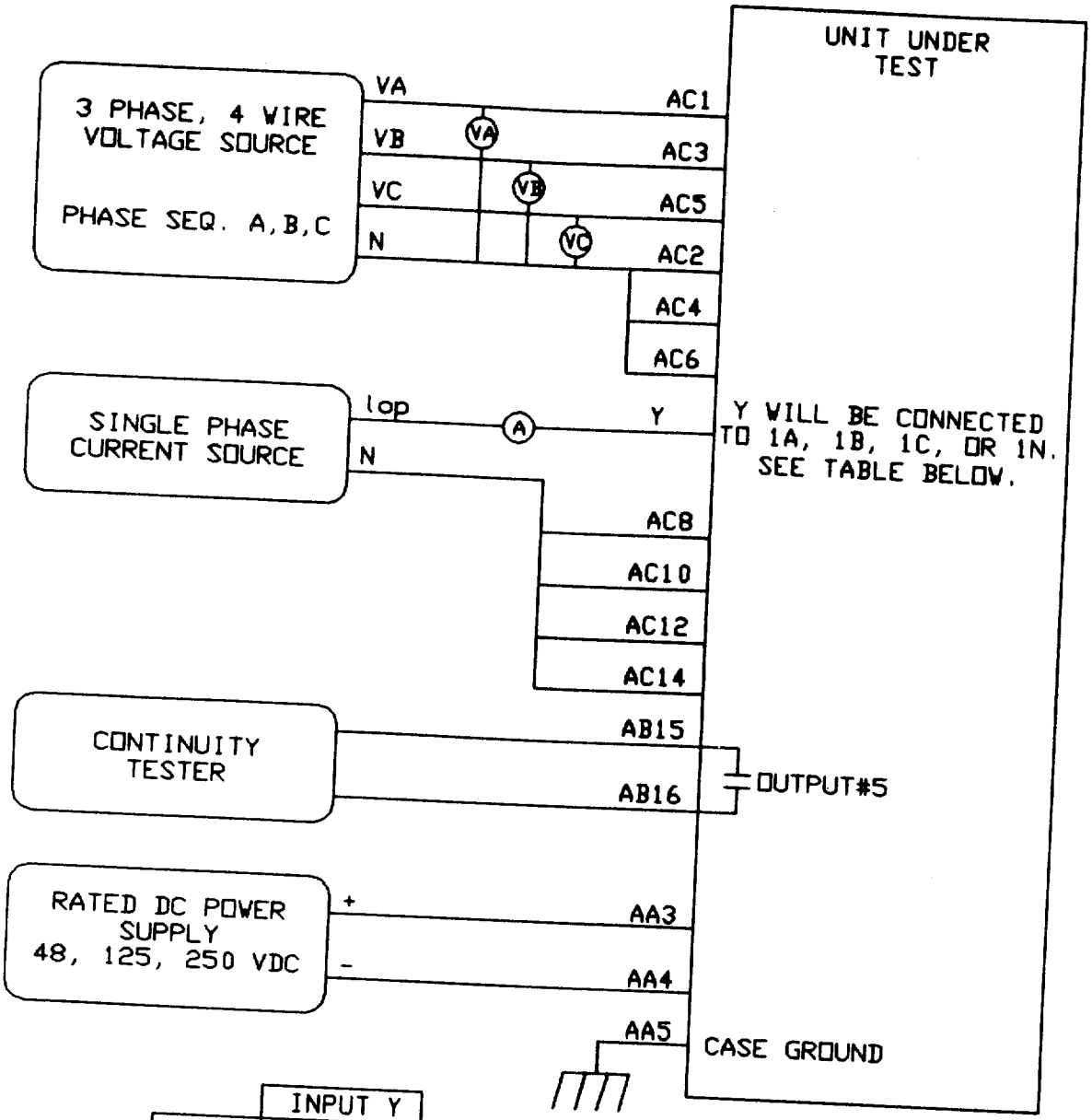


Figure 4-1 (0286A4890) Input and Output Test Connections



	INPUT Y
Phase Under Test	Terminal Block Number
A	AC7
B	AC9
C	AC11
N	AC13

Figure 4-2 (0286A5811) System Input and Overcurrent Test Connections

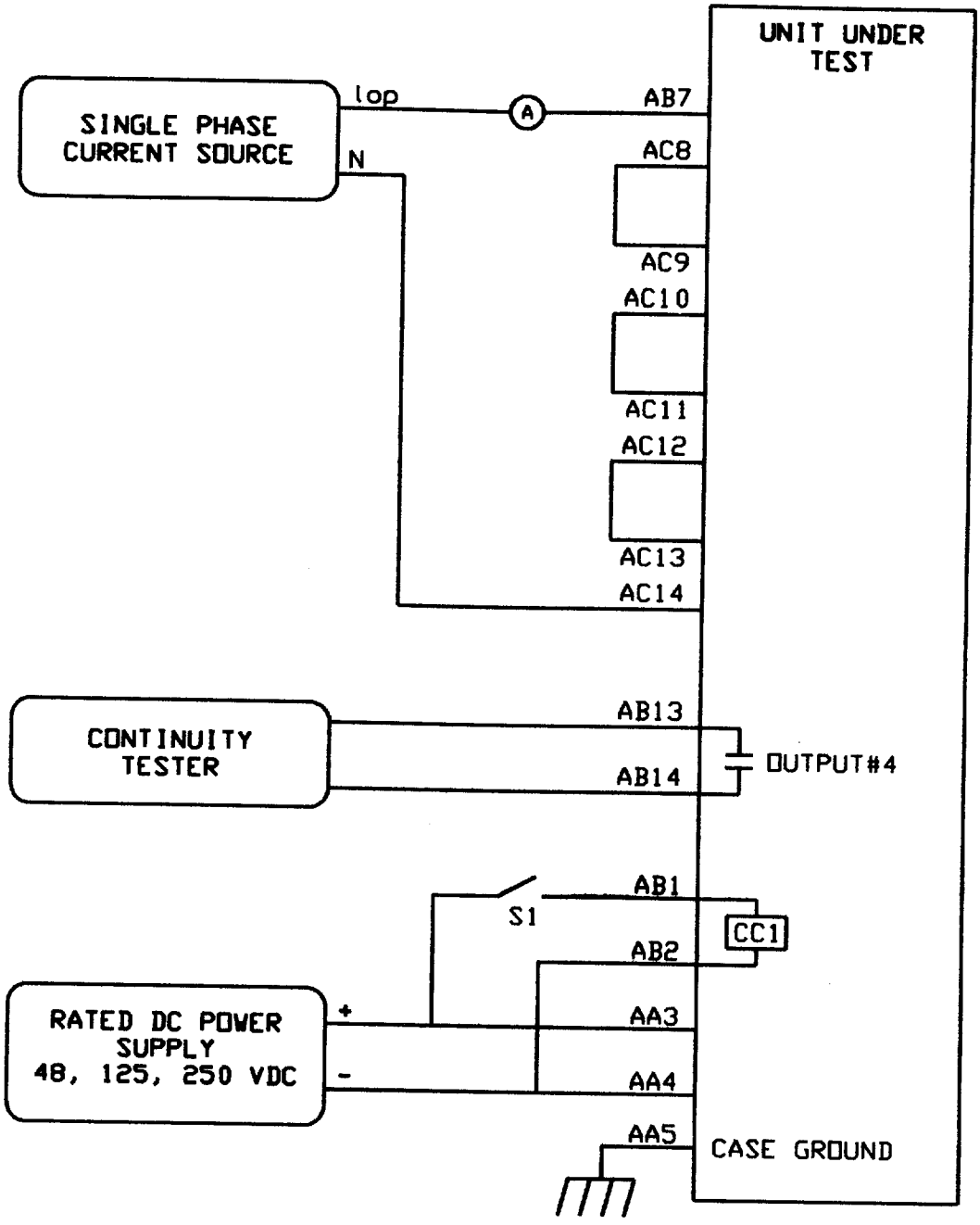
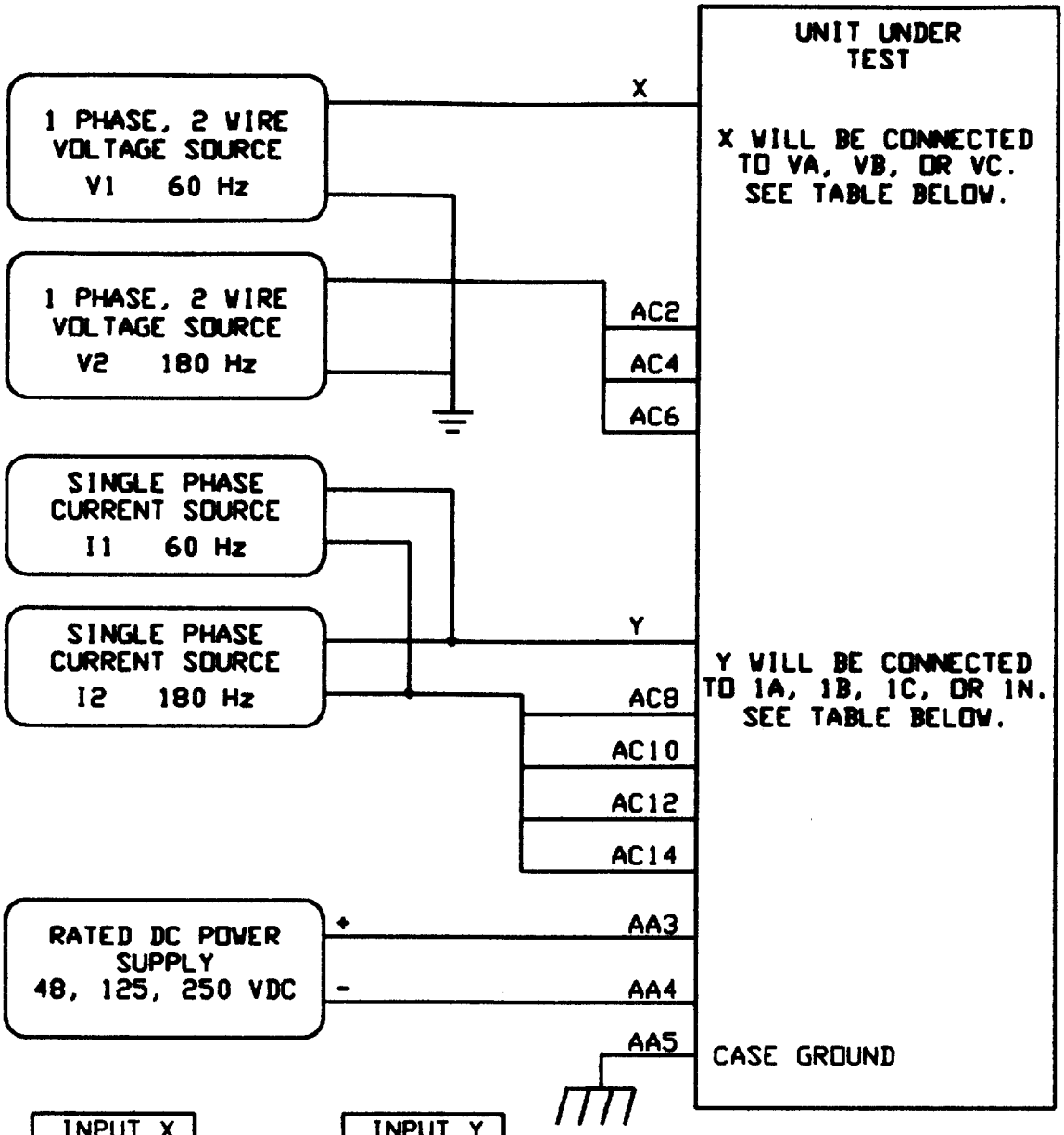


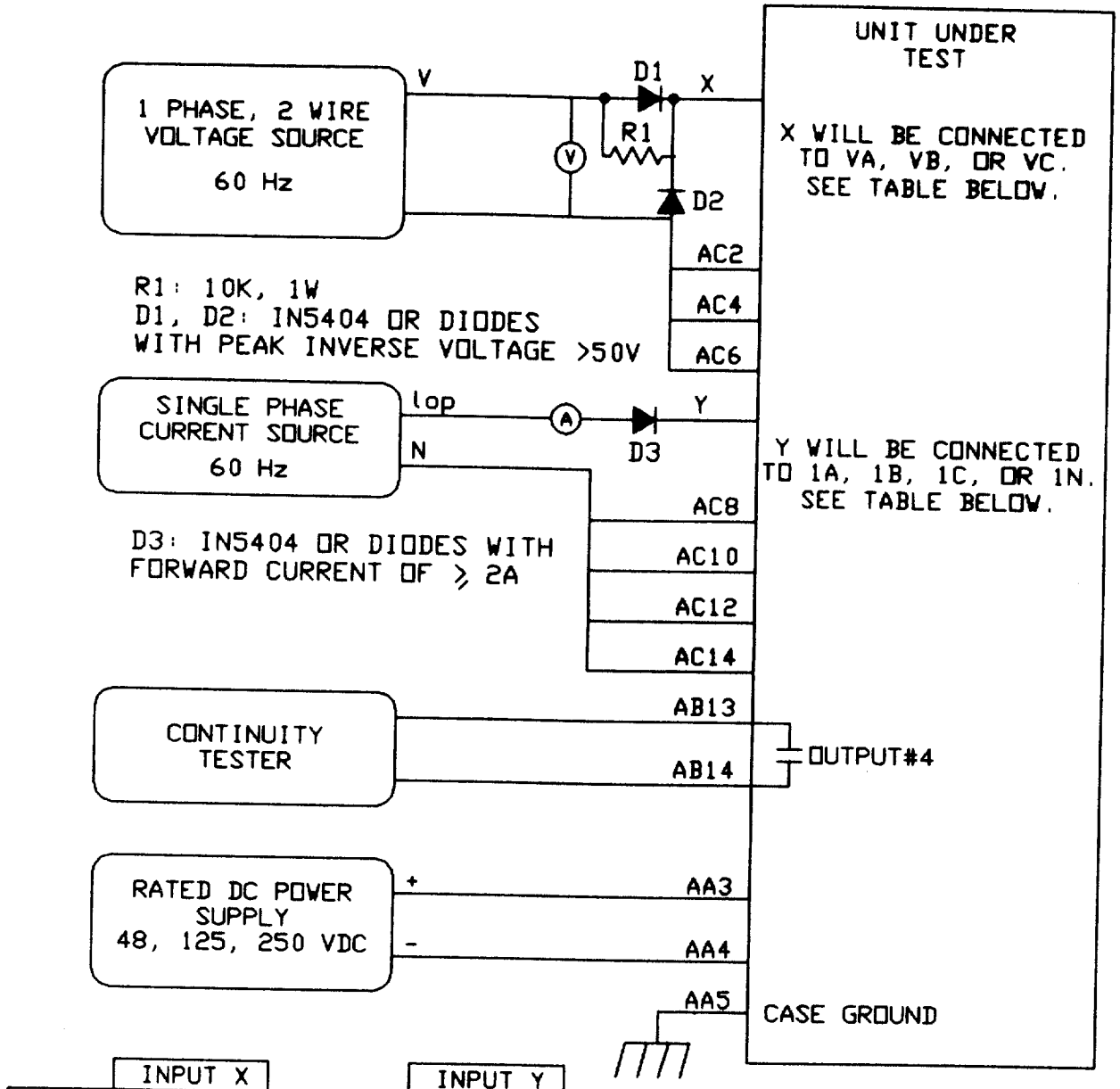
Figure 4-3 (0286A5812) Breaker-Health Test Connections



	INPUT X
Phase Under Test	Terminal Block Number
A	AC1
B	AC3
C	AC5

	INPUT Y
Phase Under Test	Terminal Block Number
A	AC7
B	AC9
C	AC11
N	AC13

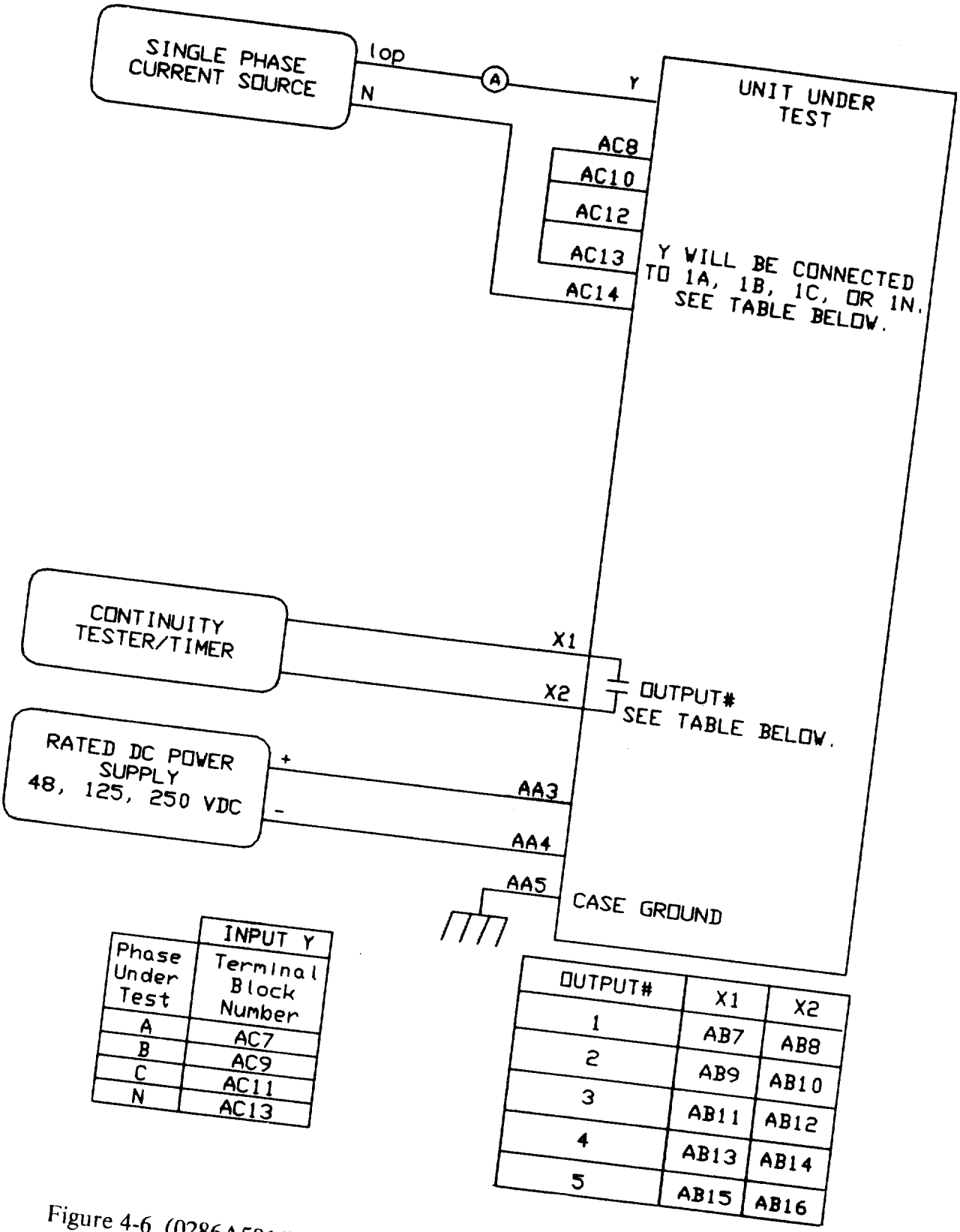
Figure 4-4 (0286A5414) THD Test Connections Using 180-Hz Source



	INPUT X
Phase Under Test	Terminal Block Number
A	AC1
B	AC3
C	AC5

	INPUT Y
Phase Under Test	Terminal Block Number
A	AC7
B	AC9
C	AC11
N	AC13

Figure 4-5 (0286A5813) THD Test Connections Without Using 180-Hz Source



	INPUT Y
Phase Under Test	Terminal Block Number
A	AC7
B	AC9
C	AC11
N	AC13

OUTPUT#	X1	X2
1	AB7	AB8
2	AB9	AB10
3	AB11	AB12
4	AB13	AB14
5	AB15	AB16

Figure 4-6 (0286A5814) Overcurrent Function Test Connections

PERIODIC TESTS

***** WARNING *****
POWER DOWN THE DFM™ RELAY BEFORE REMOVING OR INSERTING BOARDS. FAILURE TO DO SO CAN PERMANENTLY DAMAGE THE DFM™ RELAY AND CAUSE SERIOUS BODILY INJURY.

PERIODIC TESTING OF THE DFM™ RELAY

The formulas presented in this section permit the calculation of pickup currents and voltages for testing the DFM™ relay with settings specific to a particular application. The test circuits and procedures are the same as used and illustrated in the **ACCEPTANCE TESTS** section of this manual.

The user should determine the extent and frequency of periodic testing to be performed. The tests shown are guides for performing periodic tests; it is not strictly required that they be done at every periodic test of the unit. The desired test procedures can be incorporated into the user's standard test procedures.

It is suggested that the DFM™ relay's built-in "self-tests" be incorporated into the user's test procedures. They will give the operational status of the unit.

It is assumed that the user is familiar with testing the DFM™ relay. If not, refer to the **ACCEPTANCE TESTS** section for details.

5

General Tests

T1 Status Test
T2 DFM-Initiated MMI Test
T3 PC-Initiated Display and LED Test
T4 Digital Input and Output Test
T5 AC System Input Test
T6 2-Cycle RMS Overcurrent Test
T7 Current Channel Test for Overcurrent Range
T8 Breaker Health Test
T9 THD Test

These are the same tests contained in the **ACCEPTANCE TESTS** section. Tests T1, T2, T3, T4, T5, and T9 do not utilize user-specific settings and are not repeated in this section; please refer to the **ACCEPTANCE TESTS** section if these tests are to be performed as part of periodic testing.

Overcurrent Tests

T10 Instantaneous Overcurrent (IOC) Test
T11 Time Overcurrent (TOC) Test
T12 Adaptive TOC Test
T13 Cold Load Pickup Test

These are the same tests contained in the **ACCEPTANCE TESTS** section. Tests T12 and T13 do not require user-specific settings and are not repeated in this section; please refer to the **ACCEPTANCE TESTS** section if these tests are to be performed as part of periodic testing.

DRAWINGS AND REFERENCES

The Elementary Diagram (Figure 1-1 in the **PRODUCT DESCRIPTION** section) should be used for reference during testing. Text references include the entire **SPECIFICATIONS, INTERFACE,** and **SOFTWARE** sections of this manual, and the Settings Table (TABLE 2-1) in the **CALCULATION OF SETTINGS** section.

GENERAL INSTRUCTIONS

In test T7, the DFM™ relay is tested using its "test mode" capability. The test mode selects and isolates various monitoring functions and, when appropriate, routes their status to the OUTPUT #4 contact. Target information is displayed for tests that cause tripping.

***** CAUTION *****
The OUTPUT #4 contact will chatter when the unit under test is near its threshold. A single contact closure is enough to determine that the unit picked up. Do not prolong the test signal at the alarm threshold.

A continuity tester with high-input impedance, such as a digital ohmmeter, should be used to monitor the OUTPUT #4 contact during the testing of the DFM™ relay.

NOTE: NO OTHER OUTPUT CONTACTS EXCEPT OUTPUT #4 WILL OPERATE WHEN IN TEST MODE.

USING DFM-LINK SOFTWARE

The tests in this section require a PC running the DFM-LINK program. DFM-LINK is used to establish communications, change the password, change settings for the tests, and place the unit into test mode. Once in test mode, currents and voltages are applied to the DFM™ relay to simulate the desired system conditions.

TEST SETUP

Before beginning the tests in this section, settings should be uploaded from the DFM™ relay. Once uploaded, the present settings can be printed or saved to a disk file so that they can be reloaded into the DFM™ relay when testing is completed. Use the **Save settings to file** command in the **Settings** menu under **MONITOR FUNCTIONS**. DFM-LINK will prompt you for a name for the file, after which a valid MS-DOS file name should be entered. More information on how to use this command can be found in the **SOFTWARE** section of this manual.

GENERAL TESTS

T6 - 2-Cycle RMS Overcurrent Test

This test verifies the overcurrent disturbance monitoring function of the DFM™ relay.

1. Connect the DFM™ relay as shown in Figure 4-2 in the **ACCEPTANCE TESTS** section.
2. Make the following setting changes:

(0108) SETTINGS FILE = 1 (SETGRP 1)
(0305) OUTPUT #5 = 2-CYCLE RMS OC (set)
(0627) PH TOC PROTECTION = 0 (OFF)
(0628) PHASE LOW IOC PROT = 0 (OFF)
(0629) PHASE HIGH IOC PROT = 0 (OFF)
(0630) GRND TOC PROTECTION = 0 (OFF)
(0631) GRND LOW IOC PROT = 0 (OFF)
(0632) GRND HIGH IOC PROT = 0 (OFF)

3. Set Iop to

   [0.90 * PCHZ (PHASE OC)] = _____ amps RMS

   where PCHZ (PHASE OC) = setting #506

   for phase A, as shown by the "Y" connection point in Figure 4-2.

4. Slowly increase Iop until the OUTPUT #5 contact (AB15 - AB16) closes.

5. Reduce Iop to zero (0).

6. Verify that the pickup current is between

   [PCHZ - 0.01 * PCHZ] = _____ and

   [PCHZ + 0.01 * PCHZ] = _____ amps RMS.

7. Verify that the top line of the DFM™ relay's local MMI display is blinking *TRG OC A xx/xx/xx*, where *xx/xx/xx* is the current date.

8. Verify that the alarm LED and the LED for the phase-under-test, on the local MMI, are illuminated.

9. Press the [DN] button repeatedly until the ALARM DATA menu option is displayed.

10. Press the [ENTER] button.

11. Verify that there is an alarm message as follows:

    ALARM DATA: 1 of 1
    2-CYCLE RMS OC

12. Press the [ENTER] button to return to the ALARM DATA option.

13. Press the [TARGET RESET] button to clear the blinking message on the top line and open the OUTPUT #5 contact.

14. Wait one minute, and then press the [UP] button repeatedly until the DISTURBANCE DATA menu option is displayed.

15. Press the [ENTER] button.

16. Verify that there is a disturbance message as follows:

    DISTURBANCE 1:
    OC A *xx/xx xx:xx*

The number on the top line represents the number of the disturbance, with 1 being the most recent. Depending on the DFM™ relay's present configuration, there may be from one to eight disturbance reports. The last two variable fields represent the month/day and hour:minute of the disturbance.

17. Press the [ENTER] button to return to the main menu.

18. Repeat Steps 3 through 17 for phases B and C.

19. Set Iop to

    [0.90 * GCHZ (GROUND OC)] = _____ amps RMS

    where GCHZ (GROUND OC) = setting #507

    for phase N, as shown by the "Y" connection point in Figure 4-2.

20. Slowly increase Iop until the OUTPUT #5 contact (AB15 - AB16) closes.

21. Reduce Iop to zero (0).

22. Verify that the pickup current is between

    [GCHZ - 0.01 * GCHZ] = _____ and

    [GCHZ + 0.01 * GCHZ] = _____ amps RMS.

23. Verify that the top line of the DFM™ relay's front-panel display is blinking *TRG OC N xx/xx/xx*, where *xx/xx/xx* is the current date.

T7 - Current Channel Test for Overcurrent Range

This test is used to verify the RMS calculations when the overcurrent channel is involved.

1. Connect the DFM™ relay as shown in Figure 4-2 in the **ACCEPTANCE TESTS** section.

2. Verify that DFM-LINK is logged in to the DFM™ relay at the control access level.

3. Select **Actions** from the **MONITOR FUNCTIONS** menu.

4. Select **monitoR test mode** from the **Actions** menu. The Test Mode list box will appear.

5. Select **Use OC Channel for RMS Calc** from the Test Mode list box and select "OK".

6. Select "OK" when prompted with "Perform test?".

7. Set Iop to

    [2 * PCHZ (PHASE OC)] = _____ amps RMS

    for phase A (B,C), as shown by the "Y" connection point in Figure 4-2.

8. If the PRESENT VALUES menu option is displayed on the bottom line of the MMI, press the [ENTER] button. Otherwise, press the [UP] button repeatedly until the PRESENT VALUES option is displayed, and then press the [ENTER] button.

9. Using the [UP] button, scroll to the current value that corresponds to the phase-under-test.

10. Verify that the current reading is between

    [2 * PCHZ - 0.01 * (2 * PCHZ) - 0.287] = _____ and
    [2 * PCHZ + 0.01 * (2 * PCHZ) + 0.287] = _____ amps RMS.

11. Reduce Iop to zero (0).

12. Press the [ENTER] button to return to the main menu.

13. Press the [TARGET RESET] button to clear the blinking overcurrent fault message.

14. Repeat Steps 7 through 13 for phases B and C.

15. Set Iop to

    [2 * GCHZ (GROUND OC)] = _____ amps RMS

    for phase N, as shown by the "Y" connection point in Figure 4-2.

16. Press the [UP] button to view the NEUTRAL CURRENT value.

17. Verify that the current reading is between

    [2 * GCHZ - 0.01 * (2 * GCHZ) - 0.287] = _____ and
    [2 * GCHZ + 0.01 * (2 * GCHZ) + 0.287] = _____ amps RMS.

18. End the test mode by selecting **End of Monitor Test** from the **monitoR test** list box and then selecting "OK".

5

T8 - Breaker Health Test

This test verifies the breaker-health monitoring function of the DFM™ relay.

1. Connect the DFM™ relay as shown in Figure 4-3 in the **ACCEPTANCE TESTS** section.

2. Verify that DFM-LINK is logged in to the DFM™ relay at the settings access level, and then make the following setting changes:

   (0304) OUTPUT #4 = BREAKER HEALTH ("set") [all others should be "not set"]

3. Press the [DN] button repeatedly until the BREAKER HEALTH menu option is displayed.

4. Press the [ENTER] button.

5. Use the [UP] button to scroll through the breaker-health values, and record them.

   PHASE A BH ACCUM = _____
   PHASE B BH ACCUM = _____
   PHASE C BH ACCUM = _____
   TOTAL BRKR TRIPS = _____

6. Press the [ENTER] button to return to the main menu.
7. Make sure that one of the contact-converter inputs is configured for '52/b'.
8. Using DFM-LINK, select **Actions** from the **MONITOR FUNCTIONS** pull-down menu.
9. Select **reset dAta** from the **Actions** pull-down menu.
10. Select **Breaker-health data** from the **reset dAta** list box and set each of the breaker-health accumulators to zero (0).
11. Still using DFM-LINK, upload the settings from the DFM™ relay and record the value of setting (401) BREAKER HEALTH THRESH.

    (401) BREAKER HEALTH THRESH = _____
12. Now change the value of setting (401) to:

    BRKR HEALTH THRESH = (5.0(1.0) * PHASE CT RATIO) * BREAKER ARC TIME or

    BRKR HEALTH THRESH = (5.0(1.0) * PHASE CT RATIO)^2 * BREAKER ARC TIME

    depending on whether BRKR HEALTH UNITS = AMPS * SECONDS, or BRKR HEALTH UNITS = AMPS SQUARED * SECONDS.

    Note: the units for BREAKER ARC TIME must be seconds.
13. Set Iop to 5.0(1.0) amps RMS.
14. Close switch S1 and immediately remove the current input to simulate the breaker opening.
15. Use the Continuity Tester to verify that OUTPUT #4 closes.
16. Press the [ENTER] button on the MMI.
17. Use the [UP] button to scroll through the breaker-health values for verification that a breaker-health calculation was performed. Each accumulator should now be equal to BRKR HEALTH THRESH as calculated above. The TOTAL BRKR TRIPS should be 1.
18. Using DFM-LINK, set each of the breaker-health accumulators and the total number of trips to their original values recorded in step 4 above, and reset setting (401) to the value recorded under step 11 above.

T10 - Instantaneous OC Test

1. Verify that DFM-LINK is logged in to the DFM™ relay at the settings access level.
2. Select settings group 1, 2, 3, or 4 using setting #108 (SETTINGS FILE).
3. Make the following changes in the selected settings group.

   (0301) OUTPUT #1 = PHASE LOW SET IOC ("set") [all others should be "not set"]
   (0609) IOC LOW PHASE = (desired setting)
   (0613) IOC LOW PHASE DELAY = 0

(0617) PHASE AVERAGING PD = 0
(0621) GROUND AVERAGING PD = 0
(0626) COLD LOAD PICKUP = 0
(0627) PH TOC PROTECTION = 0 (OFF)
(0628) PHASE LOW IOC PROT = 1 (ON)
(0629) PHASE HIGH IOC PROT = 0 (OFF)
(0630) GRND TOC PROTECTION = 0 (OFF)
(0631) GRND LOW IOC PROT = 0 (OFF)
(0632) GRND HIGH IOC PROT = 0 (OFF)

4. Connect the DFM™ relay as shown in Figure 4-6 in the **ACCEPTANCE TESTS** section.

5. Select phase A, B, or C by wiring "Y" to the appropriate terminal point, and set Iop to:

   [0.8 * IOC LOW PHASE] = _____ amps RMS.

6. Slowly increase Iop and verify that the OUTPUT #1 contact closes, and that the pickup current is within the range of:

   [0.9 * IOC LOW PHASE] - [1.01 * IOC LOW PHASE]

7. Verify that the top line of the front display reads: TRIP IOCL A, TRIP IOCL B, or TRIP IOCL C depending on what phase was selected in step 5.

8. Remove the current, and change all settings back to their original values.

Any of the other IOC functions may be tested in a similar manner by making the appropriate modifications to steps 1 through 7.

5

T11 - Time OC Test

1. Verify that DFM-LINK is logged in to the DFM™ relay at the settings access level.

2. Select settings group 1, 2, 3, or 4 using setting #108 (SETTINGS FILE).

3. Make the following changes in the selected settings group.

(0302) OUTPUT #2 = GROUND TOC ("set") [all others should be "not set"]
(0602) GROUND TOC CURVE = (desired setting)
(0604) GROUND TOC PICKUP = (desired setting)
(0607) GROUND TIME DIAL = (desired setting)
(0617) PHASE AVERAGING PD = 0
(0621) GROUND AVERAGING PD = 0
(0626) COLD LOAD PICKUP = 0
(0627) PH TOC PROTECTION = 0 (OFF)
(0628) PHASE LOW IOC PROT = 0 (OFF)
(0629) PHASE HIGH IOC PROT = 0 (OFF)
(0630) GRND TOC PROTECTION = 1 (ON)
(0631) GRND LOW IOC PROT = 0 (OFF)
(0632) GRND HIGH IOC PROT = 0 (OFF)

4. Connect the DFM™ relay as shown in Figure 4-4 in the **ACCEPTANCE TESTS** section.

5. Select phase N by wiring "Y" to the appropriate terminal point.

6. Set Iop to the desired multiple of GROUND TOC PICKUP. Note that the multiple of pickup must be greater than or equal to 1.5.

7. Verify that the time measured from application of Iop to OUTPUT #2 contact closure is within ±7% of the time obtained from Figures 1-6, 1-7, 1-8, or 1-9.

8. Verify that the top line of the front display reads: TRIP TOC N.

9. Remove the current, and change all settings back to their original values.

Any of the other TOC functions may be tested in a similar manner by making the appropriate modifications to steps 1 through 8.

END OF TEST

Make sure that the DFM™ relay is no longer in test mode by selecting **End of monitor test** from the Test mode list box under **monitoR test**. Print out all of the settings. If no printer is available, scroll through all the settings on the front panel. Compare each setting to the initial settings of the DFM™ relay, and make all necessary changes to return all the settings to their initial values. If the initial settings were saved to a disk file before testing with DFM-LINK, download that file to the DFM™ relay.

SERVICING

SPARES

There are three possible servicing methods for the DFM™ relay. They are: (1) unit replacement, (2) spare board replacement, and (3) component level repair. Replacing the entire unit would yield the shortest "down time" and this is the preferred servicing method. The spare board replacement method could yield a minimal "down time" if a complete set of spare boards were kept at the maintenance center. The DFM™ relay's automatic self-tests would aid in the identification of failed boards and, if a complete set of spares were on hand, the defective board(s) could be replaced and the system returned to service quickly.

It is not recommended that the DFM™ relay be serviced at the component level. This requires a substantial investment in test/repair equipment and in technical expertise, and usually results in a longer "down time" than unit or spare board replacement. For those who do wish to troubleshoot at the component level, drawings can be obtained by requesting them from the factory. The only information that must be supplied to the factory when requesting drawings is the DFM™ model number.

***** WARNING *****
POWER DOWN THE DFM™ RELAY BEFORE OPENING THE CASE AND REMOVING OR INSERTING BOARDS. FAILURE TO DO SO CAN PERMANENTLY DAMAGE THE DFM™ RELAY AND CAUSE SERIOUS BODILY INJURY.

SERVICING WITH THE DFM™ SELF-TESTS

The DFM™ relay automatically performs tests of major functions and critical hardware components. The method of reporting on their status is dependent on the type or level of the failure and on the present configuration of the DFM™ relay's alarm output contacts. All failures result in an appropriate message being displayed on the top line of the local MMI display. In addition, some failures can be configured to operate one or both of the alarm output contacts and the local MMI alarm LED, while others operate only the self-test alarm contact.

There are two levels of self-test failures detected by the DFM™ relay. The first level consists of critical failures. They are indicated by a *FAIL* message on the top line of the local MMI display and the closing of the self-test alarm contact. Most critical failures place the DFM™ relay in a reduced operational mode whereby the only operable function is communication with the DFM™ relay, via the local MMI (pushbuttons and display) and via serial communications and a PC. Some critical failures prevent the DFM™ relay from even attempting to utilize either its local MMI or serial communications. If such a failure occurs, descriptions of all the failures that were detected on power-up scroll in a continuous cycle on the bottom display line, and no interaction with the DFM™ relay is possible.

The second level of self-test failures consists of non-critical failures. In the event of a non-critical failure, a *WARN* message is displayed on the local MMI. If an alarm output contact is configured to operate in the event of a non-critical DFM™ failure, that contact closes and the alarm LED on the local MMI is illuminated. These failures indicate a less critical condition than critical failures, whereby the DFM™ relay still provides some monitoring functions.

For each level of self-test failure, it is possible that more than one failure has been detected. If the local MMI display is operational, selection of the STATUS main-menu option results in the display of failure messages for all detected failures (maximum of 10), with *FAIL* messages displayed first, followed by *WARN* messages.

A general description of the types of self-tests performed is given in the **PRODUCT DESCRIPTION** section under **Power-On Self-Tests** and **Run-Time Self-Tests**. The components tested by the power-on self-tests are listed in TABLE 6-1. The components tested by the run-time self-tests are listed in TABLE 6-2.

TABLE 6-1 POWER-ON SELF-TESTS

COMPONENT	METHOD	BOARD	NATURE
A/D Converter and State Machine	Test of the DMA data transfer from the ADC to the Processor Board	ANI	Critical
Fault Range Current Signal Conditioning	Verification of signal	ANI	Non-Critical
	Verification that gain and offset are within correctable limits		Non-Critical
	Test of noise level without signal input		Non-Critical
	Verification of low-pass anti-aliasing filter cut-off frequency		Non-Critical
Normal Range Current Signal Conditioning	Verification of signal	ANI	Critical
	Verification that gain and offset are within correctable limits		Non-Critical
	Test of noise level without signal input		Non-Critical
	Verification of low-pass anti-aliasing filter cut-off frequency		Non-Critical

TABLE 6-1 POWER-ON SELF-TESTS (continued)

COMPONENT	METHOD	BOARD	NATURE
Notch-Filtered Current Signal Conditioning	Verification of signal	ANI	Critical
	Test of notch filter's ability to reject the power line fundamental frequency		Critical
	Verification that gain and offset are within correctable limits		Non-Critical
	Test of noise level without signal input		Non-Critical
Voltage Input Signal Conditioning	Verification of signal	ANI	Non-Critical
	Verification that gain and offset are within correctable limits		Non-Critical
	Test of noise level without signal input		Non-Critical
	Verification of low-pass anti-aliasing filter cut-off frequency		Non-Critical
Voltage Reference	Verification of high- and low-level test signal	ANI	Critical
LEDs	Self-test built in by manufacturer	I/O	Non-Critical
Serial Ports	Local loop-back and interrupt tests for serial interface	I/O	Non-Critical
Analog Input DMA	Test of analog data interface	PRC	Critical
CapRam Memory	Read/write verification and check for stuck address lines	PRC	Non-Critical
Data DMA Channels	Data transfer verification	PRC	Critical

TABLE 6-1 POWER-ON SELF-TESTS (continued)

COMPONENT	METHOD	BOARD	NATURE
Display	Self-test built in by manufacturer	PRC	Non-Critical
Display Output DMA	Display interface test	PRC	Non-Critical
EEPROM	Read/write verification	PRC	Critical
EPROM	CRC check	PRC	Critical
I/O Interface	Check of Processor-Board-to-I/O-Board interface	PRC	Non-Critical
Lockout Counter	Check of ability to reset the lockout count	PRC	Non-Critical
Real-Time Clock	Test of real-time clock operation and interrupts	PRC	Non-Critical
Fast RAM	Read/write verification including burst mode, and check for stuck address lines	PRC	Critical
Timer	Read verification and functional test	PRC	Critical
Watchdog Timer	Test of watchdog timer's ability to generate a reset	PRC	Non-Critical

TABLE 6-2 RUN-TIME SELF-TESTS

COMPONENT	METHOD	BOARD	NATURE
CapRam Memory	Read/write verification and check for stuck address lines	PRC	Non-Critical
EEPROM	Read verification	PRC	Critical
EPROM	CRC check	PRC	Critical

TABLE 6-2 RUN-TIME SELF-TESTS (continued)

COMPONENT	METHOD	BOARD	NATURE
I/O Interface	Check of Processor-Board-to-I/O-Board interface	PRC	Non-Critical
Local RAM	Read/write verification including burst mode, and check for stuck address lines	PRC	Critical

TROUBLESHOOTING

Troubleshooting the DFM™ relay requires three steps. The first step is to determine the type of failure, which will be either non-critical or critical. Next the list of failure and/or warning codes on the local MMI display are examined in order to identify the defective board(s). Depending on the nature of the failure(s) these codes will either scroll continuously on the display, or will be displayed upon selection of the STATUS option on the main-menu (see STATUS items in Table 8-2 in the **INTERFACE** section). Finally, each defective board is replaced in accordance with safety and static-discharge precautions.

***** WARNING *****
POWER DOWN THE DFM™ RELAY BEFORE REMOVING OR INSERTING BOARDS. FAILURE TO DO SO CAN PERMANENTLY DAMAGE THE DFM™ RELAY AND CAUSE SERIOUS BODILY INJURY. NOTE THAT REPLACEMENT OF THE I/O BOARD REQUIRES DISCONNECTING THE CONTROL INPUTS AND OUTPUTS FROM THAT BOARD, AND REPLACEMENT OF THE MAGNETICS MODULE REQUIRES DISCONNECTING ITS CT AND PT INPUTS.

Servicing a Critical Failure (*FAIL*)

A critical failure indicates total interruption of the DFM™ equipment's monitoring functions and, possibly, of its ability to communicate. If a critical failure is detected on one or more of the boards (excluding the power supply) at power-up, no attempt is made by the DFM™ relay to perform any of its monitoring functions. The DFM™ self-test alarm contact is energized, and an attempt is made to store the DFM™ status and to initialize the MMI and remote communications hardware/software in a reduced operation mode. If this attempt is unsuccessful, failure messages will continually scroll on the DFM™ relay's local MMI display indicating the nature of the power-up failure. These messages can be used to aid in the identification of the board or boards on which failures have occurred.

When a critical failure is detected during run-time (as opposed to power-up), the DFM™ relay restarts. If the failure re-occurs during the power-on self-test, the DFM™ relay will power up with a *FAIL* message on the top line of the local MMI display. If restarting corrects the failure, the DFM™ relay resumes normal operation.

A critical failure message on the local MMI display has the format *FAIL xxx: yyy*. The *xxx* field is a board abbreviation for the circuit board on which the failure occurred. The *yyy* field is a numeric code that indicates the nature of the critical failure. The *FAIL* message remains on the display until the condition causing the failure is corrected. See TABLE 6-3 for a list of critical failure codes and their meanings. As an alternative to referencing TABLE 6-3, the STATUS option on the local MMI display's main menu can be selected to display descriptions of failures as long as the failure does not involve the display itself. The STATUS option can be reached by pressing the UP or DN pushbutton until STATUS is displayed on the bottom line. See the STATUS items in Table 8-2 in the **INTERFACE** section for a detailed description of the STATUS main-menu option.

Using TABLE 6-3 or the STATUS main-menu option on the DFM™ relay's local MMI, the cause of a critical failure can be determined. When the board on which the failure occurred has been identified, the unit can be powered down and a replacement board installed. After power is re-applied, if the *FAIL* message is gone, then the unit has been successfully repaired. If the message has changed, it is possible that another board requires replacement.

TABLE 6-3 DFM™ CRITICAL FAILURE MESSAGES

CODE	DISPLAYED MESSAGE	DESCRIPTION
101	PRC: EPROM CRC	EPROM CRC check failure
102	PRC: LOCAL RAM	Local RAM data bus failure
104	PRC: SLOW DATA BUS	Slow peripheral data bus failure (EEPROM, Timer, and Real-Time Clock data bus test all failed)
105	PRC: EEPROM	EEPROM data bus failure
106	PRC: TIMER	Timer data bus failure
109	PRC: LOCAL RAM	Local RAM address bus failure
111	PRC: LOCAL RAM	Local RAM burst-mode test failure
112	PRC: LOCAL RAM	Local RAM cell integrity test failure
115	PRC: EEPROM	EEPROM cell integrity test failure
116	PRC: ANALOG DATA DMA	Analog input DMA channel failure
117	PRC: DATA XFER DMA	Data-moving DMA channel failure
118	PRC: ANALOG DATA DMA	Oscillography DMA channel failure
122	PRC: TIMER	Counter/Timer functional failure
124	PRC: MODEL NUMBER	Invalid model number
125	PRC: EEPROM CRC	EEPROM CRC check failure
202	ANI: NORM RANGE CHAN	Normal current range channel failure
204	ANI: NOTCH FLTR CHAN	Notched current channel failure
205	ANI: REFERENCE	Low-level test signal versus voltage reference test failure
206	ANI: REFERENCE	High-level test signal versus voltage reference test failure
207	ANI: NOTCH FILTER	Notch filter attenuation test failure
223	ANI: ADC INTERFACE	DMA data transfer test from the ADC to the Processor Board failed
224	ANI: SERIAL EEPROM	Analog Board serial EEPROM CRC check failure
401	MAG: SERIAL MEM	Magnetics module serial EEPROM CRC check failure
402	MAG: CT RATING	Invalid CT rating for model number

Servicing a Non-Critical Failure (*WARN*)

A non-critical failure indicates a degradation in the DFM™ equipment's monitoring functions. It is possible to configure one or both of the DFM™ relay's alarm output contacts to operate in the event of a non-critical DFM™ failure. If at least one alarm output contact is configured as such, the detection of a non-critical failure by the power-on self-tests illuminates the alarm LED on the local MMI and closes the contact(s) configured to operate in the event of a non-critical DFM™ failure. A *WARN* message is displayed on the local MMI's top display line regardless of the alarm-output-contact configurations. If a non-critical failure is detected by the run-time self-tests, the DFM™ relay restarts. If the non-critical failure is still present after the restart, a *WARN* message is displayed as before, and, depending on the alarm-output-contact configurations, the alarm LED may be illuminated and one or both of the alarm output contacts may close. If restarting the DFM™ relay corrects the condition causing the non-critical failure, the DFM™ relay resumes normal operation.

A non-critical failure message on the local MMI display has the format *WARN xxx: yyy*. The *xxx* field is a board abbreviation for the circuit board on which the failure occurred. The *yyy* field is a numeric code that indicates the nature of the non-critical failure. The *WARN* message remains on the display until the condition causing the failure is corrected. See TABLE 6-4 for a list of non-critical failure codes and their meanings. As an alternative to referencing TABLE 6-4, the STATUS option on the local MMI display's main menu can be selected to display descriptions of non-critical failures, as long as the failure does not involve the display itself. The STATUS option can be reached by pressing the UP or DN pushbutton until STATUS is displayed on the bottom line. See STATUS items in Table 8-2 in the **INTERFACE** section for a detailed description of the STATUS main-menu option.

Using TABLE 6-4 or the STATUS main-menu option on the DFM™ relay's local MMI, the cause of a non-critical failure can be determined. When the board on which the failure occurred has been identified, the unit can be powered down and a replacement board installed. After power is re-applied, if the *WARN* message is gone, then the unit has been successfully repaired. If the message has changed, it is possible that another board requires replacement.

TABLE 6-4 DFM™ NON-CRITICAL FAILURE MESSAGES

CODE	DISPLAYED MESSAGE	DESCRIPTION
103	PRC: CAPRAM MEMORY	Capacitor-backed RAM data bus failure
107	PRC: REAL TIME CLOCK	Real-Time Clock data bus failure
108	PRC: I/O INTERFACE	I/O Board data bus failure
110	PRC: CAPRAM MEMORY	Capacitor-backed RAM address test failure
114	PRC: CAPRAM MEMORY	Capacitor-backed RAM cell integrity test failure
119	PRC: DISPLAY DMA	Display output DMA channel failure
120	PRC: RESET LOCKOUT	Reset counter failure
121	PRC: WATCHDOG TIMER	Watchdog timer reset failure
123	PRC: REAL TIME CLOCK	Real-Time Clock interrupt test failure
201	ANI: VOLT INPUT CHAN	Voltage input channel failure
203	ANI: OC RANGE CHAN	Fault current range channel failure
208	ANI: EXCESS OFFSET	Excess voltage input current offset
209	ANI: EXCESS OFFSET	Excess normal current offset
210	ANI: EXCESS OFFSET	Excess fault range current offset

TABLE 6-4 DFM™ NON-CRITICAL FAILURE MESSAGES (continued)

CODE	DISPLAYED MESSAGE	DESCRIPTION
211	ANI: EXCESS OFFSET	Excess notch-filtered current offset
212	ANI: NOISE LEVEL	Excess voltage input current noise
213	ANI: NOISE LEVEL	Excess normal current range noise
214	ANI: NOISE LEVEL	Excess fault range current noise
215	ANI: NOISE LEVEL	Excess notch-filtered current noise
216	ANI: GAIN VOLT INPUT	Voltage input gain error
217	ANI: GAIN NORM RANGE	Normal current range gain error
218	ANI: GAIN OC RANGE	Fault current range gain error
219	ANI: GAIN NOTCHED	Notch-filtered current gain error
220	ANI: FREQ RESPONSE	Voltage input low-pass test failure
221	ANI: FREQ RESPONSE	Normal current range low-pass failure
222	ANI: FREQ RESPONSE	Fault current range low-pass failure
301	I/O: SERIAL PORT	Serial port failure
302	I/O: SERIAL INTR	Serial port interrupt failure
303	I/O: DIGITAL OUTPUT	Relay output latch setup failure
304	I/O: DIGITAL OUTPUT	Operate contact feedback error
305		Target Reset button self-test

SPECIFICATIONS

RATINGS

Rated Frequency	50 to 60 Hertz
Rated Voltage	Vn = 120 Volts AC (per coil phase-to-ground or phase-to-phase)
Rated Current	In = 1 or 5 AC RMS Amperes
DC Control Voltage:	
Power supply	
Vps = 48 VDC	Operating Range 38.5 - 60 VDC
Vps = 125 VDC	Operating Range 88 - 150 VDC
Vps = 250 VDC	Operating Range 176 - 300 VDC
Contact converters	Operating Range 38.5 - 300 VDC
Maximum Permissible Current:	
Continuous	2 x In
Three Seconds	50 x In
One Second	100 x In
Maximum Permissible AC Voltage:	
Continuous	2 x Vn
One Minute (Once Per Hour)	3.5 x Vn
Ambient Temperature Range:	
Storage	−40°C to +85°C
Operation	−30°C to +65°C
Humidity	95% Without Condensation
Insulation Test Voltage	2kV 50/60 Hz, One Minute
Impulse Voltage Withstand	5kV Peak, 1.2/50 Milliseconds, 0.5 Joules
Interference Withstand Tests	SWC / Fast Transient per ANSI C37.90.1 RFI per ANSI C37.90.2

BURDENS

Current Circuits	0.022 Ohm, 5 DEG, In = 5 Amps 0.12 Ohm, 30 DEG, In = 1 Amp
Voltage Circuits	0.15 VA, 60 Hz 0.20 VA, 50 Hz
DC Battery (For Contact Converters)	2.5 Milliamperes at Rated DC Input Voltage
DC Battery (Power Supply)	20 Watts

CONTACT RATINGS

All output contacts	
Continuous	3 amperes
Make and carry	30 amperes per ANSI 37.90 duty cycle

ACCURACY

Data Sample Timetag Resolution	± One-Half Millisecond
Current Measurement:	
5-Amp CT	1 %
1-Amp CT	1 %

DIMENSIONS

Height	9.125 Inches
Width	6.625 Inches
Depth	7.000 Inches (From Mounting Flange to Rear of Terminal Blocks)

WEIGHT

Approximately 15 Pounds (6.8 Kilograms)

INTERFACE

LOCAL MAN-MACHINE INTERFACE (MMI)

The DFM™ relay's man-machine interface consists of four pushbutton switches, six LEDs, and an alphanumeric display located on the front of the DFM™ relay. This user interface provides easy access for monitoring data and disturbance conditions on a distribution feeder, as well as for monitoring the status of the DFM™ relay itself. Figure 8-1 shows the front panel.

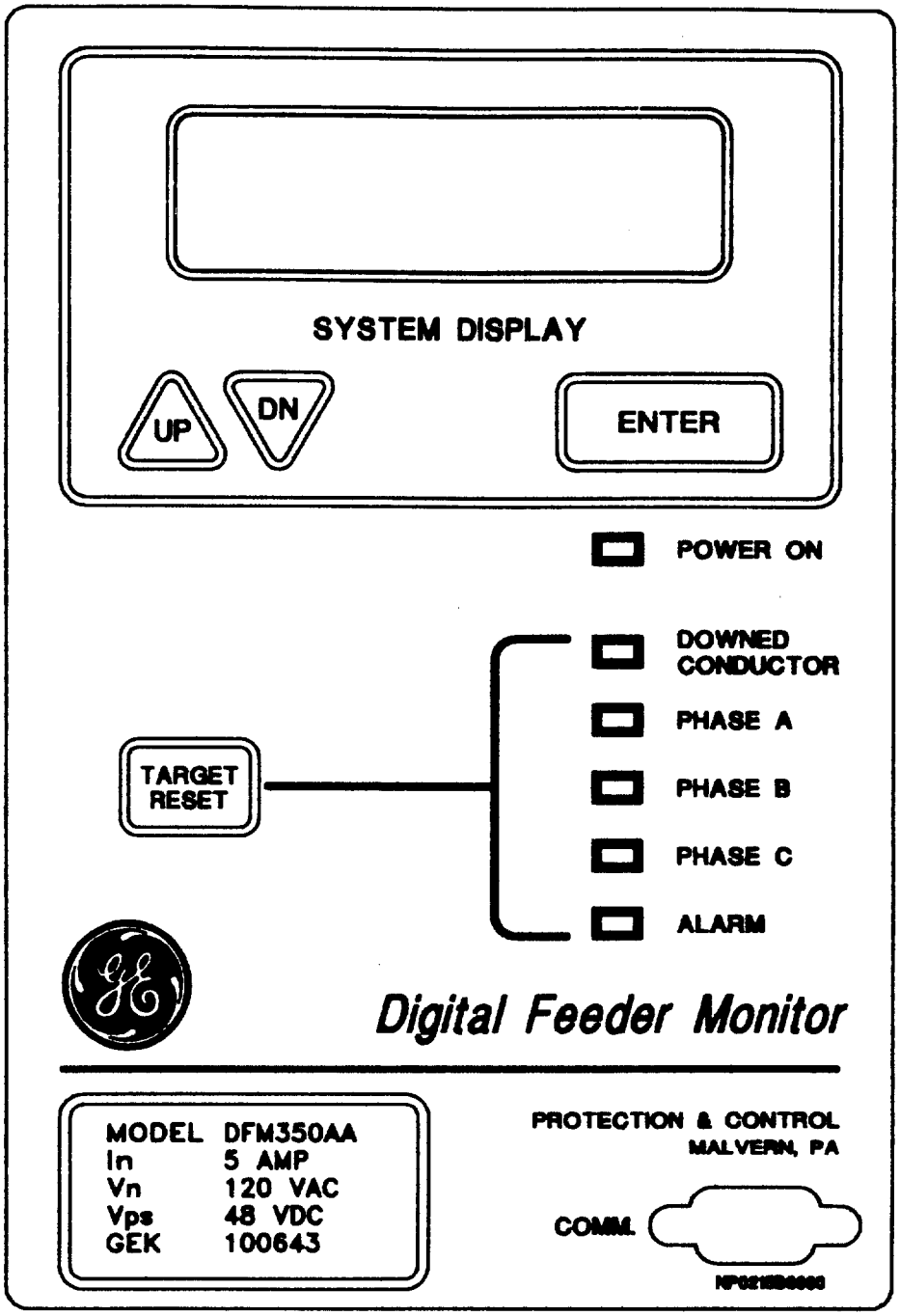


Figure 8-1 (0286A5407) DFM™ Relay Front Panel

Display

The alphanumeric display on the DFM™ relay's local MMI is a 2-line by 20-character vacuum fluorescent arrangement. On power-up, a self-test of the display is conducted by lighting up all the display segments momentarily before normal local MMI operations begin. Following power-up, the display enters its automatic operational mode (auto-scroll mode). In this mode, the feeder ID appears on the top line of the display. At the same time, present values scroll continuously on the bottom line of the display, with each measured value remaining on the screen for 4 seconds. These present values appear in the following sequence and format:

Ia = *xxx.xx* A	(Phase A Current)
Ib = *xxx.xx* A	(Phase B Current)
Ic = *xxx.xx* A	(Phase C Current)
In = *xxx.xx* A	(Neutral Current)
Va = *xxx.x* V	(Phase A Voltage)
Vb = *xxx.x* V	(Phase B Voltage)
Vc = *xxx.x* V	(Phase C Voltage)
Wtot = ±*xxxxx.x*	(Total Watts)
VARtot = ±*xxxxx.x*	(Total VARs)
3-PH VA = *xxxxx.x*	(3-Phase Volt-Amperes)
3-PH PF = ±*x.xxx*	(3-Phase Power Factor)
Ia THD = *xx.x%*	(Phase A Current THD)
Ib THD = *xx.x%*	(Phase B Current THD)
Ic THD = *xx.x%*	(Phase C Current THD)
Va THD = *xx.x%*	(Phase A Voltage THD)
Vb THD = *xx.x%*	(Phase B Voltage THD)
Vc THD = *xx.x%*	(Phase C Voltage THD)

Each value is displayed for 4 seconds, and then the next value is displayed, etc. The value displayed during each 4-second interval is a constant value, which is the latest value calculated prior to the beginning of that 4-second interval. The displayed value is not updated during the 4-second interval. DFM™ relay models that do not provide power-quality monitoring do not have the six THD values in the auto-scroll sequence.

Although individual phase values for watts, VARs, and power factors are stored in the DFM™ relay, only total watts, total VARs, and the 3-phase power factor are included in the automatic scrolling sequence. These three-phase values, and not the individual values, are of primary concern for continuous viewing. Note that for the currents, voltages, total watts, total VARs, and 3-phase VA there will be a different formatting if primary values are to be displayed (*xxxxx* A for currents, *xxx.xx* KV for voltages, and *xxxx.x* for total watts, total VARs and 3-phase VA with labels of 'K' or 'M' if these values are large enough). Note also that present values are included in the auto-scroll sequence only if their associated current transformer (CT) or potential transformer (PT) is connected. If the CT and/or PT for any phase is not active, present values for that phase are not displayed. In addition, if a CT for any phase is not active, no values for total watts, total VARs, or 3-phase VA are displayed.

The local MMI display continues in its auto-scroll mode for 15 minutes after power-up, as long as no pushbutton has been pressed, at which time it enters its 'idle mode'. This mode is characterized by a blank display that acts as a screen saver during periods of inactivity. The display then remains in its idle mode until the user initiates interaction by pressing a button or until a disturbance or a DFM™ relay failure is detected. If the idle mode is interrupted by a button being pressed, the display enters its auto-scroll mode again. If it is interrupted by the detection of a disturbance or a DFM™ relay failure, the top line displays an appropriate message, while the bottom line begins to auto-scroll present values. If a DFM™ relay failure results in the DFM™ relay being placed in a reduced operational mode, the top line displays an appropriate failure message and the bottom line enters its 'menu mode' by displaying the first main-menu option.

The user can terminate the automatic scrolling on the bottom line of the display by pressing any one of the UP, DN (DOWN), or ENTER pushbuttons. When the automatic scrolling stops, the first main-menu option of the menu structure appears on the bottom line. (Note that whatever is currently displayed on the top line remains there.) The UP, DN, and ENTER buttons are used to navigate in the menu mode. Pressing one of these buttons will result either in continued menu traversal or in the initiation of some action. (The DFM™ relay's menu structure is described in detail later in this section.) At any point in the user interaction period, if the user fails to push any button at all for 15 minutes, the display reverts to its idle mode, unless there is a current disturbance or a DFM™ relay failure.

All information on the display is the result of either the DFM™ relay's auto-scroll mode (feeder ID on top line, present values auto-scrolling on bottom line) or some button action, with the following four exceptions:

(1) The *INITIALIZING* message is displayed on the top line while the DFM™ relay is running power-on diagnostics and initializing during a power-up. This message is cleared as soon as initialization is complete.

(2) Disturbance information is displayed on the top line when a disturbance is detected.

(3) A *WARN* message is displayed on the top line when the DFM™ relay has discovered a non-critical self-test failure.

(4) A *FAIL* message is displayed on the top line when the DFM™ relay has discovered a critical self-test failure.

Except for the initialization message, these messages are displayed in a blinking mode on the top line. This distinguishes them from user-initiated displays and, more importantly, calls special attention to them.

With the exception of the *LOGON FAILURE* message, the *FAIL/WARN* messages have the formats *FAIL xxx: xxx* and *WARN xxx: xxx*, respectively, with the variable characters in each being a three-digit board abbreviation and a three-digit numeric code to indicate the nature of the failure. These messages remain blinking on the display until the condition causing the message is corrected, or until restart.

The user may select the STATUS option on the main menu to view a description of a current non-critical or critical failure. (Note that the DFM™ relay will continue to operate after a failure is detected only if the failure detected is not considered fatal to the system.) If the DFM™ relay continues to operate with a *FAIL* or *WARN* message blinking on the top display line, the user may press the ENTER button when STATUS is the menu option displayed on the bottom line, and pertinent status information will be displayed. TABLE 8-4 at the end of this section presents a sample button sequence that results in the retrieval of status information after two non-critical failure conditions have been detected. TABLE 8-5 and TABLE 8-6 present complete lists of the status messages that might appear on the display in the event of a critical or non-critical DFM™ relay failure, respectively.

If the user enters the second level of the menu structure while a *FAIL* or *WARN* message is blinking on the top line, the blinking message is overwritten by menu data. If the failure situation still exists when the user exits the second menu level and returns to the main-menu level, the *FAIL* or *WARN* message is restored to the top line. In the event that a disturbance occurs while a *FAIL* or *WARN* message is blinking, the entire top display line is overwritten with the disturbance message. Once the disturbance data has been cleared, if the failure situation still exists, the *FAIL* or *WARN* message is restored to the top line.

If a disturbance occurs, target information pertaining to the disturbance appears on the top line of the display, replacing whatever is currently displayed there. This target information has the following format: *TRG xxx xxx xx/xx/xx* where *TRG* indicates a trigger, and the rest of the formatting is made up of data specific to the triggering disturbance. An example of a disturbance message might be *TRG HIZ CG 12/03/93*. Target information for the most recent stored disturbances (maximum of 8) can be scrolled through on the bottom line if the user selects the DISTURBANCE DATA option on the main menu. The most recent of the disturbances appears first. If there is no valid disturbance information stored, the message *DISTURBANCE DATA: NO DISTURBANCES* is displayed.

The disturbance information on the top line remains displayed until the TARGET RESET button on the local MMI is pressed, until a reset command is received through the serial communications link, or until the external target reset contact (if configured) is energized. Upon reset, the top line reverts to whatever was displayed there before the disturbance occurred, and the affected LED indicators are turned off. The bottom line continues in its present mode (either auto-scroll mode or menu mode). If the user enters the second level of the menu structure while disturbance data is blinking, the disturbance data is overwritten by menu data and the blinking ceases temporarily. The disturbance data is restored to the top line in a blinking mode when the user exits the second menu level and returns to the main-menu level.

In the event that a DFM™ relay failure occurs while current fault data is blinking, no immediate change occurs in the top display line. Once the fault message is cleared, the appropriate *FAIL* or *WARN* message will then begin to blink on the top display line. In such a case, the LEDs related to the fault will remain lit as continued indicators, but the user will be required to enter the menu structure and select DISTURBANCE DATA to view the fault information.

LEDs

The six LEDs on the local MMI serve as monitoring indicators for various DFM™ relay and distribution feeder conditions. These LEDs are as follows:

POWER ON (green)
The POWER ON LED is turned on whenever power is applied to the DFM™ relay. It remains on as long as power is applied.

DOWNED CONDUCTOR (red)
The DOWNED CONDUCTOR LED is turned on when a downed conductor is detected on the feeder being monitored by the DFM™ relay. It remains on until a target reset occurs.

PHASE A (red)
The PHASE A LED is turned on if it is determined that there is an overcurrent, arcing, or downed-conductor condition involving Phase A of the feeder being monitored by the DFM™ relay. It remains on until a target reset occurs.

PHASE B (red)
The PHASE B LED is turned on if it is determined that there is an overcurrent, arcing, or downed-conductor condition involving Phase B of the feeder being monitored by the DFM™ relay. It remains on until a target reset occurs.

PHASE C (red)
The PHASE C LED is turned on if it is determined that there is an overcurrent, arcing, or downed-conductor condition involving Phase C of the feeder being monitored by the DFM™ relay. It remains on until a target reset occurs.

ALARM (yellow)
The ALARM LED is turned on if an alarm condition is present on either of the two alarm output contacts. TABLE 2-5 in the **CALCULATION OF SETTINGS** section describes the conditions that activate the alarm output contacts and also indicates the activation duration for each.

If the ALARM LED is on, selection of the ALARM DATA option on the DFM™ relay's main menu allows the user to view the condition(s) causing the alarm. Possible messages that might appear when the ALARM DATA option is selected are as follows:

ARCING DETECTED
ARCING SUSPECTED
BREAKER HEALTH
CNTRL OUTPT #1 FAIL
CNTRL OUTPT #2 FAIL
LOGIN FAILURE
NON-CRIT DFM FAILURE
THD ALARM (optional)
2-CYCLE RMS OC

UP and DN Pushbuttons

The UP and DN (DOWN) pushbuttons on the local MMI serve three purposes, all of which produce feedback on the display. Either may be pressed to terminate the automatic scrolling of present values on the bottom line of the display. If either is pressed while present values are auto-scrolling, the bottom display line enters its menu mode, with DATE/TIME being the first main-menu option displayed. The top display line is not affected by this button action.

Either the UP or DN pushbutton may be pressed to terminate the display's idle mode (blank display because no button has been touched for 15 minutes) and cause it to enter its auto-scroll mode (feeder ID on top, present values auto-scrolling on bottom). Finally, either the UP or DN pushbutton may be pressed to scroll through the main-menu options on the bottom display line or to scroll through the second-level data once a main-menu option has been selected.

Note that while the UP button scrolls in a "forward" direction, the DN button can be used to scroll "backward" through a list. For example, if the first main-menu option (DATE/TIME) were currently displayed on the bottom line, pressing the UP button would produce the second main-menu option (DEVICE PARAMETERS); pressing the UP button again would then produce the third main-menu option, etc. If the third main-menu option were currently displayed on the bottom line, pressing the DN button would produce the second main-menu option; pressing it again would produce the first main-menu option, etc.

When the user is scrolling through the main menu or through the second-level menu items via the UP button and gets to the last item in the list, pressing the UP button again will cause the first item to be displayed (wrap-around). Pressing the DN button when the first item in the list is displayed will likewise result in wrap-around from the first item to the last.

ENTER Pushbutton

The ENTER pushbutton on the local MMI produces feedback on the display in four different ways. As with the UP and DN buttons, the ENTER button may be pressed to terminate the automatic scrolling of present values on the bottom line of the display or to terminate the display's idle mode. In addition, the ENTER button is used to "select" a main-menu option or to exit the second menu level and return to the main menu.

Pressing the ENTER button to terminate the display's idle mode (blank display) results in the display entering its auto-scroll mode (feeder ID on top, present values auto-scrolling on bottom). Pressing the ENTER button to terminate auto-scrolling results in the bottom display line entering its menu mode, with DATE/TIME being the first main-menu option displayed. The top display line is not affected when the ENTER button is pressed to terminate auto-scrolling.

When the user is scrolling through the main-menu options via the UP and DN buttons and reaches the desired option, pressing the ENTER button will then produce the first second-level item associated with that option on the display (or initiate the action associated with that option in the case of the TEST MMI and RETURN TO SCROLL options). For example, if the user presses ENTER when the HI-Z SETTINGS option is displayed on the bottom line, *BELIEF-IN-ARC CONF:* will replace whatever is currently displayed on the top line, and the present value for the belief-in-arcing confidence sensitivity setting will replace *HI-Z SETTINGS* on the bottom line. The UP or DN pushbutton can then be used to scroll through the complete list of high-impedance settings.

If the user is scrolling through a list of second-level menu items and decides to return to the main menu, the ENTER button must be pressed. It is not necessary that the currently displayed second-level item be *RETURN TO MAIN MENU* when the ENTER button is pressed; exit can occur from any second-level element. For example, if the user is scrolling through the Hi-Z settings and presses the ENTER button, the HI-Z SETTINGS option will be restored to the bottom display line, and the top display line will either display the feeder ID, disturbance data, or a *FAIL* or *WARN* message, depending on the present state of the feeder being monitored and the present state of the DFM™ relay. Having returned to the main-menu level, the user may then use the UP or DN pushbutton to scroll through the main-menu options.

TARGET RESET Pushbutton

The TARGET RESET pushbutton on the local MMI is used to zero the disturbance data for the most recent disturbance, or to clear any latched alarms. This, in turn, clears blinking disturbance information from the top display line and turns off the alarm LED and any LEDs that were lit because of the disturbance or alarm condition. When the "targets" are reset in this manner, the information pertaining to the disturbance is not erased from the system memory. The disturbance information may be viewed by selecting the DISTURBANCE DATA option on the main menu; information pertaining to the most recent disturbance will be displayed first.

In addition to its primary purpose, the TARGET RESET button may also be pressed to terminate the display's idle mode (blank display), causing it to enter its auto-scroll mode (feeder ID on top, present values auto-scrolling on bottom). Note that pressing it will <u>not</u> terminate the automatic scrolling of present values on the bottom display line, as is the case with the other three pushbuttons.

Menu Structure

The menu structure implemented on the DFM™ relay's local MMI display provides the user access to information such as present values, peak data, configuration values, contact-converter (CC) states, and historical disturbance data. In addition, there are menu options to view the current date and time stored in the DFM™ relay, as well as the DFM™ relay model and EPROM version numbers and encrypted serial-communications passwords. DFM™ relay status and alarm messages provide information on the current state of the DFM™ relay and the feeder being monitored by the DFM™ relay, and current assignments for the configurable input and output contacts can be viewed. Action options allow the user to zero the peak values, zero the breaker-health values, initiate a self-test of the MMI, or initiate the auto-scrolling of present values on the display's bottom line.

The local MMI main-menu options are presented in their correct sequence in **Table 8-1**. The second-level menu items associated with each main-menu option are presented and described in **Table 8-2**, with the main-menu options listed in the first column and their associated second-level elements listed in the second column and described in the third column. Main-menu options that have actions associated with them, or that result in the display of variable numbers of second-level items, are explained in detail after the tables. In addition, sample key sequences are presented to illustrate how to navigate through the DFM™ relay's menu structure.

TABLE 8-1 and TABLE 8-2 apply to DFM™ relay models that include power-quality monitoring. For models that do not, the following differences should be noted:

(1) No THD values are included as submenu items under PRESENT VALUES.

(2) No minimum 2-second RMS average voltages are included as submenu items under PEAK VALUES.

(3) No POWER QUALITY DATA option appears on the main menu.

(4) No CURRENT THD THRESH or VOLTAGE THD THRESH submenu items appear under MONITORING SETTINGS.

(5) No alarm output contact can be configured for THD ALARM.

TABLE 8-1 and TABLE 8-2 apply to DFM™ relay models that include conventional instantaneous and time-overcurrent protection functions. For models that do not, the PROTECTION GROUP 1, 2, 3, and 4 menu items are not present.

Once the user has entered the DFM™ relay's main menu, the UP and DN pushbuttons control scrolling forward or backward, respectively, through the main-menu options. The ENTER button must be pressed to enter the second level for a particular main-menu option, then the UP and DN buttons may again be used to scroll through the list of second-level elements. From the second menu level, the ENTER button may be pressed at any time to return to the main menu.

TABLE 8-1 MAIN MENU OPTIONS

DATE/TIME
DEVICE PARAMETERS
STATUS
ALARM DATA
PRESENT VALUES
BREAKER HEALTH
CONTACT INPUTS
DISTURBANCE DATA
PEAK VALUES
POWER QUALITY DATA
GENERAL SETTINGS
HARDWARE SETTINGS
CONTACT SETTINGS
MONITORING SETTINGS
HI-Z GROUP 1
HI-Z GROUP 2
HI-Z GROUP 3
HI-Z GROUP 4
PROTECTION GROUP 1
PROTECTION GROUP 2
PROTECTION GROUP 3
PROTECTION GROUP 4
RESET PEAK VALUES
RESET BREAKER HEALTH
CHANGE FRONT BAUD
CHANGE REAR BAUD
TEST MMI
RETURN TO SCROLL

TABLE 8-2 SECOND LEVEL MENU STRUCTURE

MAIN MENU	SECOND LEVEL ELEMENTS	DESCRIPTIONS
DATE/TIME	DATE AND TIME: *xx/xx/xx xx:xx:xx*	Month/Day/Year followed by Hours:Minutes:Seconds
	RETURN TO MAIN MENU	Return to DATE/TIME on main menu
DEVICE PARAMETERS	DFM MODEL #: *xxxxxxxxxxxxxxx*	DFM™ relay model number
	EPROM VERSION #: *xxxxxxxxxxxxxxx*	EPROM version number
	DFM SERIAL ID: *xxxxxxxxxx*	DFM™ relay serial number

TABLE 8-2 SECOND LEVEL MENU STRUCTURE (CONTINUED)

MAIN MENU	SECOND LEVEL ELEMENTS	DESCRIPTIONS
DEVICE PARAMETERS (continued)	VIEWING PASSWORD: *xxxxxxxxxxxxxxx*	View-only communications password (encrypted) [see TABLE 8-8]
	SETTING PASSWORD: *xxxxxxxxxxxxxxx*	View/change settings communications password (encrypted) [see TABLE 8-8]
	CONTROL PASSWORD: *xxxxxxxxxxxxxxx*	Contact control communications password (encrypted) [see TABLE 8-8]
	STATION ID: *xxxxxxxxxxxxxxxxxxx*	Alphanumeric identification of substation (up to twenty characters)
	FEEDER ID: *xxxxxxxxxxxxxxxxxxx*	Alphanumeric identification of distribution feeder being monitored (up to twenty characters)
	CONTACT CONVERTR ID: *xxxxxxxxxxxxxxxxxx*	Alphanumeric identification of substation event logged when CC is assigned to be TIME-TAG-STORE (see TABLE 2-3 in the **CALCULATION OF SETTINGS** section)
	RETURN TO MAIN MENU	Return to DEVICE PARAMETERS on main menu
STATUS	STATUS: OK	Displayed if DFM™ relay is working properly and monitoring the feeder
	- or -	
	STATUS: FAIL *x* of *x* *xxxxxxxxxxxxxxxxxx*	Running count of FAIL messages displayed on top line; description of critical failure displayed on bottom line (may be multiple FAIL messages)
	- and / or -	

TABLE 8-2 SECOND LEVEL MENU STRUCTURE (CONTINUED)

MAIN MENU	SECOND LEVEL ELEMENTS	DESCRIPTIONS
STATUS (continued)	STATUS: WARN *x* of *x* *xxxxxxxxxxxxxxxxxx*	Running count of WARN messages displayed on top line; description of non-critical failure displayed on bottom line (may be multiple WARN messages)
	- and / or -	
	STATUS: DISABLED OUTPUTS	Displayed if the output contacts have been disabled by the serial communications or via a contact-converter input
	RETURN TO MAIN MENU	Return to STATUS on main menu
ALARM DATA	ALARM DATA: NO ALARMS	Displayed if there are no current alarm conditions
	- or -	
	ALARM DATA: *x* of *x* *xxxxxxxxxxxxxxxxxx*	Running count of alarms displayed on top line; descriptive string of a current alarm condition displayed on bottom line (may have as many messages as there are configured alarms)
	RETURN TO MAIN MENU	Return to ALARM DATA on main menu
PRESENT VALUES	PHASE A CURRENT: *xxx.xx* A *	Phase A current present value
	PHASE B CURRENT: *xxx.xx* A *	Phase B current present value
	PHASE C CURRENT: *xxx.xx* A *	Phase C current present value
	NEUTRAL CURRENT: *xxx.xx* A *	Neutral current present value
	PHASE A VOLTAGE: *xxx.x* V *	Phase A voltage present value

* See note at end of table.

TABLE 8-2 SECOND LEVEL MENU STRUCTURE (CONTINUED)

MAIN MENU	SECOND LEVEL ELEMENTS	DESCRIPTIONS
PRESENT VALUES (continued)	PHASE B VOLTAGE: *xxx.x* V *	Phase B voltage present value
	PHASE C VOLTAGE: *xxx.x* V *	Phase C voltage present value
	PHASE A WATTS: ±*xxxxx.x* *	Phase A watts present value
	PHASE B WATTS: ±*xxxxx.x* *	Phase B watts present value
	PHASE C WATTS: ±*xxxxx.x* *	Phase C watts present value
	TOTAL WATTS: ±*xxxxx.x* *	Total watts present value
	PHASE A VARs: ±*xxxxx.x* *	Phase A VARs present value
	PHASE B VARs: ±*xxxxx.x* *	Phase B VARs present value
	PHASE C VARs: ±*xxxxx.x* *	Phase C VARs present value
	TOTAL VARs: ±*xxxxx.x* *	Total VARs present value
	3-PHASE VA: *xxxxx.x* *	3-phase volt-amperes present value
	PHASE A PWR FACTOR: ±*x.xxx*	Phase A power factor present value
	PHASE B PWR FACTOR: ±*x.xxx*	Phase B power factor present value
	PHASE C PWR FACTOR: ±*x.xxx*	Phase C power factor present value
	3-PHASE PWR FACTOR: ±*x.xxx*	3-phase power factor present value
	PHASE A CURRENT THD: *xx.x* %	Phase A current THD present value
	PHASE B CURRENT THD: *xx.x* %	Phase B current THD present value

* See note at end of table.

TABLE 8-2 SECOND LEVEL MENU STRUCTURE (CONTINUED)

MAIN MENU	SECOND LEVEL ELEMENTS	DESCRIPTIONS
PRESENT VALUES (continued)	PHASE C CURRENT THD: *xx.x %*	Phase C current THD present value
	PHASE A VOLTAGE THD: *xx.x %*	Phase A voltage THD present value
	PHASE B VOLTAGE THD: *xx.x %*	Phase B voltage THD present value
	PHASE C VOLTAGE THD: *xx.x %*	Phase C voltage THD present value
	PHASE A TOC PICKUP: *xx.xx* A	Phase A TOC pickup setting for active settings group
	PHASE B TOC PICKUP: *xx.xx* A	Phase B TOC pickup setting for active settings group
	PHASE C TOC PICKUP: *xx.xx* A	Phase C TOC pickup setting for active settings group
	GROUND TOC PICKUP: *xx.xx* A	Ground TOC pickup setting for active settings group
	RETURN TO MAIN MENU	Return to PRESENT VALUES on main menu
BREAKER HEALTH	PHASE A BH ACCUM: *xxxxxxxx.xx* It/I2t *	Phase A breaker-health accumulation
	PHASE B BH ACCUM: *xxxxxxxx.xx* It/I2t *	Phase B breaker-health accumulation
	PHASE C BH ACCUM: *xxxxxxxx.xx* It/I2t *	Phase C breaker-health accumulation
	TOTAL BRKR TRIPS: *xxxxx*	Running count of number of breaker operations
	RETURN TO MAIN MENU	Return to BREAKER HEALTH on main menu
CONTACT INPUTS	CC 1 STATUS: *xxxxxxxxx - xxxxxx*	Identification -- state of the first contact converter (State can be ON or OFF, OPEN or CLOSED, NORM or ALT, or TRG or OFF, depending on the configuration)

* See note at end of table.

TABLE 8-2 SECOND LEVEL MENU STRUCTURE (CONTINUED)

MAIN MENU	SECOND LEVEL ELEMENTS	DESCRIPTIONS
CONTACT INPUTS (continued)	CC 2 STATUS: *xxxxxxxxx - xxxxxx*	Identification -- state of the second contact converter (State can be ON or OFF, OPEN or CLOSED, NORM or ALT, or TRG or OFF, depending on the configuration)
	CC 3 STATUS: *xxxxxxxxx - xxxxxx*	Identification -- state of the third contact converter (State can be ON or OFF, OPEN or CLOSED, NORM or ALT, or TRG or OFF, depending on the configuration)
	RETURN TO MAIN MENU	Return to CONTACT INPUTS on main menu
DISTURBANCE DATA	DISTURBANCE DATA: NO DISTURBANCES	Displayed if there is no stored oscillography data for disturbances
	- or -	
	DISTURBANCE *x*: *xxx xxx xx/xx xx:xx*	Disturbance number displayed on top line, with "1" being the most recent; disturbance data displayed on bottom line. Example: DISTURBANCE 1: HIZ AG 12/03 15:30 (High-impedance fault occurred from phase A to ground on December 3rd at 3:30 p.m.)
	RETURN TO MAIN MENU	Return to DISTURBANCE DATA on main menu
PEAK VALUES	PEAK Ia: *xxx.xx* A * *xx/xx/xx xx:xx:xx*	Peak Phase A current value and associated date and time
	PEAK Ib: *xxx.xx* A * *xx/xx/xx xx:xx:xx*	Peak Phase B current value and associated date and time
	PEAK Ic: *xxx.xx* A * *xx/xx/xx xx:xx:xx*	Peak Phase A current value and associated date and time

* See note at end of table

8

TABLE 8-2 SECOND LEVEL MENU STRUCTURE (CONTINUED)

MAIN MENU	SECOND LEVEL ELEMENTS	DESCRIPTIONS
PEAK VALUES (continued)	PEAK In: *xxx.xx* A * *xx/xx/xx xx:xx:xx*	Peak neutral current value and associated date and time
	3-PH VA: *xxxxx.x* * *xx/xx/xx xx:xx:xx*	Maximum 3-phase VA value and associated date and time
	3-PH WATTS: ±*xxxxx.x* * *xx/xx/xx xx:xx:xx*	Maximum magnitude signed 3-phase W value and associated date and time
	3-PH VARs: ±*xxxxx.x* * *xx/xx/xx xx:xx:xx*	Maximum magnitude signed 3-phase VAR value and associated date and time
	MIN 3-PH PF: ±*x.xxx* *xx/xx/xx xx:xx:xx*	Minimum 3-phase power factor value and associated date and time
	RETURN TO MAIN MENU	Return to PEAK DEMAND VALUES on main menu
POWER QUALITY DATA	PEAK Ia THD: *xx.x* % *xx/xx/xx xx:xx:xx*	Phase A current THD maximum and its associated date and time
	PEAK Ib THD: *xx.x* % *xx/xx/xx xx:xx:xx*	Phase B current THD maximum and its associated date and time
	PEAK Ic THD: *xx.x* % *xx/xx/xx xx:xx:xx*	Phase C current THD maximum and its associated date and time
	PEAK Va THD: *xx.x* % *xx/xx/xx xx:xx:xx*	Phase A voltage THD maximum and its associated date and time
	PEAK Vb THD: *xx.x* % *xx/xx/xx xx:xx:xx*	Phase B voltage THD maximum and its associated date and time
	PEAK Vc THD: *xx.x* % *xx/xx/xx xx:xx:xx*	Phase C voltage THD maximum and its associated date and time
	MIN 2s Va: *xxx.x* V * *xx/xx/xx xx:xx:xx*	Minimum Phase A two-second average RMS voltage value and associated date and time

*See note at end of table

TABLE 8-2 SECOND LEVEL MENU STRUCTURE (CONTINUED)

MAIN MENU	SECOND LEVEL ELEMENTS	DESCRIPTIONS
POWER QUALITY DATA (continued)	MIN 2s Vb: *xxx.xx* V * *xx/xx/xx xx:xx:xx*	Minimum Phase B two-second average RMS voltage value and associated date and time
	MIN 2s Vc: *xxx.xx* V * *xx/xx/xx xx:xx:xx*	Minimum Phase C two-second average RMS voltage value and associated date and time
	RETURN TO MAIN MENU	Return to PEAK THD VALUES on main menu
GENERAL SETTINGS	DFM UNIT ID: *xxxx*	A unique numerical identifier for each DFM™ relay
	PHASE CT RATIO: *xxxx*	Ratio of phase primary to secondary amps
	GROUND CT RATIO: *xxxx*	Ratio of ground primary to to secondary amps
	PT RATIO: *xxxx*	Ratio of primary to secondary volts
	FRONT PORT SETTINGS: *xxxxx yyyy z*	Communications settings for front serial port xxxxx = baud rate yyyy = parity z = stop bits
	REAR PORT SETTINGS: *xxxxx yyyy z*	Communications settings for rear serial port
	SYSTEM FREQUENCY: *xx* Hz	System frequency: 50 Hz or 60 Hz
	SETTINGS FILE: *xxxxxxx*	GROUP 1, GROUP 2, GROUP 3, GROUP 4
	PHASE DESIGNATION: *x-x-x*	Phase rotation: A-B-C or A-C-B
	PHASE POTENTIAL: *x-x*	Voltage connection: L-N or L-L
	DISPLAYED VALUES: *xxxxxxxx*	SECONDARY if secondary values are to be displayed; PRIMARY for primary values

TABLE 8-2 SECOND LEVEL MENU STRUCTURE (CONTINUED)

MAIN MENU	SECOND LEVEL ELEMENTS	DESCRIPTIONS
GENERAL SETTINGS (continued)	FRONT PANEL RESETS: *xxxxxxxxxx*	Indication of whether or not breaker-health and peak-demand resets are allowed through the local MMI: NOT ALLOWED or ALLOWED
	CONFIGURED CTs: *xxxx*	Configured currents (ABCN if all are configured)
	CONFIGURED PTs: *xxx*	Configured voltages (ABC if all are configured)
	LOGIN TIMEOUT: *xx*	Time interval of no serial link activity after which the DFM™ relay automatically logs out from DFM-LINK
	RETURN TO MAIN MENU	Return to GENERAL SETTINGS on main menu
HARDWARE SETTINGS	REMOTE BREAKER OP: *xxxxxxxxxx*	Remote breaker operation indicator: NOT ALLOWED or ALLOWED
	REMOTE CONFIG: *xxxxxxxxxx*	Remote configuration indicator: NOT ALLOWED or ALLOWED
	CT RATING: *xxxx-xxx*	Nominal rating of the CT on the magnetics module: FIVE-AMP or ONE-AMP
	RETURN TO MAIN MENU	Return to HARDWARE SETTINGS on main menu
CONTACT SETTINGS	OUTPUT #1: *x* of *x* *xxxxxxxxxxxxxxxxxx*	Present assignment of OUTPUT #1 contact (may have multiple activation states)
	OUTPUT #2: *x* of *x* *xxxxxxxxxxxxxxxxxx*	Present assignment of OUTPUT #2 contact (may have multiple activation states)
	OUTPUT #3: *x* of *x* *xxxxxxxxxxxxxxxxxx*	Present assignment of OUTPUT #3 contact (may have multiple activation states)

TABLE 8-2 SECOND LEVEL MENU STRUCTURE (CONTINUED)

MAIN MENU	SECOND LEVEL ELEMENTS	DESCRIPTIONS
CONTACT SETTINGS (continued)	OUTPUT #4: *x* of *x* *xxxxxxxxxxxxxxxxxx*	Present assignment of OUTPUT #4 contact (may have multiple activation states)
	OUTPUT #5: *x* of *x* *xxxxxxxxxxxxxxxxxx*	Present assignment of OUTPUT #5 contact (may have multiple activation states)
	CC 1 CONFIGURATION: *xxxxxxxxxxxxxxxxxx*	Present assignment of the first contact-converter input
	CC 2 CONFIGURATION: *xxxxxxxxxxxxxxxxxx*	Present assignment of the second contact-converter input
	CC 3 CONFIGURATION: *xxxxxxxxxxxxxxxxxx*	Present assignment of the third contact-converter input
	CNTRL CKT MONITORS: *xxxxxxxxxxxxxxxxxx*	Configuration of the monitoring of Control Output #1 or Control Output #2 circuitry
	RETURN TO MAIN MENU	Return to CONTACT SETTINGS on main menu
MONITORING SETTINGS	BRKR HEALTH THRESH: *xxxxxxxx.xx* It/I2t *	Breaker-health threshold
	CURRENT THD THRESH: *xx.x* %	Current THD threshold value
	VOLTAGE THD THRESH: *xx.x* %	Voltage THD threshold value
	# DISTURBANCE RPTS: *x*	Number of disturbances for which oscillography is presently stored
	BREAKER ARC TIME: *xxx* ms	Time allowed for breaker to operate
	BRKR HEALTH UNITS: *xxxxxxxxxxxxxxxxxx*	Breaker-health measurement units (AMP* SECONDS or AMP SQUARED* SECONDS)

* See note at end of table

TABLE 8-2 SECOND LEVEL MENU STRUCTURE (CONTINUED)

MAIN MENU	SECOND LEVEL ELEMENTS	DESCRIPTIONS
MONITORING SETTINGS (continued)	DEMAND PERIOD: *xx* min	Calculation time interval for demand data storage (15, 30, or 60 minutes)
	RETURN TO MAIN MENU	Return to MONITORING SETTINGS on main menu
HI-Z GROUP 1	ARCING SENSITIVITY: *xx*	Belief-in-arcing confidence level sensitivity and arc-detection sensitivity
	PHASE EVENT COUNT: *xxx*	Number of phase events that define a trend
	GROUND EVENT COUNT: *xxx*	Number of ground events that define a trend
	EVENT COUNT TIME: *xxx* min	Time period for event count
	OC COORD TIMEOUT: *xxx* s	Overcurrent coordination timeout period
	PCHZ (PHASE OC): *xx.xx* A	Phase 2-cycle RMS overcurrent threshold
	GCHZ (GROUND OC): *xx.xx* A	Ground 2-cycle RMS overcurrent threshold
	PHASE RATE OF CHNGE: *xxx* amps/2 cycles	Phase current rate-of-change threshold
	GROUND RATE OF CHNG: *xxx* amps/2 cycles	Ground current rate-of-change threshold
	LOSS OF LOAD THRESH: *xxx* %	Loss-of-load threshold
	3-PH EVENT THRESH: *xxx*	3-phase event threshold
	HI-Z MONITORING: *xxx*	Set HI-Z detection to be ON or OFF
	RETURN TO MAIN MENU	Return to HI-Z SETTINGS on main menu
HI-Z GROUP 2 HI-Z GROUP 3 HI-Z GROUP 4	(GROUP 2, 3, and 4 identical to GROUP 1)	

TABLE 8-2 SECOND LEVEL MENU STRUCTURE (CONTINUED)

MAIN MENU	SECOND LEVEL ELEMENTS	DESCRIPTIONS
PROTECTION GROUP 1	PHASE TOC CURVE: *xx*	Phase TOC curve selection
	GROUND TOC CURVE: *xx*	Ground TOC curve selection
	PHASE TOC PICKUP: *xx.xx*	Phase TOC pickup setting (secondary amps)
	GROUND TOC PICKUP: *xx.xx*	Ground TOC pickup setting (secondary amps)
	PHASE TIME DIAL: *xx.xx*	Phase time-dial setting
	PHASE DEFINITE TIME: *xx.xx*	Phase definit time setting (seconds)
	GROUND TIME DIAL: *xx.xx*	Ground time-dial setting
	GRND DEFINITE TIME: *xx.xx*	Ground definite-time setting (seconds)
	IOC LOW PHASE: *xx.xx*	Phase IOC LOW setting (secondary amps)
	IOC HIGH PHASE: *xx.xx*	Phase IOC HIGH setting (secondary amps)
	IOC LOW GROUND: *xx.xx*	Ground IOC LOW setting (secondary amps)
	IOC HIGH GROUND: *xx.xx*	Ground IOC HIGH setting (secondary amps)
	IOC LOW PHASE DELAY: *xxx* ms	Phase IOC LOW delay (milliseconds)
	IOC HI PHASE DELAY: *xx* ms	Phase IOC HIGH delay (millisenconds)
	IOC LOW GRND DELAY: *xxx* ms	Ground IOC LOW delay (milliseconds)
	IOC HI GRND DELAY: *xx* ms	Ground IOC HIGH delay (milliseconds)
	PHASE AVERAGING PD: *xxx* s	Phase averaging period (seconds)

TABLE 8-2 SECOND LEVEL MENU STRUCTURE (CONTINUED)

MAIN MENU	SECOND LEVEL ELEMENTS	DESCRIPTIONS
PROTECTION GROUP 1 (continued)	PHASE ADAPTIVE: *xxx %*	Phase adaptive multiplier (percent)
	MIN PHASE ADAPTIVE: *xxx %*	Phase adaptive minimum value (percent)
	MAX PHASE ADAPTIVE: *xxx %*	Phase adaptive maximum value (percent)
	GROUND AVERAGING PD: *xx* s	Ground averaging period (seconds)
	GROUND ADAPTIVE: *xxx %*	Ground adaptive multiplier (percent)
	MIN GRND ADAPTIVE: *xxx %*	Ground adaptive minimum value (percent)
	MAX GRND ADAPTIVE: *xxx %*	Ground adaptive maximum value (percent)
	TOC RESET OPTION: *x*	Phase and gound TOC reset characteristic selection
	COLD LOAD PICKUP: *xx* min	Minutes that Cold Load Pickup settings are in effect
	PH TOC PROTECTION: *xxx*	Set Phase TOC to be ON or OFF
	PH HIGH IOC PROT: *xxx*	Set Phase IOC HIGH to be ON or OFF
	PHASE LOW IOC PROT: *xxx*	Set Phase IOC LOW to be ON or OFF
	GRND TOC PROTECTION: *xxx*	Set Ground TOC to be ON or OFF
	GRND HIGH IOC PROT: *xxx*	Set Ground IOC HIGH to be ON or OFF
	GRND LOW IOC PROT: *xxx*	Set Ground IOC LOW to be ON or OFF
	RETURN TO MAIN MENU	Return to PROTECTION GROUP 1 on main menu
PROTECTION GROUP 2 PROTECTION GROUP 3 PROTECTION GROUP 4	(GROUP 2, 3, and 4 identical to GROUP 1)	

TABLE 8-2 SECOND LEVEL MENU STRUCTURE (CONTINUED)

MAIN MENU	SECOND LEVEL ELEMENTS	DESCRIPTIONS
RESET PEAK VALUES	RESET PEAKS: NO?	Prompt to allow user to "undo" a request to reset the peak demands (Automatic return to RESET PEAK DEMANDS on main menu)
	RESET PEAKS: YES?	Prompt to make sure user does indeed want to reset the peak demands (Automatic return to RESET PEAK DEMANDS on main menu after message *PEAK DEMANDS WERE RESET* is displayed)
RESET BREAKER HEALTH	RESET BRKR HEALTH: NO?	Prompt to allow user to "undo" a request to reset the breaker-health values (Automatic return to RESET BREAKER HEALTH on main menu)
	RESET BRKR HEALTH: YES?	Prompt to make sure user does indeed want to reset the breaker-health values (Automatic return to RESET BRKR HEALTH on main menu after message *BRKR HEALTH VALUES WERE RESET* is displayed)
CHANGE FRONT BAUD	FRONT PORT SETTINGS: *1200 y 8 z* *2400 y 8 z* *4800 y 8 z* *9600 y 8 z* *19200 y 8 z* *NO CHANGE - CANCEL*	Set front-port baud rate (only baud rate may be set - other values displayed for information only) y = parity z = stop bits

TABLE 8-2 SECOND LEVEL MENU STRUCTURE (CONTINUED)

MAIN MENU	SECOND LEVEL ELEMENTS	DESCRIPTIONS
CHANGE REAR BAUD	REAR PORT SETTINGS: *1200 y 8 z* *2400 y 8 z* *4800 y 8 z* *9600 y 8 z* *19200 y 8 z* *NO CHANGE - CANCEL*	Set rear-port baud rate (only baud rate may be set - other values displayed for information only) y = parity z = stop bits
TEST MMI	N/A	Initiates self-test of MMI (Automatic return to TEST MMI on main menu after message *SELF-TEST OF MMI COMPLETE* is displayed)
RETURN TO SCROLL	N/A	Initiates auto-scrolling of present values on bottom line

* **Note:** Formats presented for currents, voltages, watts, VARs, and VA assume the use of secondary values. A primary formatting will be used for these values if primary values are to be displayed. Primary formatting for currents is *xxxx* A; for voltages *xxx.xx* V; for watts, VARs, and VA, *xxxx.x*, with labels of 'K' or 'M' added if values are large enough to be converted to thousands or millions, respectively. Breaker-health values may be labeled as either I^2t or It, depending on the configuration setting for breaker-health units.

Action Menu Options

All but the last four main-menu options in TABLE 8-1 and TABLE 8-2 are used for the display of information. Selecting any of the last six options, however, will result in some action being taken that will either alter some of the DFM™ relay data/settings or change the state of the DFM™ relay user interface. These six menu options are RESET PEAK VALUES, RESET BREAKER HEALTH, CHANGE FRONT BAUD, CHANGE REAR BAUD, TEST MMI, and RETURN TO SCROLL.

RESET PEAK VALUES

The RESET PEAK VALUES option is used to zero the peak data and store the present time in all peak timestamps. If the ENTER button is pressed while the RESET PEAK VAULES option is displayed, the following message appears on the display:

RESET PEAKS:
NO?

If the user does not want to reset the peak data, pressing the ENTER button at this point will cause a return to the main-menu level, with RESET PEAK VALUES being the currently displayed option. If, however, the user does want to reset the peak data, pressing either the UP or DN button at this point will produce the following message:

RESET PEAKS:
YES?

Pressing the ENTER button when this message is displayed indicates that the user does indeed wish to reset the peak data. Pressing either the UP or DN button at this point, on the other hand, restores the *RESET PEAKS: NO?* message, and subsequent presses of UP or DN will toggle back and forth between the "YES" and "NO" reset messages.

If the user presses the ENTER button when *RESET PEAKS: YES?* is displayed, and local MMI resets are not allowed in the present configuration, the following message appears momentarily on the display:

FRONT PANEL RESETS
NOT ALLOWED

After a few seconds, the display automatically reverts to the main-menu level, with RESET PEAK VALUES being the currently displayed option.

If local MMI resets are allowed in the present configuration, the peak-demand values are all zeroed and the present time is stored in all the peak-demand timestamps. The message *PEAK VALUES WERE RESET* appears momentarily on the display, and then the display automatically reverts to the main-menu level with RESET PEAK VALUES being the currently displayed option.

If the user successfully resets the peaks from the local MMI, scrolling through the main menu with the UP or DN button and selecting the PEAK VALUES option (and PEAK THD VALUES option for models that include power-quality monitoring) will enable the user to view the current peak-demand values and verify that they are all now zero and that the peak-demand times have all been set to the present time.

RESET BREAKER HEALTH

The RESET BREAKER HEALTH option is used to zero the breaker-health data. If the ENTER button is pressed while the RESET BREAKER HEALTH option is displayed, the following message appears on the display:

RESET BRKR HEALTH:
NO?

If the user does not want to reset the breaker-health data, pressing the ENTER button at this point will cause a return to the main-menu level, with RESET BREAKER HEALTH being the currently displayed option. If, however, the user does want to reset the breaker-health data, pressing either the UP or DN button at this point will produce the following message:

RESET BRKR HEALTH:
YES?

Pressing the ENTER button when this message is displayed indicates that the user does indeed wish to reset the breaker-health data. Pressing either the UP or DN button at this point, on the other hand, restores the *RESET BRKR HEALTH: NO?* message, and subsequent presses of UP or DN will toggle back and forth between the "YES" and "NO" reset messages.

If the user presses the ENTER button when *RESET BRKR HEALTH: YES?* is displayed, and local MMI resets are not allowed in the present configuration, the following message appears momentarily on the display:

FRONT PANEL RESETS
NOT ALLOWED

After a few seconds, the display automatically reverts to the main-menu level, with RESET BREAKER HEALTH being the currently displayed option.

If local MMI resets are allowed in the present configuration, the breaker-health accumulators and number of trips are all zeroed in the capacitor-backed RAM. The message *BRKR HEALTH VALUES WERE RESET* appears momentarily on the display, and then the display automatically reverts to the main-menu level with RESET BREAKER HEALTH being the currently displayed option.

If the user successfully resets the breaker-health values from the local MMI, scrolling to and selecting the BREAKER HEALTH option will enable the user to view the current breaker-health values and verify that they have all been zeroed.

CHANGE FRONT BAUD

This menu option allows the user to change the baud-rate setting of the serial port located on the front panel. Note that the parity and number of stop bits cannot be changed here, but the existing settings are shown. If the ENTER button is pressed while the CHANGE FRONT BAUD option is displayed, the following message appears on the display:

FRONT PORT SETTINGS:
1200 N 8 1

Pressing the UP key at this point will display the next baud-rate selection (see Table 8-2 for the subsequent menu choices). When the desired baud rate (assume 9600) is displayed, pressing ENTER results in the following message on the display:

FRONT BAUD = 9600
NO?

Pressing ENTER at this point will cause a return to CHANGE FRONT BAUD without changing the baud rate. If the UP or DN key is pressed instead, the following message will appear on the display:

FRONT BAUD = 9600
YES?

Pressing ENTER at this point will change the baud rate to 9600 and cause a return to CHANGE FRONT BAUD.

CHANGE REAR BAUD

This menu option allows the user to change the baud-rate setting of the serial port located on the rear panel. The menu selections are similar to those described above under CHANGE FRONT BAUD.

TEST MMI

The TEST MMI self-test option is included in the local MMI main menu to offer a means of testing the local MMI display, TARGET RESET button, and LEDs. Selection of this option puts the DFM™ relay in an interactive mode whereby testing of the local MMI's various components is performed by the user. Power system monitoring is continued throughout these testing procedures.

If the ENTER button is pressed while the TEST MMI option is displayed, the entire display (all 20 character positions of both the top and bottom lines) is lit for 4 seconds, enabling the user to verify that all the display segments are working. After four seconds, the following message appears on the top line of the display to prompt the user to press the TARGET RESET button:

PRESS
TARGET RESET BUTTON

If the user then presses the TARGET RESET button, and it is determined internally that the TARGET RESET button was pressed, the following message will appear on the display:

LEDs SHOULD BLINK
*** CHECK PLEASE ***

All the LEDs should then commence blinking and continue blinking for four seconds, enabling the user to verify that all the LEDs are working properly. At the end of four seconds, the message *SELF-TEST OF MMI COMPLETE* momentarily appears on the display, and then the bottom line automatically reverts to the main-menu level with TEST MMI being the currently displayed option. The top display line and the LEDs assume their present states, which are determined by their states prior to the self-test and by what (if any) events occurred during the self-test procedure.

If, after the user is prompted to press the TARGET RESET button, one minute passes without the button press being "read" correctly by the device, it is concluded that there is a TARGET RESET button failure. The message *TARGET RESET BUTTON FAILURE* appears momentarily on the display, and then the bottom line of the display automatically reverts to the main-menu level with TEST MMI being the currently displayed option. The top display line and the LEDs will assume their present states just as if the MMI test had concluded successfully.

No specific button test for the UP, DN, or ENTER buttons is incorporated into the TEST MMI option, because those buttons are tested on a continuous basis any time the user interacts with the local MMI.

RETURN TO SCROLL

The RETURN TO SCROLL option on the local MMI main menu forces the bottom display line into its auto-scroll mode, in which present values scroll automatically. The top display line is not affected by the selection of this menu option.

Message List Menu Options

Selection of four particular DFM™ relay main-menu options results in the display of itemized information, which varies in number depending on the current DFM™ relay and distribution feeder conditions. These four options are STATUS, ALARM DATA, DISTURBANCE DATA, and CONTACT SETTINGS.

STATUS

If the DFM™ relay is working properly and monitoring the feeder, selection of the STATUS option results in the following display:

STATUS:
OK

If, however, a non-critical or critical failure has been detected and persists even after rebooting, selection of the STATUS option produces one or more status messages. One message is displayed for each detected failure. It is possible that both critical and non-critical failure conditions exist simultaneously. If such is the case, critical-failure messages appear first, followed by non-critical failure messages.

If the DFM™ relay's output contacts have been disabled, the following message appears under the status option:

STATUS:
DISABLED OUTPUTS

If critical and/or non-critical failure conditions exist and the output contacts have been disabled, the *STATUS: DISABLED OUTPUTS* message is displayed after the failure messages when the STATUS option is selected.

TABLE 8-4 presents a situation in which two non-critical failures have been detected and defines one possible button sequence for accessing the associated status messages (assuming the bottom display line is currently auto-scrolling present values). The actual messages that are displayed, as can be seen in TABLE 8-4, are as follows:

STATUS: WARN 1 of 2
PRC: RESET LOCKOUT

STATUS: WARN 2 of 2
ANI: VOLT INPUT CHAN

For the critical and non-critical failure status messages, a running count will appear on the top line to inform the user of how many of that type message to expect (1 of 4, 2 of 4, ...). The first three letters of the bottom line indicate the circuit board on which the failure occurred, and this prefix is followed by a brief description of the nature of the failure. Complete lists of possible status conditions that might appear on the bottom line in critical and non-critical failure messages are presented in TABLE 8-5 and TABLE 8-6, respectively.

ALARM DATA

If there are no current alarm conditions, selection of the ALARM DATA option produces:

ALARM DATA:
NO ALARMS

If, however, one or more alarm conditions do currently exist, selection of the ALARM DATA option produces one or more alarm messages in the following format:

ALARM DATA: *x* of *x*
xxxxxxxxxxxxxxxxxx

For any alarm message other than *ALARM DATA: NO ALARMS*, a running count appears on the top line to inform the user how many alarm messages to expect (1 of 3, 2 of 3, etc.). The bottom line will be a brief description of the nature of the alarm. The possible descriptions that may appear on the bottom line of an alarm message correspond to the possible alarm-output-contact assignments, which are presented in TABLE 2-4 in the **CALCULATION OF SETTINGS** section.

As an example of an alarm data display, assume that a breaker-health accumulator has exceeded the breaker-health threshold, and that one of the alarm-output contacts is configured for a breaker-health alarm. Selection of the ALARM DATA main-menu option would result in the following display:

ALARM DATA: 1 of 1
BREAKER HEALTH

DISTURBANCE DATA

If there is no stored disturbance data, selection of the DISTURBANCE DATA option produces:

DISTURBANCE DATA:
NO DISTURBANCES

If, however, data is stored for one or more disturbances, selection of the DISTURBANCE DATA option produces one or more disturbance messages in the following format:

DISTURBANCE *x*:
xxx xxx xx/xx xx:xx

The variable on the top line is an integer used to order the disturbances from the most recent to the oldest. Depending on the current configuration, there may be from one to eight sets of disturbance data stored. The most recent disturbance is labeled *DISTURBANCE 1:* on the top line, and the disturbances listed progress in backwards chronological order from there.

The bottom line of the disturbance message contains pertinent information related to a disturbance. The first set of characters is either *HIZ* or *OC*, indicating either a high-impedance or an overcurrent disturbance, respectively. The second set of characters can be either A, B, C, N,

ABG, ..., 3-PH, indicating the phases identified as being involved in the disturbance. The last two sets of characters are the month/day and hour:minute that the disturbance occurred.

The following is a sample display that might appear upon selection of the DISTURBANCE DATA option:

DISTURBANCE 1:
HIZ A 12/03 15:30

This message should be interpreted as meaning that a high-impedance disturbance occurred on Phase A on December 3rd at 3:30 p.m.

CONTACT SETTINGS

Selection of the CONTACT SETTINGS main-menu option results in the display of the current configurations for the three digital inputs and the four configurable output contacts. Each of the three contact-converter inputs is configurable to one and only one input activation state at any given time. Each of the four configurable output contacts, on the other hand, may have multiple output activation states in its configuration at the same time, and it is possible for both control output contacts or both alarm output contacts to have the same activation states in their configurations. Thus, a running count is used in the display of the output-contact configurations to inform the user of how many activation states to expect for the present configuration.

There are eight possible configurations for each of the three contact-converter (CC) inputs, with no duplication allowed (meaning that no two CCs may have the same configuration at the same time). All possible configurations are presented in TABLE 2-3 in the **CALCULATION OF SETTINGS** section.

Two of the configurable output contacts are designated as control output contacts, and each of these may be configured for either one or two activation states. The other two configurable output contacts are designated as alarm output contacts, and each of these may be configured for as many as nine different activation states. All possible assignments for the output contacts are listed in TABLE 2-4 in the **CALCULATION OF SETTINGS** section and explained further in TABLE 2-5 in that same section.

Sample Button Sequences

TABLE 8-3 and TABLE 8-4 contain button sequences that demonstrate how information is retrieved from the DFM™ relay via the local MMI. The first example (TABLE 8-3) checks the value of the loss-of-load threshold in the high-impedance settings. The second example (TABLE 8-4) retrieves DFM™ relay status information.

Note that in TABLE 8-3 the DN button is pressed to exit the auto-scroll mode and enter the menu mode, and also to "move through" the main menu. In the second example, however, the UP button is used for those same two purposes. In either sequence, the ENTER pushbutton could also have been used to exit the auto-scroll mode. These variations illustrate that there is more than one way to terminate the automatic scrolling, and that the user has the option of scrolling through data either in a "forward" or "backward" direction.

Since there are twenty main-menu options, and since some of the second-level menu sequences contain twenty or more data displays, the option of traversing forward or backward can potentially save the user a significant number of button presses. Once the user becomes familiar with the menu structure of the DFM™ relay, the quickest routes (fewest button presses) to particular options or second-level elements will become obvious, and the user will instinctively know when it is more advantageous to use the UP button versus the DN button in navigating to a particular piece of information.

TABLE 8-3 SAMPLE BUTTON SEQUENCE - RETRIEVING A Hi-Z SETTING

Note: It is assumed that the beginning state of the local MMI display is its auto-scroll mode, with present values auto-scrolling on the bottom line. Although they are not centered in this table, each line of the resulting displays would be centered on its respective display line on the DFM™ relay.

BUTTON	RESULTING DISPLAY
DN	FEEDER ID: *xxxxxxxxxx* DATE/TIME
DN	FEEDER ID: *xxxxxxxxxx* RETURN TO SCROLL
DN	FEEDER ID: *xxxxxxxxxx* TEST MMI
DN	FEEDER ID: *xxxxxxxxxx* CHANGE REAR BAUD
DN	FEEDER ID: *xxxxxxxxxx* CHANGE FRONT BAUD
DN	FEEDER ID: *xxxxxxxxxx* RESET BREAKER HEALTH
DN	FEEDER ID: *xxxxxxxxxx* RESET PEAK VALUES
DN	FEEDER ID: *xxxxxxxxxx* HI-Z GROUP 4
ENTER	ARCING SENSITIVITY: *xx*
DN	RETURN TO MAIN MENU
DN	HI-Z MONITORING: *xxx*
DN	3-PH EVENT THRESH: *xxx* A
DN	LOSS OF LOAD THRESH: *xxx*
ENTER	FEEDER ID: *xxxxxxxxxx* HI-Z GROUP 4

TABLE 8-4 SAMPLE BUTTON SEQUENCE RETRIEVING DFM™ RELAY STATUS INFORMATION

Note: It is assumed that the beginning state of the local MMI display is its auto-scroll mode, with present values auto-scrolling on the bottom line. Although they are not centered in this table, each line of the resulting displays would be centered on its respective display line on the DFM™ relay.

BUTTON	RESULTING DISPLAY
UP	FEEDER ID: xxxxxxxxxx DATE/TIME
UP	FEEDER ID: xxxxxxxxxx MODEL/VERSION
UP	FEEDER ID: xxxxxxxxxx STATUS
ENTER	STATUS: WARN 1 of 2 PRC: RESET LOCKOUT
UP	STATUS: WARN 2 of 2 ANI: VOLT INPUT CHAN
UP	RETURN TO MAIN MENU
ENTER	FEEDER ID: xxxxxxxxxx STATUS

TABLE 8-5 FAIL STATUS MESSAGES

ANI: ADC INTERFACE
ANI: NORM RANGE CHAN
ANI: NOTCH FILTER
ANI: NOTCH FLTR CHAN
ANI: REFERENCE
ANI: SERIAL EEPROM
MAG: CT RATING
MAG: SERIAL MEM
PRC: ANALOG DATA DMA
PRC: DATA XFER DMA
PRC: EEPROM
PRC: EPROM CRC
PRC: EEPROM CRC
PRC: FAST SRAM
PRC: MODEL NUMBER
PRC: PROG LOGIC DEV
PRC: TIMER

TABLE 8-6 WARN STATUS MESSAGES

ANI: EXCESS OFFSET
ANI: FREQ RESPONSE
ANI: GAIN NORM RANGE
ANI: GAIN NOTCHED
ANI: GAIN OC RANGE
ANI: GAIN VOLT INPUT
ANI: NOISE LEVEL
ANI: OC RANGE CHAN
ANI: VOLT INPUT CHAN
I/O: DIGITAL INPUT
I/O: DIGITAL OUTPUT
I/O: LOGIN FAILURE
I/O: MON CONTROL #1
I/O: MON CONTROL #2
I/O: SERIAL INTR
I/O: SERIAL PORT
PRC: DATA XFER DMA
PRC: DISPLAY DMA
PRC: I/O INTERFACE
PRC: LOST NVRAM DATA
PRC: NONVOLATILE RAM
PRC: REAL TIME CLOCK
PRC: RESET LOCKOUT
PRC: WATCHDOG TIMER

REMOTE COMMUNICATIONS INTERFACE

Passwords

A separate password is required for each of three access levels: VIEW, SETTING, and CONTROL. These three passwords allow the user to view information, change settings, and perform actions, using the DFM-LINK communications software as explained in the **SOFTWARE** section. A password must consist of ASCII characters only. The valid ASCII characters are A to Z, 0 to 9, and SPACE. As shipped from the factory the three passwords contain an invalid character (!), which forces the user to select valid passwords before DFM-LINK may be used to view information, change settings, or perform actions. The factory passwords are:

VIEW PASSWORD	DFM VIEW!
SETTING PASSWORD	DFM SETT!
CONTROL PASSWORD	DFM CONTROL!

Passwords are case sensitive. DfmView is a distinct password as compared to DFMVIEW. The passwords can only be viewed at the local MMI, and they are displayed in encoded form. Use Table 8-7 to decode the passwords.

Hardware Jumpers

There are two factory-installed hardware jumpers on the Input/Output circuit board that inhibit either remote breaker operation or the ability to make setting changes via the rear serial port. These hardware jumpers need to be removed if one wishes to perform those two functions.

***** WARNING *****
POWER DOWN THE DFM™ RELAY BEFORE REMOVING THE HARDWARE JUMPERS. FAILURE TO DO SO CAN PERMANENTLY DAMAGE THE RELAY AND CAUSE SERIOUS BODILY INJURY.

The hardware jumpers are defined as follows (see Figure 3-8 in the **HARDWARE** section):

Hardware Jumper J1 = Remote Breaker Operation
Hardware Jumper J2 = Remote Configuration

Modem Connections and Settings

When establishing communication between the DFM™ relay and a remote PC, two modems connected via a phone line are required; one modem is located at the DFM™ relay and the other is located at the PC. The cables that connect the modem with either the DFM™ relay or the PC are shown in Figure 8-2. Each modem must be "Hayes-compatible", meaning that it must accept configuration commands first developed by Hayes. This is necessary since the DFM-LINK communications software that runs on the PC sends a Hayes-compatible command string to the modem located at the PC. The DFM™ relay does not send any configuration commands to its modem. **Both the DFM™ relay modem and the PC modem must be uniquely configured to permit the user to log in to, and communicate with, the DFM™ relay using DFM-LINK software.**

The required configuration settings are presented as changes to the factory-default configuration settings for a Hayes V-Series 2400 SmartModem. These default settings are:

B1	&C0	S0=0	S36=1
E1	&D0	S6=2	S37=0
L2	&G0	S7=30	S38=20
M1	&J0	S8=2	
N1	&K3	S9=6	
P	&L0	S10=14	
Q0	&P0	S11=95	
V1	&Q5	S12=50	
W0	&R0	S18=0	
X4	&S0	S25=5	
Y0	&X0	S26=1	

Other "Hayes-compatible" modems may implement a subset of the full Hayes command set. **It is the responsibility of the user to ascertain the exact commands accepted by a particular modem.** The proper syntax for entering the Hayes-compatible commands (sometimes referred to as the "AT" command set) is not described here. Refer to the manual of your modem for an explanation of this syntax.

PC Modem

The PC modem must be configured for "intelligent" operation (e.g. command recognition enabled). For the Hayes V-Series 2400 SmartModem, this setting is made via an internal jumper. The default settings listed above are valid for DFM-LINK. Those configuration settings critical to the operation of DFM-LINK are changed by DFM-LINK. The configuration commands sent to the modem from DFM-LINK are:

```
+ + +                          (set modem to command mode)
(delay 2 seconds)
ATE0L0Q0S7=60V0X4Y0 (see explanation below)
```

Command explanation:

AT	-	modem attention command
E0	-	disable command state echo
L0	-	low speaker volume (desirable, not required)
Q0	-	modem returns result codes
V0	-	result codes returned in numeric form
X4	-	enables features represented by result codes
Y0	-	disable long space disconnect
S7=60	-	allows modem to hang up if connection is not made within 60 seconds

If all of the above commands are not programmable, the modem will not operate properly. In addition to the required configuration settings listed above, it is suggested that two other settings be made by the user. These are:

&D3	-	causes the modem to reset on the ON-to-OFF transition of DTR (Data Terminal Ready)
&C1	-	causes DCD (Data Carrier Detect) to track the received carrier signal

The modem will operate properly without making these two settings, but the modem will not hang up if the appropriate handshaking signal is lost.

A DFM-LINK setting establishes the baud rate, which must match the baud-rate setting of the DFM™ relay. DFM-LINK then sets the specified PC serial port (e.g. COM1, COM2) to the proper baud rate, parity, data bits, and stop bits. If the PC modem is capable of operating at more than one baud rate, then it must be able to configure automatically its baud rate, character length, and parity setting by examining the "AT" command prefix.

DFM™ relay Modem

The DFM™ relay modem must be configured for "dumb" operation (e.g. command recognition disabled). For the Hayes V-Series 2400 SmartModem, this setting is made via an internal jumper. Since the DFM™ relay does not send any configuration commands to its modem, the required configuration settings must be made prior to connecting the modem to the DFM™ relay. **Additionally, the modem must be initialized to the required configuration settings each time modem power is turned OFF and then ON.** Depending on the design of the modem, this is accomplished by making all the required settings via switches or saving the settings in non-volatile memory.

The required configuration settings are:

E0	-	disable command state echo
L0	-	low speaker volume (advisable, not necessary)
Q1	-	disable result code display
&C1	-	causes DCD (Data Carrier Detect) to track the received carrier signal
&D3	-	causes the modem to reset on the ON-to-OFF transition of DTR (Data Terminal Ready)
&Q0	-	asynchronous mode
S0=1	-	enable auto-answer

If any of the above settings cannot be implemented, the modem may not answer, the DFM™ relay may not connect properly, or the user may not be able to log in to the DFM™ relay.

With a Hayes V-Series 2400 SmartModem or equivalent, the DFM™ relay modem performs a modulation handshake with the PC modem to set the baud rate of the DFM™ relay modem. The default setting of "N1" permits handshaking to occur at any baud rate supported by both modems. This is one reason why it is preferable to use identical modems at each end.

Note that auto-answering is controlled with register S0. S0=0 disables auto-answer. S0=1 causes the DFM™ relay modem to answer the incoming call after one ring. S0 can be set for any value between 1 and 255, for the Hayes-compatible modem assumed here, if it is desirable to delay modem answering. Note that DFM-LINK configures the PC modem to wait 60 seconds for the DFM™ relay modem to answer. If the DFM™ relay modem register S0 is set higher than 12, the PC modem may time out and hang up before the DFM™ relay modem can answer. S0=12 means that the DFM™ relay modem will answer after twelve rings and corresponds **approximately** to the 60-second delay (S7=60) at the PC modem; however, the user should verify the number of rings that correspond to 60 seconds for a particular application.

Connection to G-NET™ Host Computer (Optional)

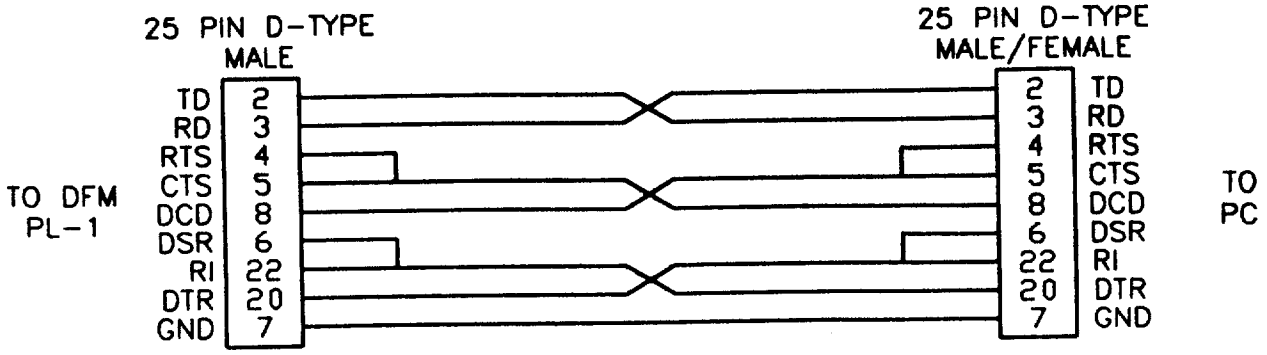
The G-NET™ host computer provides a complete communication package to send and retrieve information automatically from the DFM™ relay. The pin-to-pin connections to the G-NET™ host are shown in Figure 8-2.

Null Modem Connections

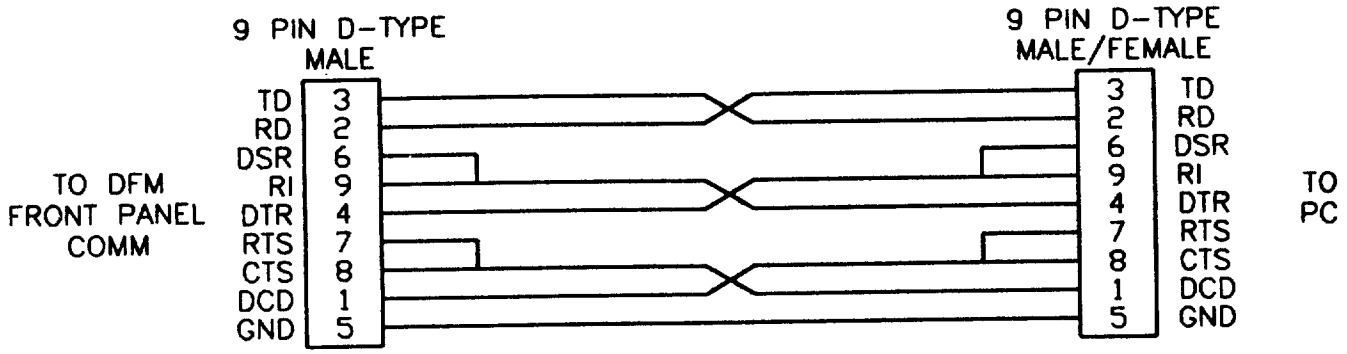
A PC can be connected to a DFM™ relay without the intervening modems and phone line by using a special cable called a "null-modem" cable. The required pin-to-pin connections for a null-modem cable to the DFM™ relay's rear serial port are shown in Figure 8-2 A) and C). The pin-to-pin connections for a null-modem cable to the DFM™ relay's front serial port are shown in Figure 8-2 B). Neither null-modem cable should exceed 50 feet in length.

TABLE 8-7 PASSWORD DECODER KEY
ENCRYPTED PASSWORD CONVERSION TABLE

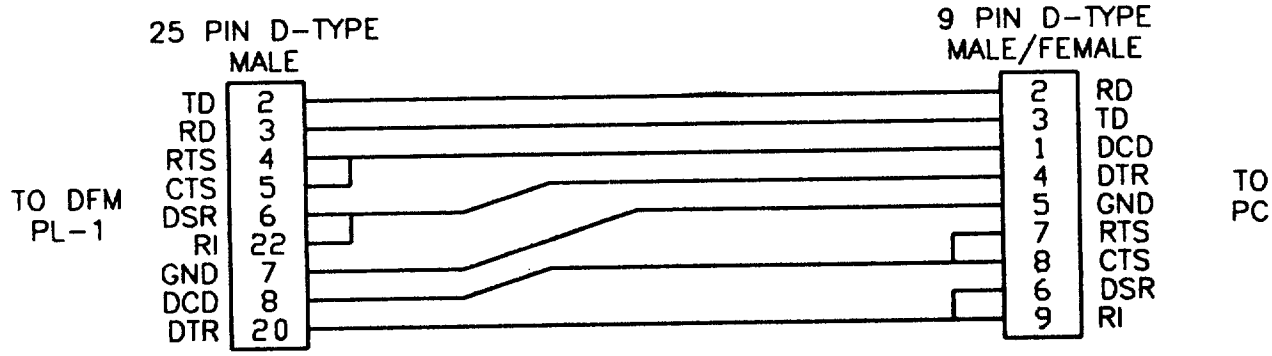
MMI	DECODED	MMI	DECODED	FACTORY USE ONLY MMI	FACTORY USE ONLY DECODED
(sp)	P	:	J	Q	$
!	T	;	N	R	(
"	X	<	C	S	,
$	Q	=	G	T	!
%	U	>	K	U	%
&	Y	?	O	V	)
(	R	@	0	W	-
)	V			X	"
*	Z	A	4	Y	&
,	S	B	8	Z	*
-	W	D	1	[	.
		E	5	\	#
1	D	F	9	]	'
2	H	H	2	^	+
3	L	I	6	_	/
4	A	L	3		
5	E	M	7		
6	I	P	(sp)		
7	M				
8	B				
9	F				



A) DFM REMOTE COMMUNICATIONS TO PC DIRECTLY



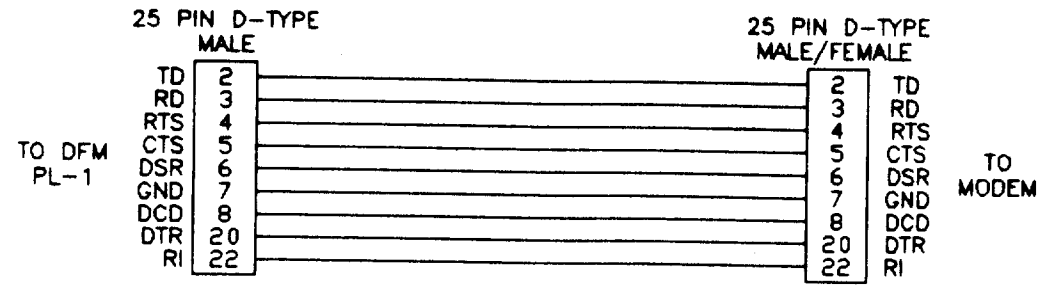
B) DFM REMOTE COMMUNICATIONS TO PC DIRECTLY



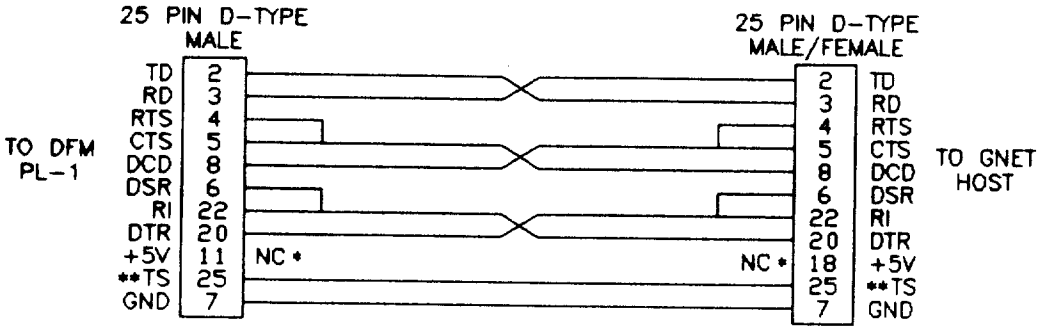
C) DFM REMOTE COMMUNICATIONS TO PC DIRECTLY

If there should be a need for a nul modem cable from a DFM™ 9-pin connector to a PC 25-pin connector, an adapter may be used with one of the cables shown above

Figure 8-2 (0286A5408 Sh.1 [2]) DFM™ Relay Communication Nul Modem Cables



D) DFM REMOTE COMMUNICATIONS VIA MODEM CABLE



* +5V IS FOR FIBER OPTIC ADAPTER USE ONLY
** TS = TIME SYNC SIGNAL RS-232 LEVEL 200 uS POSITIVE GOING PULSE
E) DFM REMOTE COMMUNICATIONS TO GNET HOST

CABLES AVAILABLE UNDER GE PART NO. 0246A9866. SPECITY CABLE TYPE AND CONNECTOR GENDER.

8

Figure 8-2 (0286A5408 Sh.2) DFM™ Relay Communication Cables, continued

DFM-LINK SOFTWARE

OVERVIEW

A personal computer (PC) will provide a man-machine interface to the monitor for operating personnel. This interface is intended to be used either remotely, through a modem to the rear panel of the DFM™ relay, or locally through the DFM™ relay's front-panel port.

SYSTEM REQUIREMENTS

Hardware

The minimum PC hardware requirements consist of the following components. An IBM-AT or compatible with one serial port, a minimum of 400K bytes of free memory (RAM) to run the program in, 40MB hard drive, a low density 3 1/2 inch floppy drive, and EGA monitor.

Software

Requires MSDOS (PCDOS) 3.1 or above for the PC operating system.

INSTALLATION

View the file README.TXT for updated information and installation instructions for this program. This file is found on the 3.5" floppy disk located at the end of this section.

GENERAL OPERATION

Mouse/Keyboard Usage

Either the mouse or the keyboard can be used to access all items in menus, dialog boxes and list boxes. For a description of how to use the mouse and keyboard in the various boxes and menus, refer to the following sections. For full manipulation of graphical data, the mouse is required.

The mouse is used to access items in menus and dialog boxes by moving the cursor to the item, followed by pressing and then releasing the left mouse button (clicking).

Main Horizontal Menu Bar

Items in the main horizontal menu are selected in one of three ways:

1. Position the mouse cursor on top of the menu item and click the left button.
2. Use a hot key. The hot key is the combination of the ALT key and the letter that is highlighted in the item description.
3. Once either of the above methods has been used to select an item on the menu, indicated by one item being highlighted, the RIGHT and LEFT ARROW keys can be used to go to adjacent menu items. If the desired menu is not visible just below the highlighted item on the menu bar, use the DOWN ARROW key to display the menu.

Pull-Down Menus

Pull-down menu items are selected in a number of ways:

Mouse

Position the mouse cursor on top of the menu item, then press the left button once and release it (hereafter known as clicking on the mouse button) to display the pull-down menu. If the user wishes to select an item in the pull-down menu, position the mouse over the desired item and click on the left mouse button.

Both may be done at once by positioning the cursor over the menu item on the menu bar and holding the left mouse button down, moving the mouse cursor to the desired entry, and then releasing the mouse button.

Keyboard

"Activating a hot key" is the combination of holding the ALT key and pressing the highlighted letter. Using a hot key will activate the associated menu or dialog box. If there is no hot key for a desired menu item, use the UP and DOWN ARROW keys to highlight the desired item, then press the ENTER/RETURN key. Pressing the ENTER key will activate the associated menu or dialog box.

Dialog Boxes

Dialog boxes are generally characterized by a title bar, a grey box, and OK and CANCEL buttons. The dialog box cannot be moved, resized, or iconized. In addition, when a dialog box is displayed, the user can only access items in the dialog box, not any other items on the screen.

If an item in the dialog box has a title with a highlighted character, the user can access this item from the keyboard by using the ALT key with the highlighted character (the hot key). Items in a dialog box can also be accessed from the keyboard by using the cursor keys: UP/DOWN/LEFT/ RIGHT ARROW keys, PAGE UP/DOWN keys and the TAB/SHIFT TAB keys. In any dialog box the TAB key will move sequentially in one direction, or the SHIFT TAB key in the opposite direction, selecting items in the dialog box with each keystroke. The other cursor keys will generally move within a selected item.

Buttons in the dialog box can be accessed from the keyboard by using the UP/DOWN ARROW keys, the TAB/SHIFT TAB keys, or, if the button has a highlighted character, the hot key. If the buttons require the user to make a selection, the selection is made by using the ENTER key once the selection is highlighted.

To exit from the dialog box and clear it from the screen, the user selects either the OK button or the CANCEL button. The mouse can be used to select these buttons by moving the mouse cursor over the button and clicking the left mouse button. In addition, the keyboard can be used to select these buttons by using their hot keys. The hot key for the OK button is ALT-O and the hot key for the CANCEL button is ALT-C.

The mouse can be used to select any item in a dialog box by moving the cursor with the mouse to the desired item and clicking on it with the left mouse button.

The OK button accepts the selection(s) made by the user and allows the program to use these selections. The CANCEL button does not accept the selections made by the user, and thus the program uses the previous selections. Any highlighted button can be selected by pressing the ENTER key.

List Boxes

A list box is another box within a dialog box that lists all choices for an item in the dialog box (for example, a list of file names). If the list of available entries is longer than the displayed list box, the list box has a vertical scroll bar, on the right side of the list box, that allows the user to scroll through the list.

To operate the scroll bar with the mouse, place the tip of the pointing arrow cursor in the gray hatched area, or on the arrows at the top and bottom of the scroll bar, and click on the left mouse button. If the mouse arrow cursor is in the grey hatched area, then the contents of the list box will move a section at a time. If the mouse cursor is on one of the arrows at the top or bottom, the contents of the list box will move one line at a time. Holding down the mouse button will cause the movement to be repeated until the mouse button is released or the end of the list is reached.

Once the desired item can be seen, click on the item with the left mouse button to select it. Once an item has been selected it will be highlighted.

To operate the scrolling of the list box with the keyboard, use the PAGE UP/DOWN keys to move the contents of the list box a section at a time and the UP/DOWN ARROW keys to move the contents one line at a time. Holding down the keys will cause the movement in the list box to repeat until the key is released.

Once the desired item can be seen, use the UP/DOWN ARROW keys to select it. The selected item is the highlighted one.

The following table lists the valid keys and their functions for list boxes:

UP ARROW	Move up one selection.
DOWN ARROW	Move down one selection.
PAGE UP	Move up one page of selections.
PAGE DOWN	Move down one page of selections.
HOME	Move to the first selection.
END	Move to the last selection.
RETURN/ENTER	Accept the current selection and exit the list box.
ALT-X	Exit the list box without making a selection.

Entering Text and Numbers

The following keys are used when entering and editing text and numbers.

LEFT ARROW	Move the cursor one character to the left.
RIGHT ARROW	Move the cursor one character to the right.
DELETE	Delete the character at the cursor.
BACKSPACE	Delete the character to the left of the cursor.
INSERT	Toggle between the insert and overwrite mode. -Overwrite mode is indicated by an underscore-character cursor. -Insert mode is indicated by a block-character cursor.
ENTER	Accept the text or number in the field/box
ESCAPE	Clear the text or number in the field/box.

The first keystroke other than the arrow keys will clear the field/box; this enables a new entry without having to clear the box first. If a minor change is desired and the user does not wish to clear the field/box, move the cursor a space to the right first, and then do the editing to the entry.

PROGRAM OPERATION

Main Menu

The main horizontal menu has the following items and hot keys.

Monitor functions	ALT-M
Local functions	ALT-L
Setup	ALT-S
Help	ALT-H

Each item in the main horizontal menu has a pull-down menu associated with it.

MONITOR FUNCTIONS

This menu has the following items and hot keys:

Login	ALT-L
lOgout	ALT-O
Change access level	ALT-C
Hang up phone	ALT-H
Actions...	ALT-A
Information...	ALT-I
Settings...	ALT-S
Device parameters	ALT-D
TOC Curves	ALT-T

Login

Login is used to gain access to the monitor. When logging into a DFM™ relay for the first time, the user must use the factory passwords. When a user is logged in under a factory password, the only commands that can be used at the PC are those to change the password and to logout. The factory password is changed to the user's password by selecting the **change Password** menu item from the **Device parameters** menu item in the **MONITOR FUNCTIONS** menu. The current passwords are the factory passwords and the new passwords are the users' passwords. The encoded View, Setting and Control passwords can **only** be viewed locally, in encrypted form, on the MMI.

The **Login** dialog box contains a list of the currently configured DFM™ relays, a place to enter the password, a place to enter the unit ID, a button for adding a new DFM™ relay to the configured list, an OK button and a CANCEL button.

The list of currently configured DFM™ relays contains the unit description, phone number, baud rate, multiplexor switch code, and protocol description for each DFM™ relay.

The 'New monitor' button in the dialog box allows the user to add a device that has not been previously entered into the list of configured monitors. The user enters the unit description, the phone number, the multiplexor switch code, phone number, and protocol description for the new monitor. The new monitor is added to the list of configured monitors.

Once a monitor is selected from the list of monitors, the user is asked for the password and the unit ID. Neither of these is echoed on the screen. Once this information is entered, the user selects the OK button to log in to the monitor. Any of the three passwords for Communications can be used to log in to the monitor. (See PASSWORDS in the **INTERFACE** section.) The password used will determine the access level when the login procedure is complete. For example, if settings changes will be performed, then the password should be the Settings access

password. Another method of logging in would be to use the View access password to log into the DFM™ relay, and change the access level when settings changes are needed. See **Change access level** below for more information.

lOgout

Logout disables access to the monitor. A check is made to determine the operability of the output contacts at the DFM™ relay (enabled or disabled). The status is displayed in the dialog box. Selecting the OK button logs out of the monitor. Selecting the CANCEL button leaves the user logged in to the monitor. If the status of the output contacts is "disabled" due to the unit being in the test mode, pick the CANCEL button and choose **End of monitor test** under **Monitor test** in the **Actions** menu.

Change access level

Change access level allows the user to enter another password so that the settings can be changed, actions can be performed, or access is restricted to viewing only. The access level is displayed on the bottom line of the screen.

To choose **Change access level**, move the mouse cursor to the item and click on it with the left mouse button or use the hot key ALT-C. A dialog box will appear with space to enter a password. The user can change the access level by entering a password for one of the other levels and selecting the OK button by clicking on it with the left mouse button or using the ALT-O hot key. (Selecting the CANCEL button will exit **Change access level** without changing the level.) Once the level has been changed, the new level will be displayed at the bottom of the screen. The following table contains operations performed by DFM-LINK and the associated password level required to perform the operation. All items can be viewed at any level, but only changed with the proper access level displayed.

DFM-LINK Operation	Required Access Level
Change Password	Any Level
Open Breaker	Control Level
Close Breaker	Control Level
Enable Outputs	Control Level
Disable Outputs	Control Level
Change Time and Date	Settings Level
Change Station/Line Id	Settings Level
Fixup settings	Any Level
Monitor Test	Control Level
Digital Output Test	Control Level
Perform Settings Changes	Settings Level

Hang up phone

This selection will disconnect the telephone line at the modem. If the user is logged in to the monitor, The logout procedure will be completed before hanging up the phone. To pick this selection, use the hot key ALT-H or click on the menu item with the left mouse button.

Actions...

This menu has the following items and hot keys:

Manual open	ALT-M
manual Close	ALT-C
Enable outputs	ALT-E
Disable outputs	ALT-D
change Time and date	ALT-T
Fixup settings	ALT-F
reset dAta	ALT-A
monitoR test	ALT-R
digital Output test	ALT-O

Manual open

This item allows the user to open the breaker manually. Note that the breaker can be operated through the front-panel communication port regardless of whether or not the jumper that inhibits remote operations is installed on the I/O board (see Figure 3-8 in the HARDWARE DESCRIPTION Section for the location, and **Hardware Jumpers** in the INTERFACE section for description of the jumpers). To select **Manual open**, use the hot key ALT-M or click on the menu item with the left mouse button.

When the user selects the OK button, the user is asked to confirm the action. If the user selects the OK button, the breaker is opened and the user is returned to the previous screen. Selecting the CANCEL button from the confirmation dialog box will return the user to the **Actions** menu, without opening the breaker.

Upon reception of the **Manual open** message, the DFM™ relay can energize one or more output contacts depending on the configuration. Contact configuration is defined by settings #301 through #305. Refer to the **CALCULATION OF SETTINGS** section in this manual.

Note: If the DFM™ relay has a breaker 52/b status contact available and configured, DFM-Link will indicate if the operation was successful. If a breaker-status contact is not available, DFM-Link will indicate that the proper response has been received from the DFM™ relay, but this does not necessarily mean the breaker operation is complete.

manual Close

This item allows the user to close the breaker manually. Note that the breaker cannot be closed through the rear communication port if the appropriate jumper is installed (see the HARDWARE DESCRIPTION and INTERFACE Sections for the location and description of the jumpers). To select **manual Close**, use the hot key ALT-C or click on the menu item with the left mouse button.

When the user selects the OK button, the user is asked to confirm the action. If the user selects the OK button, the breaker is closed and the user is returned to the confirmation dialog box. Selecting the CANCEL button from the confirmation dialog box returns the user to the **Actions** menu. Read note in the above **Manual open** section pertaining to applications where the breaker-status contact is not available.

Upon reception of the **manual Close** message, the DFM™ relay can energize one or more output contacts depending on the configuration. Contact configuration is defined by settings #301 through #305. Refer to the **CALCULATION OF SETTINGS** section in this manual.

Enable outputs

This item allows the user to permit the DFM™ relay to energize the monitor outputs. This item is selected by using the ALT-E hot key or clicking on the menu item with the left mouse button. If the user selects the CANCEL button, then no action is taken and the **Actions** menu is redisplayed. If the user selects the OK button, another dialog box is displayed to confirm the action. If the user selects the OK button, the outputs are enabled. If the CANCEL button is selected, there is no change in the status of the digital outputs, and the previous dialog box will be displayed.

Disable outputs

This item allows the user to inhibit the DFM™ relay from energizing any of the monitor outputs including the four Alarm Outputs. This item is selected by using the ALT-D hot key or clicking on the menu item with the left mouse button.

If the user selects the CANCEL button, then no action is taken and the **Actions** menu is redisplayed. If the user selects the OK button, another dialog box is displayed to confirm the action. If the user selects the OK button, the outputs are disabled. If the CANCEL button is selected, there is no change in the status of the digital outputs, and the previous dialog box will be displayed.

change Time and date

This item allows the user to set the time and date in the DFM™ relay to the current time and date. Changing the time and date through this menu does not affect the time and date in the PC.

First the DFM™ relay's current time and date is displayed. The time is displayed in the format HH:MM:SS (for example: 10:55:09). The date is displayed in the format MM/DD/YY (for example: 07/16/90). The user may then edit the time and date.

When the user selects the OK button, the user is asked to confirm the action. If the user selects the OK button, the time and date are changed in the DFM™ relay.

Fixup settings

This item allows the user to recalculate the settings CRC code in non-volatile RAM. Fixup settings is selected by using the ALT-F hot key or clicking on the menu item with the left mouse button. Once Fixup settings has been chosen, a dialog box will be displayed. The dialog box contains only the OK and CANCEL buttons. If the user selects the CANCEL button at any time the user will be returned to the **Actions** menu box. For further information see the section on **SERVICING**.

If the OK button is selected, the user is asked to confirm the action with another dialog box. If the user selects the OK button, the settings CRC code is recalculated and all the settings are sent back to the PC. In addition, a message is displayed telling the user to verify all settings.

NOTE: If settings have been uploaded previous to executing this command, and have not been saved to a disk file or downloaded, they will be lost.

If the user selects the CANCEL button, the CRC value is not recalculated and the previous dialog box will be displayed again.

reset dAta

This item allows the user to reset stored information in the DFM™ relay. This function can be selected with the ALT-A hot key or by placing the mouse cursor over the menu item and clicking on the left mouse button. Once reset dAta has been selected, the five options are displayed in a list box. See **List Boxes** under **GENERAL OPERATION** in this **DFM-LINK SOFTWARE** section for more information.

The user selects the desired data classification to reset by clicking on it with the left mouse button, or pressing the ENTER key once the correct test has been highlighted. If the user selects the OK button, another dialog box will be displayed to confirm the test. If the user again selects the OK button, the corresponding data is reset. If the CANCEL button is selected, then the data will not be reset and the user will be returned to the previous dialog box.

monitoR test

This item allows the user to test the monitor functions of the DFM™ relay. **monitoR test** is selected with the ALT-R hot key or by placing the mouse cursor over the menu item and clicking on the left mouse button. Once **monitoR test** has been selected, the test functions are displayed in a list box. To find the desired test, use the PAGE UP/DOWN and UP/DOWN ARROW keys or use the mouse on the scroll bar. See **List Boxes** under **GENERAL OPERATION** in this **DFM-LINK SOFTWARE** section for more information.

The user selects the desired test function to perform by clicking on it with the left mouse button, or pressing the ENTER key once the correct test has been highlighted. If the user selects the OK button, another dialog box will be displayed to confirm the test. If the user again selects the OK button, the test is performed. This will put the monitor in test mode for the selected test. If the CANCEL button is selected, then the monitor will not be put in test mode for the selected test and the user will be returned to the previous dialog box.

If the user selects the CANCEL button from the dialog box with the list of tests, the user will be returned to the **Actions** menu box. To put the monitor back in operating mode, "End test mode" is selected from the list of tests.

digital Output test

This item allows the user to perform digital output tests in the monitor. The tests are displayed in a list box. The user selects the test to perform. When the user selects the OK button, the user is asked to confirm the test. If the user again selects the OK button, the test is performed. This will put the monitor in test mode, with protection OFF. To put the monitor back in operating mode, the user executes "End test mode".

Information...

This menu has the following items and hot keys:

request Present values	ALT-P
request disturbance report Identification	ALT-I
request disturbaNce report	ALT-N
request Events	ALT-E
request Breaker health	ALT-B
request Harmonics	ALT-H
request peaK values	ALT-K
request demAnd data	ALT-A
request power-Quality report identification	ALT-Q
request Oscillography data	ALT-O
request Rms oscillography data	ALT-R
request power-qUality snapshot data	ALT-U
request dfm Status	ALT-S
request hi-Z status	ALT-Z
request hi-z Data	ALT-D

request Present values

This item allows the user to display, print and/or file the present values. To select this menu item, either click on it with the left mouse button or use the ALT-P hot key. Once this item is selected, a dialog box will appear with three independent choices for displaying, printing and filing the present values. To change any of the three choices, either click on it with the left mouse button or use the TAB key to highlight the selection and the space bar to change it. An X in the brackets indicates that choice has been selected, and no X indicates that choice has not been selected. At least one must be chosen for the present values to be retrieved from the monitor.

If the user chooses to save the report in a file, a file name must be entered in the box supplied. To enter the file name, either move the mouse cursor to the box and click on the left mouse button or use the TAB key to highlight the box. Once the box has been selected, enter the filename followed by the ENTER key.

After all the choices have been made, click on the OK button, or use the ALT-O hot key, to retrieve the report from the monitor. Selecting the CANCEL button will return to the **Information** menu without any further action. If the report is displayed, when finished, either click on the small box in the upper left corner with the left mouse button, or use the ALT-F4 hot key (F4 is the Function key F4, not the F key followed by the 4 key.). Once the present values have been cleared from the screen the **Present values** dialog box will be redisplayed. Use the ALT-C hot key or click on the CANCEL button to exit Present values.

NOTE: Currents and voltages are RMS values and are always displayed in secondary quantities.

request disturbance report Identification

This item allows the user to display and/or print the identification of each disturbance report, which includes the time, date, and trigger type for each disturbance. This information allows the user to determine easily which disturbance to examine.

To select this menu item either click on it with the left mouse button or use the ALT-I hot key. Once this item is selected, a dialog box will appear with three independent choices for displaying, printing and filing the disturbance report IDs. To change any of the three choices, either click on

it with the left mouse button or use the TAB key to highlight the selection and the space bar to change it. An X in the brackets indicates that choice has been selected, and no X indicates that choice has not been selected. At least one must be chosen for the disturbance report identifications to be retrieved from the monitor.

If the user chooses to save the report in a file, a file name must be entered in the box supplied. To enter the file name, either move the mouse cursor to the box and click on the left mouse button or use the TAB key to highlight the box. Once the box has been selected, enter the filename followed by the ENTER key.

After all the choices have been made, click on the OK button or use the ALT-O hot key to retrieve the identifications from the monitor. (Selecting the CANCEL button will return to the **Information** menu without any further action.) If the identifications have been displayed, when finished, either click on the small box in the upper left corner with the left mouse button, or use the ALT-F4 hot key (F4 is the Function key F4, not the F key followed by the 4 key). Once the identifications have been cleared from the screen, the **disturbance report Identification** dialog box will be redisplayed. Use the ALT-C hot key or click on the CANCEL button to exit.

request disturbaNce report

This item allows the user to display, print and/or file a disturbance report and its associated events. To select this menu item, either click on it with the left mouse button or use the ALT-N hot key. Once this item is selected, a dialog box will appear with three independent choices for displaying, printing and filing the disturbance report. To change any of the three choices, either click on it with the left mouse button or use the TAB key to highlight one of the selections and the UP/DOWN ARROW keys to choose one of the three choices. An X in the brackets indicates that choice has been selected, and no X indicates that choice has not been selected. Use the space bar to change any of the choices. At least one must be chosen for the disturbance report to be retrieved from the monitor. The user must enter the disturbance report number (from 1 to 8, depending on configuration) in the box supplied on the first line of the disturbance report dialog box.

If the user chooses to save the report in a file, a file name must be entered in the box supplied. To enter the file name, either move the mouse cursor to the box and click on the left mouse button, or use the TAB key to highlight the box. Once the box has been selected, enter the filename followed by the ENTER key.

After all the choices have been made, click on the OK button or use the ALT-O hot key to retrieve the disturbance report from the monitor. Selecting the CANCEL button will return to the **Information** menu without any further action. To clear the disturbance report from the screen, if it has been displayed, either click on the small box in the upper left corner with the left mouse button or, use the ALT-F4 hot key (F4 is the Function key F4, not the F key followed by the 4 key). Once the disturbance report has been cleared from the screen, the **disturbaNce report** dialog box will be redisplayed. Use the ALT-C hot key or click on the CANCEL button to exit.

The user may scroll the screen to view the events associated with the disturbance. To scroll through the report, use the PAGE UP/DOWN keys, or place the mouse on the UP or DOWN ARROW on the scroll bar and use the left mouse button. Clicking the left mouse button will move one line in that direction and holding the button down will cause the scrolling to happen repetitively. The events are displayed with the most recent event last.

request Events

This item allows the user to display, print and/or file the events stored in the monitor. To select this menu item, either click on it with the left mouse button or use the ALT-E hot key. Once this

item is selected, a dialog box will appear with three independent choices for displaying, printing and filing the events. To change any of the three choices, either click on it with the left mouse button or use the TAB key to highlight one of the selections and the UP/DOWN ARROW keys to choose one of the three choices. An X in the brackets indicates that choice has been selected, and no X indicates that choice has not been selected. Use the space bar to change any of the choices. At least one must be chosen for the events to be retrieved from the monitor.

If the user chooses to save the report in a file, a file name must be entered in the box supplied. To enter the file name, either move the mouse cursor to the box and click on the left mouse button or use the TAB key to highlight the box. Once the box has been selected, enter the filename followed by the ENTER key.

After all the choices have been made, click on the OK button or use the ALT-O hot key to retrieve the events from the monitor. Selecting the CANCEL button will return to the **Information** menu without any further action. The events are displayed chronologically, starting with the most recent event. There may be more events than can be displayed on one screen. If there are more events to see, a scroll bar will appear on the left side of the box. Use the PAGE UP/DOWN keys, or use the mouse on the scroll bar, to see the other events. To clear the events from the screen, if they have been displayed, either click on the small box in the upper left corner with the left mouse button or use the ALT-F4 hot key (F4 is the Function key F4, not the F key followed by the 4 key). Once the events have been cleared from the screen the **Events** dialog box will be redisplayed. Use the ALT-C hot key or click on the CANCEL button to exit.

NOTE: If DC power is removed for more than 24 hours, all event information will be lost.

request Breaker health

This item allows the user to display, print and/or file the Breaker Interrupting data values from the DFM™ relay. To select this menu item, either click on it with the left mouse button or use the ALT-B hot key. Once this item is selected, a dialog box will appear with three independent choices for displaying, printing and filing the data. To change any of the three choices, either click on it with the left mouse button or use the TAB key to highlight one of the selections and the UP/DOWN ARROW keys to choose one of the three choices. An X in the brackets indicates that choice has been selected, and no X indicates that choice has not been selected. Use the space bar to change any of the choices. At least one must be chosen for the events to be retrieved from the monitor.

If the user chooses to save the report in a file, a file name must be entered in the box supplied. To enter the file name, either move the mouse cursor to the box and click on the left mouse button or use the TAB key to highlight the box. Once the box has been selected, enter the filename followed by the ENTER key.

After all the choices have been made, click on the OK button or use the ALT-O hot key to retrieve the data from the monitor. Selecting the CANCEL button will return to the **Information** menu without any further action. The data is displayed along with the units. The station and line ID are provided for identification purposes. To clear the breaker-health information from the screen, if they have been displayed, either click on the small box in the upper left corner with the left mouse button or use the ALT-F4 hot key (F4 is the Function key F4, not the F key followed by the 4 key). Once this information has been cleared from the screen the **Breaker health** dialog box will be redisplayed. Use the ALT-C hot key or click on the CANCEL button to exit.

NOTE: Breaker-health data is not susceptible to loss of power. This information is stored in memory that has an extended data retention period.

request Harmonics

This item allows the user to display, print and/or file the frequency content of the user-selected line quantity. To select this menu item, either click on it with the left mouse button or use the ALT-H hot key. Once this item is selected, a dialog box will appear that is used to select the line quantity along with three independent choices for displaying, printing and filing the data. To select an option, either click on it with the left mouse button or use the TAB key to highlight one of the choices in either region of the dialog box. Then use the UP/DOWN ARROW keys to move the cursor within that region. With respect to the output options, an X in the brackets indicates that choice has been selected, and no X indicates that choice has not been selected. Use the space bar to change any of the choices. At least one output option must be chosen for the harmonic content data to be retrieved from the monitor.

If the user chooses to save the report in a file, a file name must be entered in the box supplied. To enter the file name, either move the mouse cursor to the box and click on the left mouse button or use the TAB key to highlight the box. Once the box has been selected, enter the filename followed by the ENTER key.

After all the choices have been made, click on the OK button or use the ALT-O hot key to retrieve the data from the monitor. Selecting the CANCEL button will return to the **Information** menu without any further action. The data is displayed in rectangular component format. The station and line ID are provided for identification purposes. The user may scroll the screen to view the frequency content in the higher range of the spectrum. To scroll through the report, use the PAGE UP/DOWN keys, or place the mouse on the UP or DOWN ARROW on the scroll bar and use the left mouse button. Clicking the left mouse button will move one line in that direction and holding the button down will cause the scrolling to happen repetitively.

To clear the harmonic content information from the screen, if it has been displayed, either click on the small box in the upper left corner with the left mouse button or use the ALT-F4 hot key (F4 is the Function key F4, not the F key followed by the 4 key). Once this information has been cleared from the screen, the **request Harmonics** dialog box will be redisplayed. Use the ALT-C hot key or click on the CANCEL button to exit.

request peaK values

This item allows the user to display, print and/or file the peak data stored in the DFM™ relay. To select this menu item, either click on it with the left mouse button or use the ALT-K hot key. Once this item is selected, a dialog box will appear that is used to select the day of interest, along with three independent choices for displaying, printing and filing the data. To select an option, either click on it with the left mouse button or use the TAB key to highlight one of the choices in either region of the dialog box. The UP/DOWN ARROW keys can be used to move the cursor within the output-options region. Within this region, an X in the brackets indicates that choice has been selected, and no X indicates that choice has not been selected. Use the space bar to change any of the choices. At least one output option must be chosen for the **peaK values** data to be retrieved from the monitor.

The upper field is used to select the day of interest. Enter an integer value to select a particular day. A value of one (1) selects the present day and thirty-five represents the data stored five weeks in the past. A value of zero selects the peak data since last user reset of peak data.

After all the choices have been made, click on the OK button or use the ALT-O hot key to retrieve the data from the monitor. Selecting the CANCEL button will return to the **Information** menu without any further action. The data is displayed in rectangular component format. The station and line ID are provided for identification purposes. To scroll through the report, use the PAGE UP/DOWN keys, or place the mouse on the UP or DOWN ARROW on the scroll bar and use the left mouse button. Clicking the left mouse button will move one line in that direction and

holding the button down will cause the scrolling to happen repetitively.

To clear the peak data information from the screen, if it has been displayed, either click on the small box in the upper left corner with the left mouse button or use the ALT-F4 hot key (F4 is the Function key F4, not the F key followed by the 4 key). Once this information has been cleared from the screen the **peaK values** dialog box will be redisplayed. Use the ALT-C hot key or click on the CANCEL button to exit.

NOTE: If DC power is removed for more than 24 hours, all peak data information will be lost.

request demAnd data

This item allows the user to save to file all or part of the demand data stored in the DFM™ relay. To select this menu item, either click on it with the left mouse button or use the ALT-A hot key. Once this item is selected, a dialog box will appear that is used to select the start date and time, the end date and time, the directory in which the data file will be located, and the name of the data file. To select an option, either click on it with the left mouse button or use the TAB key.

An ASCII format data file is created with the name and extension specified. If the optional GE-DATA presentation software will be used to display this data graphically, then place an "X" in bracketed area, "[ ]", preceding the "Create plot file" option, using the keyboard or mouse. A second file with the same name but a "DMG" extension is created. For instance, if the file name selected was "TEST.DMD" and the "Create plot file" option was selected, then both an ASCII file named TEST.DMD, and a binary file named TEST.DMG, are created. The binary-format file TEST.DMG is required by GE-DATA to facilitate scaling and labeling of the data. Both files contain the demand data for the date/time interval specified. The ASCII file can be read directly by most spreadsheet programs by using their "import" feature.

After all the choices have been made, click on the OK button or use the ALT-O hot key to retrieve the data from the monitor. Selecting the CANCEL button will return to the **Information** menu without any further action.

NOTE: If DC power is removed for more than 24 hours, all demand data information will be lost.

request power-Quality report identification

This item allows the user to display, print and/or file the **Power-Quality report identification** summary information stored in the DFM™ relay. This data consists of a summary of the five most recent power-quality snapshots. A power-quality snapshot capture will be triggered any time the calculated THD (Total Harmonic Distortion) for a particular line quantity exceeds the user-configurable threshold value for either current or voltage. To select this menu item, either click on it with the left mouse button or use the ALT-Q hot key. Once this item is selected, a dialog box will appear with three independent choices for displaying, printing and filing the summary report of power-quality activity. To change any of the three choices, either click on it with the left mouse button or use the TAB key to highlight the selection and the space bar to change it. An X in the brackets indicates that choice has been selected, and no X indicates that choice has not been selected. At least one output option must be chosen for the **Power-Quality report identification** information to be retrieved from the monitor.

If the user chooses to save the summary report in a file, a file name must be entered in the box supplied. To enter the file name, either move the mouse cursor to the box and click on the left mouse button, or use the TAB key to highlight the box. Once the box has been selected, enter the filename followed by the ENTER key.

After all the choices have been made, click on the OK button or use the ALT-O hot key to retrieve the events from the monitor. Selecting the CANCEL button will return to the **Information** menu without any further action. The power-quality snapshots are displayed chronologically, starting with the most recent capture. To clear the events from the screen, if they have been displayed, either click on the small box in the upper left corner with the left mouse button or use the ALT-F4 hot key (F4 is the Function key F4, not the F key followed by the 4 key). Once the captures have been cleared from the screen the **power-Quality ID** dialog box will be redisplayed. Use the ALT-C hot key or click on the CANCEL button to exit.

NOTE: If DC power-is removed for more than 24 hours, all power-quality information will be lost.

request Oscillography data

This item allows the user to save to file the oscillography data for a particular disturbance. To select this menu item, either click on it with the left mouse button or use the ALT-O hot key. Once this item is selected, a dialog box will appear with places to enter the disturbance number and a file name where the data are to be stored. To select one of the entries to change, click on it with the left mouse button or use the TAB key to highlight one of the selections. Once an entry has been chosen, use the editing keys to enter and/or change the information in the selected box or field. The disturbance number associated with the oscillography data (1 to 8, depending on configuration), and the file name for the data **must** be supplied to have the oscillography data retrieved from the monitor.

An ASCII-format data file is created with the name and extension specified. If the optional GE-DATA presentation software will be used to display this data graphically, then place an "X" in bracketed area, "[ ]", preceding the "Create plot file" option, using the keyboard or mouse. A second file with the same name but an "OSG" extension is created. For instance, if the file name selected was "TEST.OSC" and the "Create plot file" option was selected, then both an ASCII file named TEST.OSC. and a binary file named TEST.OSG, are created. The binary-format file TEST.OSG is required by GE-DATA to facilitate scaling and labeling of the data. The ASCII file contains the disturbance report, the events associated with the disturbance report, the settings, the currents, the voltages, the digital inputs, digital outputs, and internal status flags. The binary-format file does not contain the settings or any text-format information. The ASCII file can be read directly by most spreadsheet programs by using their "import" feature.

After the file name and disturbance number have been entered, click on the OK button or use the ALT-O hot key to retrieve the oscillography data from the monitor.

NOTE: If DC power is removed for more than 24 hours, the oscillography data will be lost.

request Rms oscillography data

This item allows the user to save to file the RMS oscillography data for a particular disturbance. The difference between this RMS information and information described under **request Oscillography data** is the fact that this data is compressed; a single point represents the RMS value of 32 points of the waveform sampled data. To select this menu item, either click on it with the left mouse button or use the ALT-R hot key. Once this item is selected, a dialog box will appear with places to enter the disturbance number and a file name where the data are to be stored. To select one of the entries to change, click on it with the left mouse button or use the TAB key to highlight one of the selections. Once an entry has been chosen, use the editing keys to enter and/or change the information in the selected box or field. The disturbance number associated with the oscillography data (1 to 8 depending on configuration) and the file name for the data **must** be supplied to have the RMS oscillography data retrieved from the monitor.

An ASCII-format data file is created with the name and extension specified. If the optional GE-DATA presentation software will be used to display this data graphically, then place an "X" in bracketed area, "[ ]", preceding the "Create plot file" option, using the keyboard or mouse. A second file, with the same name but an "RMG" extension is created. For instance, if the file name selected was "TEST.RMS" and the "Create plot file" option was selected, then both an ASCII file named TEST.RMS, and a binary file named TEST.RMG, are created. The binary-format file TEST.RMG is required by GE-DATA to facilitate scaling and labeling of the data. The ASCII file contains the disturbance report, the events associated with the disturbance report, the settings, the currents, the voltages, the digital inputs, digital outputs, and internal status flags. The binary-format file does not contain the settings or any text-format information. The ASCII file can be read directly by most spreadsheet programs by using their "import" feature.

After the file name and disturbance number have been entered, click on the OK button or use the ALT-O hot key to retrieve the oscillography data from the monitor.

NOTE: If DC power is removed for more than 24 hours, the oscillography data will be lost.

request power-qUality snapshot

This item allows the user to save to file the two-cycle oscillography data for a particular **power-qUality snapshot**. A power-quality snapshot capture will be triggered any time the calculated THD (Total Harmonic Distortion) for a particular line quantity exceeds the user-configurable threshold value for either current or voltage. To select this menu item, either click on it with the left mouse button or use the ALT-U hot key. Once this item is selected, a dialog box will appear with places to enter the snapshot number and a file name where the data are to be stored. To select one of the entries to change, click on it with the left mouse button or use the TAB key to highlight one of the selections. Once an entry has been chosen, use the editing keys to enter and/or change the information in the selected box or field. The snapshot number associated with the oscillography data (1 to 5) and the file name for the data **must** be supplied to have the oscillography data retrieved from the monitor.

An ASCII-format data file is created with the name and extension specified. If the optional GE-DATA presentation software will be used to display this data graphically, then place an "X" in bracketed area, "[ ]", preceding the "Create plot file" option, using the keyboard or mouse. A second file with the same name but a "THG" extension is created. For instance, if the file name selected was "TEST.THD" and the "Create plot file" option was selected, then both an ASCII file named TEST.THD, and a binary file named TEST.THG, are created. The binary-format file TEST.THG is required by GE-DATA to facilitate scaling and labeling of the data. Both files contain the sampled data of the available currents and voltages over a 2-cycle interval. The ASCII file can be read directly by most spreadsheet programs by using their "import" feature.

After the file name and snapshot number have been entered, click on the OK button or use the ALT-O hot key to retrieve the two-cycle oscillography data from the monitor. The waveform sampled data is saved to the specified file.

NOTE: If DC power is removed for more than 24 hours, the oscillography data will be lost.

request dfm Status

This item allows the user to display, print and/or file the DFM™ relay's status. To select this menu item, either click on it with the left mouse button or use the ALT-S hot key. Once this item is selected, a dialog box will appear with three independent choices for displaying, printing and filing the DFM™ relay's status. To change any of the three choices, either click on it with the left mouse button or use the TAB key to highlight one of the selections and the UP/DOWN ARROW

keys to choose one of the three choices. An X in the brackets indicates that choice has been selected, and no X indicates that choice has not been selected. Use the space bar to change any of the choices. At least one must be chosen for the status to be retrieved from the monitor.

If the user chooses to save the report in a file, a file name must be entered in the box supplied. To enter the file name, either move the mouse cursor to the box and click on the left mouse button or use the TAB key to highlight the box. Once the box has been selected, enter the filename followed by the ENTER key.

After all the choices have been made, click on the OK button or use the ALT-O hot key to retrieve the status from the monitor. Selecting the CANCEL button will return to the **Information** menu without any further action. To clear the status from the screen, if it has been displayed, either click on the small box in the upper left corner with the left mouse button, or use the ALT-F4 hot key (F4 is the Function key F4, not the F key followed by the 4 key). Once the status has been cleared from the screen, the **Status** dialog box will be redisplayed. Use the ALT-C hot key or click on the CANCEL button to exit.

The status messages are displayed in the same order as those at the DFM™ relay (see Tables 6-3 and 6-4in the SERVICING section).

request hi-Z status

This item allows the user to display, print and/or file the HI-Z event summary information stored in the DFM™ relay. This information consists of a summary of the four most recent HI-Z events. To select this menu item, either click on it with the left mouse button or use the ALT-Z hot key. Once this item is selected, a dialog box will appear with three independent choices for displaying, printing and filing the HI-Z event summary. To change any of the three choices, either click on it with the left mouse button or use the TAB key to highlight one of the selections and the UP/DOWN ARROW keys to choose one of the three choices. An X in the brackets indicates that choice has been selected, and no X indicates that choice has not been selected. Use the space bar to change any of the choices. At least one must be chosen for the status to be retrieved from the monitor.

If the user chooses to save the report in a file, a file name must be entered in the box supplied. To enter the file name, either move the mouse cursor to the box and click on the left mouse button or use the TAB key to highlight the box. Once the box has been selected, enter the filename followed by the ENTER key.

After all the choices have been made, click on the OK button or use the ALT-Z hot key to retrieve the status from the monitor. Selecting the CANCEL button will return to the **Information** menu without any further action. To clear the status from the screen, if it has been displayed, either click on the small box in the upper left corner with the left mouse button, or use the ALT-F4 hot key (F4 is the Function key F4, not the F key followed by the 4 key). Once the status has been cleared from the screen, the **Hi-Z fault status** dialog box will be redisplayed. Use the ALT-C hot key or click on the CANCEL button to exit.

request hi-z Data

This item allows the user to save to file the HI-Z data for a particular HI-Z event. This data consists of internal time-tagged flags that trace the operation of the HI-Z algorithms for the selected event. To select this menu item, either click on it with the left mouse button or use the ALT-D hot key. Once this item is selected, a dialog box will appear with places to enter the HI-Z event number and a file name where the data are to be stored. To select one of the entries to change, click on it with the left mouse button or use the TAB key to highlight one of the selections. Once an entry has been chosen, use the editing keys to enter and/or change the

information in the selected box or field. The HI-Z event number (1 to 4) and the file name for the data **must** be supplied to have the HI-Z data retrieved from the monitor.

An ASCII-format data file is created with the name and extension specified. If the optional GE-DATA presentation software will be used to display this data graphically, then place an "X" in bracketed area, "[ ]", preceding the "Create plot file" option, using the keyboard or mouse. A second file with the same name but an "HIG" extension is created. For instance, if the file name selected was "TEST.HIZ" and the "Create plot file" option was selected, then both an ASCII file named TEST.HIZ, and a binary file named TEST.HIG, are created. The binary-format file TEST.HIG is required by GE-DATA to facilitate scaling and labeling of the data. Both files contain the HI-Z event data. The ASCII file can be read directly by most spreadsheet programs by using their "import" feature.

After the file name and event number have been entered, click on the OK button or use the ALT-D hot key to retrieve the HI-Z event data from the monitor.

NOTE: If DC power is removed for more than 24 hours, the HI-Z data will be lost.

Settings...

This menu has the following items and hot keys:

Upload settings	ALT-U
Print settings	ALT-P
view/change Category of settings	ALT-C
Download changed settings	ALT-D
download All settings	ALT-A
End setting changes	ALT-E
Save settings to file	ALT-S

Upload settings

This menu item uploads the settings from the DFM™ relay. To select this menu item, use the ALT-U hot key or click on the menu item with the left mouse button. Once the item has been selected, a dialog box will ask for the desired group of the settings. Enter the group and select the OK button, by using the ALT-O hot key or clicking on the OK button with the left mouse button. Selecting the CANCEL button returns the user to the **Settings** menu.

If the access level is not Settings, the option to **Download changed settings** will not be available.

Print settings

This item allows the user to print all settings or a specific category of settings. First a list box is displayed with the category names, plus one additional item for printing all categories. If the desired selection is not visible, use PAGE UP/DOWN or the UP/DOWN ARROW keys to see the other entries. To select an entry, either click on it with the left mouse button or highlight the item with the cursor control keys and press ENTER.

After all desired categories have been picked, selecting the OK button will print the settings. The settings are printed by category, with one setting name and value per line. Selecting the CANCEL button will return the user to the **Settings** menu. If CANCEL is picked before the OK button, then no settings will be printed.

view/change Category of settings

This item allows the user to change or view one or all of the settings in a category. To select this menu item, use the ALT-C hot key or click on the menu item with the left mouse button. Once the menu item has been selected, a list box of category names is displayed. The user must select a category to view or change, with the left mouse button or the UP and DOWN ARROW keys followed by the ENTER key. Once a category has been chosen, selecting the OK button will display a dialog box with the settings in the category. Selecting the CANCEL button will return the user to the **Settings...** menu.

The dialog box for the category consists of a list box containing the settings, the usual OK and CANCEL buttons, a box for a setting number to be entered, and a box for the setting value to be changed. The TAB key will select any of the above items in the list box. The arrow keys and PAGE UP/DOWN keys will move the contents to display the unseen settings. A setting can be chosen to be changed by highlighting it with the cursor keys and the pressing the ENTER key, or clicking on it with the left mouse button. After the setting has been selected, it can be changed in the box marked setting value.

After all the settings changes have been completed, selecting the OK button will save the settings changes and return to the **Settings** menu. Selecting the CANCEL button at any time will return to the **Settings** menu without any further action.

If the access level is not Settings, the option to **Download changed settings** will not be available.

Download changed settings

This item allows the user to transmit all the changed settings to the DFM™ relay. Note that if the appropriate jumper is installed, the DFM™ relay will not allow setting changes from the PC if the user is logged on through the rear communications port. See the **HARDWARE DESCRIPTION** and **INTERFACE** sections for more information on the jumpers.

Selecting Download with the ALT-D hot key or clicking on it with the left mouse button will display a dialog box with the changed settings. There is an option to end the settings change automatically. To pick this option, either place the mouse cursor over the box and click on the left mouse button, or use the TAB key to highlight the selection and use the SPACE BAR to select it. Pressing the SPACE BAR, or clicking the left mouse button, again, will deselect the option.

If the CANCEL button is selected, the **Settings** menu is redisplayed and no further action is taken. If the OK button is selected, another dialog box is displayed to confirm that the settings are to be downloaded. If the OK button is selected the changed settings are sent, and the changes are ended if the automatic end settings option was chosen. If the CANCEL button is selected, no settings are sent and the **Download changed settings** dialog box is redisplayed.

download All settings

This item allows the user to transmit all the settings to the DFM™ relay. Note that if the appropriate jumper is installed, the DFM™ relay will not allow setting changes from the PC if the user is logged on through the rear communications port. See the **HARDWARE DESCRIPTION** section for more information on the jumpers.

Selecting All with the ALT-A hot key or clicking on it with the left mouse button will display a dialog box with all the settings. There is an option to end the settings change automatically. To pick this option, either place the mouse cursor over the box and click on the left mouse button, or use the TAB key to highlight the selection and use the SPACE BAR to select it. Pressing the SPACE BAR, or clicking the left mouse button, again, will deselect the option.

If the CANCEL button is selected, the **Settings** menu is redisplayed and no further action is taken. If the OK button is selected, another dialog box is displayed to confirm that the settings are to be downloaded. If the OK button is selected the changed settings are sent, and the changes are ended if the automatic end settings option was chosen. If the CANCEL button is selected, no settings are sent and the **download All settings** dialog box is redisplayed.

End setting changes

This item is selected after downloading settings to tell the DFM™ relay that settings changes are complete and protection should use the new settings. (If the option to end settings changes automatically was picked when downloading settings to the DFM™ relay, this menu item does not need to be selected again.) To select this menu item, use the ALT-E hot key or click on it with the left mouse button. Once the item is selected, a dialog box that only contains the OK and CANCEL buttons is displayed. To end the settings changes, select the OK button with the ALT-O hot key or by clicking on it. Selecting the CANCEL button will return to the **Settings** menu. If the CANCEL button is selected before ending the settings changes, then the new settings will not be used.

If the OK button is selected, another dialog box will appear, to confirm the choice to end the settings changes, since protection will be enabled with the new settings. If the user selects the OK button, the setting changes are ended. If the CANCEL button is selected from the confirmation dialog box, the settings changes are not ended and the previous dialog box will be active again.

Save settings to file

This item allows the user to write the settings to a disk file. To select this item, use the ALT-S hot key or click on the menu item with the left mouse button. The user enters a file name (it may also include a path) in the field labeled "Enter file name". The user selects the OK button to save the settings in the specified file. The CANCEL button returns to the **Settings** menu. If CANCEL is selected before saving the settings, no settings will be saved.

The contents of the settings file saved with this menu item are raw numbers; there is no description of the contents in the file because it is used to download settings to the DFM™ relay. Use **Print settings** in the **Settings** menu if a printed description of the settings is desired.

Device parameters

This menu has the following items and hot keys:

change Password	ALT-P
request Model	ALT-M
request sTation/line id	ALT-T
request cOntact converter id	ALT-O
change Station/line id	ALT-S
change Contact converter id	ALT-C
Upgrade model number	ALT-U

change Password

To select this menu item, either click on it with the left mouse button or use the ALT-P hot key. This item allows the user to change the password in the DFM™ relay. The password always consists of ASCII characters, even the factory password. The valid password characters are A to Z, 0 to 9, and space. The factory password contains one or more characters that are not valid for subsequent password use. The Communications (View, Setting, Control) passwords can only be

viewed on the MMI, in encrypted form; therefore it is **IMPORTANT** that the user keep a record of these passwords in a safe place.

First, the user must enter the present password. If the entered password is valid, the user must then enter the new password. If the new password is valid, the user must enter the identical new password again.

The user selects the OK button; this does not yet cause the password to be changed. Next, the user is asked to confirm the change. If the user selects this OK button, the password is changed.

request Model

To select this menu item, either click on it with the left mouse button or use the ALT-M hot key. This item allows the user to display, print and/or file the DFM™ relay's model number and PROM version. To select this menu item, either click on it with the left mouse button or use the ALT-M hot key. Once this item is selected, a dialog box will appear with three independent choices, for displaying, printing, and filing the DFM™ relay's model number and PROM version. To change any of the three choices, either click on it with the left mouse button or use the TAB key to highlight one of the selections and the UP/DOWN ARROW keys to choose one of the three choices. An X in the brackets indicates that choice has been selected, and no X indicates that choice has not been selected. Use the space bar to change any of the choices. At least one must be chosen for the data to be retrieved from the monitor.

If the user chooses to save the report in a file, a file name must be entered in the box supplied. To enter the file name, either move the mouse cursor to the box and click on the left mouse button, or use the TAB key to highlight the box. Once the box has been selected, enter the filename, followed by the ENTER key.

After all the choices have been made, click on the OK button or use the ALT-O hot key to retrieve the model and PROM version from the monitor. Selecting the CANCEL button will return to the **Device parameters** menu without any further action. To clear the model and version from the screen, if they have been displayed, either click on the small box in the upper left corner with the left mouse button, or use the ALT-F4 hot key (F4 is the Function key F4, not the F key followed by the 4 key). Once the model and version have been cleared from the screen, the **request Model** dialog box will be redisplayed. Use the ALT-C hot key or click on the CANCEL button to exit.

request sTation/line id

To select this menu item, either click on it with the left mouse button or use the ALT-T hot key. This dialog box displays the station and line ID of the monitor from which information is being uploaded. Both the station ID and line ID can only be **viewed** with this item. To change the station ID and line ID, select **change Station/line id** from the same menu. When finished viewing the IDs, click on the OK button or use the ALT-O hot key.

request cOntact-converter id

To select this menu item, either click on it with the left mouse button or use the ALT-O hot key. This dialog box displays the contact-converter ID of the monitor from which information is being uploaded. The contact-converter ID can only be **viewed** with this item. To change the contact-converter ID, select **change Contact-converter id** from the same menu. When finished viewing the IDs, click on the OK button or use the ALT-O hot key.

change Station/line id

To select this menu item, either click on it with the left mouse button or use the ALT-S hot key. The dialog box displays the station and line ID for the monitor the user is logged in to. The IDs can be up to 32 characters long and must be all printable characters. To change an ID, select the desired ID with the TAB key or click on it with the left mouse button. Once the correct ID has been selected, use the insert, delete and backspace keys to edit and enter data. After the correct data has been entered, select the OK button by clicking on it with the left mouse button or using the ALT-O hot key.

The user will be asked to confirm the IDs before sending them to the DFM™ relay. Selecting the OK button again will send the IDs to the DFM™ relay. Selecting the CANCEL button in the confirmation dialog box will return the user to the **change Station/line ID** dialog box. Selecting the CANCEL button in the **change Station/line ID** dialog box will simply return the user to the **Device parameters** menu.

change Contact-converter id

To select this menu item, either click on it with the left mouse button or use the ALT-C hot key. The dialog box displays the contact-converter ID for the monitor the user is logged in to. The ID can be up to 32 characters long and must be all printable characters. To change the ID, use the insert, delete and backspace keys to edit and enter data. After the correct data has been entered, select the OK button by clicking on it with the left mouse button or using the ALT-O hot key.

The user will be asked to confirm the IDs before sending them to the DFM™ relay. Selecting the OK button again will send the ID to the DFM™ relay. Selecting the CANCEL button in the confirmation dialog box will return the user to the **change Contact-converter id** dialog box. Selecting the CANCEL button in the **change Contact-converter id** dialog box will simply return the user to the **Device parameters** menu.

Upgrade model number

To select this menu item, either click on it with the left mouse button or use the ALT-U hot key. This item allows the user to change or upgrade the functions available in a particular DFM™ relay by reading an encrypted file keyed to the DFM™ relay's unique serial number. The encrypted file is sold by GE and can only be used to upgrade one particular DFM™ relay. For instance, it is possible to field upgrade a DFM351DB to a DFM351HB (i.e., add IOC/TOC functions) by using this process.

When this item is selected, a dialog box is displayed that allows selection of the filename for the encrypted file. Once the encrypted file is read by DFM-LINK, the serial number embedded in the file is compared with the DFM™ relay's serial number. If the serial numbers are the same, the model number of the DFM™ relay is updated and the additional functions associated with the new model number are enabled.

After completion of this process, logout and login again so that DFM-LINK will read the new model number and use the proper text files. Failure to logout and login results in DFM-LINK using the incorrect settings for the new model number.

TOC Curves

This menu has the following items and hot keys:

Upload TOC curve	ALT-U
dOwnload TOC curve	ALT-O

Upload TOC curve

To select this menu item, either click on it with the left mouse button or use the ALT-U hot key. When this item is selected a dialog box appears that allows selection of one of four user-defined TOC curves to be uploaded to the PC and stored as a file. The dialog box permits selection of the path and filename.

The format of this file is identical to that of a file required to download a TOC curve under **dOwnload TOC curve** below.

dOwnload TOC curve

To select this menu item, either click on it with the left mouse button or use the ALT-O hot key. When this item is selected a dialog box appears that permits selection of a file containing the data for a user-defined TOC curve. Once DFM-LINK reads the file, the curve data will be downloaded to the DFM™ relay as user curve 1, 2, 3, or 4. Note that the file containing the user-defined TOC curve data is not created by DFM-LINK. Another program is used for this purpose.

LOCAL FUNCTIONS

This menu has the following items and hot keys.

Settings...	ALT-S
Graph oscillography data	ALT-G
go to DOS	ALT-D

Settings...

This menu has the following items and hot keys.

Load settings from file	ALT-L
Print local settings	ALT-P
view/change Category of local settings	ALT-C
view/change station/Line id	ALT-L
Save local settings to file	ALT-S
Model/version number	ALT-M
Download local settings	ALT-D
End setting changes	ALT-E

Load settings from file

This item allows the user to read settings from a disk file into the program as local settings. To select this item, either click on it with the left mouse button or use the ALT-L hot key. This permits the user to load and work on another set of settings other than the set that was initially loaded.

If the user then loads another set of local settings, the previous set of local settings is overwritten and lost, unless the user has saved the previous set of local settings by selecting the **Save local settings to file** menu item from the **Settings...** menu.

Once this item has been selected, a dialog box is displayed containing several fields, including a list of files in the current directory and a list of disk drives and subdirectories. A file may be

selected either by entering a file name in the field labeled "File name", or by selecting a file from the list box labeled "Files".

The field marked "File name" contains the file that is currently selected. This field may be selected by the user to specify a file containing settings (a file previously created by the **Save local settings to file** menu item, or the **Save settings to file** menu item under **MONITOR FUNCTIONS**), or enter a partial file name using the standard DOS wild card characters * and ?.

The field labeled "Directory" indicates the current drive and directory from which the list of files is obtained. This field cannot be edited by the user.

The next two fields are list boxes. The list box labeled "Files" contains a list of files in the current directory from which the user can select a file. The list box labeled "Directories" contains a list of subdirectories and drives where the user can go for additional lists of files.

The user selects the OK button to read the local settings from the selected file.

Print local settings

This item allows the user to print all settings or categories of settings. To select this item, use the ALT-P hot key or click on it with the left mouse button. Once this item has been selected, a list box is displayed with the category names, plus one additional item for printing all categories.

The user selects the desired category of settings to print. To select a category that is out of sight, use the PAGE UP/DOWN and ARROW keys or place the mouse cursor in the scroll bar or on the arrows at each end and click on the left mouse button. The highlighted item in the list box is the one that is selected. The user selects the OK button to print the settings. The settings are printed by category, with one setting name and value per line.

view/change Category of local settings

This item allows the user to change or view one or all of the settings in a category. To select this menu item, use the ALT-C hot key or click on the menu item with the left mouse button. Once the menu item has been selected, a list box of category names is displayed. The user must select a category to view or change with the left mouse button or the UP and DOWN ARROW keys followed by the ENTER key. Once a category has been chosen, selecting the OK button will display a dialog box with the settings in the category. Selecting the CANCEL button will return the user to the **Settings** menu.

The dialog box for the category consists of a list box containing the settings, the OK and CANCEL buttons, a box for a setting number to be entered and a box for the setting value to be changed. The TAB key will select any of the above items in the list box. The ARROW keys and PAGE UP/DOWN keys will move the contents to display the unseen settings. A setting can be chosen to be changed, by highlighting it with the cursor keys and then pressing the ENTER key, or clicking on it with the left mouse button. After the setting has been selected, it can be changed in the box marked "Setting Value".

After all the settings changes have been completed, selecting the OK button will save the settings changes and return to the **Settings** menu. Selecting the CANCEL button at any time will return to the category names dialog box without changing any setting present when **view/change Category** was selected, or any further action.

view/change station/Line ID

To select this menu item, either click on it with the left mouse button or use the ALT-L hot key.

The dialog box displays the station and line ID contained in the settings file. The IDs can be up to 32 characters long and must be all printable characters. To change an ID, select the desired ID with the TAB key or click on it with the left mouse button. Once the correct ID has been selected, use the insert, delete and backspace keys to edit and enter data. After the correct data has been entered, select the OK button by clicking on it with the left mouse button or using the ALT-O hot key. Selecting the CANCEL button will simply return the user to the **Settings** menu.

Save local settings to file

This item allows the user to write the settings to a disk file. To select this item, either click on it with the left mouse button or use the ALT-S hot key. The user enters a file name (which may include a path) in the field labeled "Enter file name". Selecting the OK button will save the settings in the specified file. Selecting the CANCEL button will return the user to the **Settings** menu without any further action.

Model/version number

This entry displays the model number and PROM firmware revision that match the settings. To select this item, either click on it with the left mouse button or use the ALT-M hot key. These entries should **match** any monitor to which you wish to send the local settings. If they do not match, the local settings download **will fail.**

Download local settings

This item will appear on the menu only if the Communications access level is Settings. This item allows the user to transmit all the local settings to the DFM™ relay. To select this item, either click on it with the left mouse button or use the ALT-D hot key. The user must be logged in to a DFM™ relay in order to use this menu item. Note that if the user is logged on to the rear communication port and the appropriate jumper is installed, the DFM™ relay will not allow setting changes from the PC. (See the **HARDWARE DESCRIPTION** and **INTERFACE** sections for more information on the jumpers.) The local-settings file firmware revision **must** match the PROM version number in the monitor, or the settings download **will fail.**

Once this item has been selected, a dialog box is displayed containing a list box of all the settings being downloaded, and two selections in the lower right corner to 1) end the settings changes automatically and re-enable monitoring and 2) change station/line ID. To select the automatic end of settings change, either click on it with the left mouse button or use the TAB key to highlight it and the space bar to change it. If an X appears in the brackets, it has been selected. The same procedure is used to select change station/line ID.

To download the settings to the monitor, select the OK button with the mouse or the ALT-O hot key. If the OK button is selected, another dialog box will be displayed to confirm the download. To continue the download process, select the OK button. If the settings are not to be downloaded, then select the CANCEL button.

End setting changes

This item allows the user to tell the DFM™ relay that settings changes are complete and monitoring should be re-enabled. This item is not necessary if the option to end settings changes automatically was selected when the settings were downloaded. To select this item, either click on it with the left mouse button or use the ALT-E hot key.

Once this item has been selected, a dialog box containing the OK and CANCEL buttons is displayed. The user selects the OK button to end setting changes. Selecting the CANCEL button will exit **End setting change** without any further action. If the OK button was selected, another dialog box is displayed to confirm the ending of setting changes. Selecting the CANCEL button will return to the previous dialog box without ending the setting changes. Selecting the OK button will end the settings changes.

Graph oscillography data

The optional program GE-DATA will be started (if present) if this entry is chosen. This enables the user to graph oscillography data without leaving DFM-LINK. The DOS path for the GE-DATA program needs to be entered. The path is entered from the **SETUP** menu (see below) and is stored for later use.

Note: DFM-LINK must be started by running DFM-LINK.BAT to allow starting GE-DATA from within DFM-LINK. If DFM-LINK is started by running DFMLINK.EXE, then GE-DATA cannot be started from within DFM-LINK.

go to DOS

This choice enables the user to leave DFM-LINK temporarily and go to the DOS prompt to execute DOS commands. Any program or command that can run in the available memory can be executed. To return to the DFM-LINK program, type EXIT at the DOS prompt.

SETUP

This menu has the following items and hot keys.

Communication port number	ALT-C
Dial Type	ALT-D
Modem connection time	ALT-M
dIsplay mode	ALT-I
MonitoR parameters	ALT-R
Add monitor to list	ALT-A
dElete monitor from list	ALT-E
Set path for Plot program	ALT-P
Memory Available	no hot key

Communication port number

The communication port for the PC is chosen with this selection. To select this item, either click on it with the left mouse button or use the ALT-C hot key. Once this item is selected, a dialog box containing the port number and IRQ number will be displayed. The serial port that is connected to the DFM™ relay, or the modem used to talk to the DFM™ relay, must be entered before logging in to the monitor. If the port chosen is not COM1(1) or COM2(2), the IRQ number for the port chosen must be entered. Use the TAB key to move between the port and IRQ fields and the buttons, or click on the desired field with the left mouse button.

Once a field has been selected, use the editing keys to change and/or enter data. When the port and IRQ numbers are correct, select the OK button to save the numbers. If the CANCEL button is selected, the **SETUP** menu will be redisplayed without any further action.

Dial type

To select this item, either click on it with the left mouse button or use the ALT-D hot key. Once this item is selected, a dialog box containing the dialing type will be displayed. Either tone or pulse dialing can be chosen. The UP and DOWN ARROW keys will toggle between the tone and pulse choices. The TAB key will move between the selected dialing type and the OK and CANCEL choices in the box. Once the dialing type has been chosen, selecting the OK button will store the change. Selecting the CANCEL button will exit **Dial type** without any further action.

Modem connection time

This item will change the time-out period for DFM-LINK to wait for the modem to make a connection. To select this item, either click on it with the left mouse button or use the ALT-M hot key. The modem connection time can be set for any time up to 999 seconds, provided the modem being used will accommodate that long a time-out period. This setting is useful for applications where the modem is set to pickup after a large number of rings, or if the telephone system has a lot of delay in making the initial connection. Once a connection time has been set, selecting the OK button with the left mouse button or the ALT-O hot key will store the new time-out period. Selecting the CANCEL button will exit this item without any further action.

display mode

This item allows the user to select whether DFM-LINK runs in a color mode or black and white mode on the PC's monitor. To select this item, either click on it with the left mouse button or use the ALT-I hot key. Once a display mode has been chosen, selecting the OK button with the left mouse button or the ALT-O hot key will store the new display mode. Selecting the CANCEL button will exit this item without any further action.

monitoR parameters

Monitor parameters allows the communication parameters for a specific DFM™ relay's unit description to be changed or viewed. An entry in the list must be selected first, by clicking on it with the mouse or using the UP and DOWN ARROW keys to highlight the selection, and pressing the ENTER key.

Once a monitor unit description has been picked, another window appears with the phone number, switch code, baud rate, number of stop bits, parity and a communication channel description for the selected monitor. Any of the entry values may be selected by clicking on it with the mouse or using the TAB key to move between the items, and then using the UP and DOWN ARROW keys to select the value for that item. To exit the dialog box for that unit description, select either the OK button or the CANCEL button. The OK button will accept the values in the dialog box and store them. Selecting the CANCEL button will exit the dialog box and will use the values that were already present when the unit description was selected.

The user should note that once a unit description has been picked, there are no more hot keys available to select items. The TAB key may be used to move from item to item, or the mouse may be used to select a specific item at any time.

To enter or change the phone number, select it by clicking on it with the left mouse button or use the TAB key to move the cursor to the phone number box. The normal text-editing keys may be used to enter or modify the phone number. This is an optional item, and **should only be filled in if DFM-LINK is using a modem to communicate with the unit being described.**

To enter or change the switch code, select it by clicking on it with the left mouse button or use the TAB key to move the cursor to the switch code box. The normal text-editing keys may be used to enter or modify the switch code. This is an optional item, and **should only be filled in if a code-operated switch is being used.**

The baud rate must have one of the values selected. The baud-rate item can be selected by clicking on it with the left mouse button or using the TAB key until the selected item is highlighted. The UP and DOWN ARROW keys select the desired value. A specific value can be selected by clicking on it directly with the left mouse button.

A choice of one, or two, stop bits must be made for communications to work properly. The stop bits item can be selected by clicking on it with the left mouse button or using the TAB key until the selected item is highlighted. The UP and DOWN ARROW keys select the desired value. A specific value can also be selected by clicking on it directly with the left mouse button.

Parity must have one of the values selected for communications to work properly. The parity item can be selected by clicking on it with the left mouse button or using the TAB key until the selected item is highlighted. The UP and DOWN ARROW keys select the desired value. A specific value can also be selected by clicking on it directly with the left mouse button.

Protocol selection is necessary so the PC operates the hardware handshaking properly at the PC communications port. If the PC is communicating to a DFM™ relay through a modem or directly to the DFM™ relay through a cable, RS232 should be selected. If an RS485 protocol converter adapter is in use, select this option. The parity item can be selected by clicking on it with the left mouse button or using the TAB key until the selected item is highlighted. The UP and DOWN ARROW keys select the desired value.

Add monitor to list

Selecting this item will enable the user to add a unit description and the related values to the list of stored monitor unit descriptions. The user can either move the mouse cursor to the entry in the menu and click on the left mouse button or use the hot key ALT-A to select this entry. Once the entry has been selected, the user is prompted for a unit description. The description is limited to 30 characters. After the description has been entered, the user can either click on the OK button with the left mouse button or use the ALT-O hot key to accept it. Selecting the CANCEL button will not add the new unit description and will exit the user from the menu entry.

After the new unit description has been accepted, a dialog box will appear with the phone number, switch code, baud rate, stop bits, parity items and protocol description. Each item can be selected with the TAB or SHIFT TAB key and a value chosen with the UP and DOWN ARROW keys, or a value can be chosen by placing the mouse cursor over the desired value and clicking on the left mouse button.

dElete monitor from list

This item allows the user to delete a monitor unit description from the configuration file. To select this item, either click on it with the left mouse button or use the ALT-E hot key. Once this item has been selected, a dialog box will be displayed containing a list box with all the monitor unit descriptions and the OK and CANCEL buttons.

The user selects the desired monitor from a list box displaying the unit descriptions by using the UP and DOWN ARROW keys to highlight the desired monitor and pressing the ENTER key, or moving the mouse cursor to the desired monitor and clicking on it with the left mouse button. Selecting the OK button with the ALT-O hot key or clicking on it with the left mouse button will mark the unit description for deletion. Selecting the CANCEL button will exit without deleting

any monitor unit descriptions. If the OK button is selected, the user is asked to confirm the deletion of the unit description. Selecting the OK button will delete the monitor unit description. Selecting the CANCEL button will return to the list box without deleting any monitor unit description. Selecting the CANCEL button in the dialog box will exit from the menu entry.

set path for Plot program

GE-DATA (optional) can be started from DFM-LINK from the **LOCAL FUNCTIONS** menu if DFM-LINK has been started by running DFM-LINK.BAT. The DOS path must first be set so DFM-LINK knows from where to start the program. To set the path, select this menu item by using the hot key ALT-P or click on it with the left mouse button. A dialog box will appear, with space to enter a path. After entering the path, select the OK button to accept the new path, or the CANCEL button to exit without changing the previous path.

Memory available

To display the amount of available memory while DFM-LINK is running, either click on this menu item with the left mouse button, or use the UP or DOWN ARROW keys to highlight the menu item, and press the ENTER key. There is no hot key for this item.

HELP

This item displays a pull-down menu with a selection of topics for which help exists. This pull-down menu is different from the other pull-down menus in that the items do not have hot keys associated with them. The user must either click on the mouse or use the UP and DOWN ARROW keys followed by the ENTER key, to access the menu items.

Exiting the DFM-LINK Program

There are two ways to exit DFM-LINK:

ALT-F4 will produce a dialog box with the exit message. Selecting the OK button with the mouse or using the ALT-O hot key will exit DFM-LINK. Selecting the CANCEL button will return to the program without exiting.

The ALT key combined with the space bar will produce the System Menu after all menus have been cleared from the screen. Choosing the CLOSE entry, with the mouse or the hot key ALT-C, will produce a dialog box with the exit message. Selecting the OK button with the mouse or using the ALT-O hot key will exit DFM-LINK. Selecting the CANCEL button will return to the program without exiting.

NOTE: To exit DFM-LINK, all dialog boxes and list boxes must be cleared from the screen. It is not necessary to clear all the menus from the screen.

GE Power Management

215 Anderson Avenue
Markham, Ontario
Canada L6E 1B3
Tel: (905) 294-6222
Fax: (905) 201-2098
www.ge.com/indsys/pm