WARNING

Because of possible shock or fire hazards, connection of this instrument should be performed in compliance with the National Electric Code (ANSI C2-1990) or any other requirements applicable to your installation. Installing, operating, and maintaining this instrument should be performed only by qualified personnel.

TM-115000-G1
OPERATOR'S MANUAL
VOLUME 1

DRANETZ MODEL 658
POWER QUALITY ANALYZER

January 1, 1991

Change 5 - June 15, 1992

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List of Effective Pages

Page No.	Change No. *
Title	5
ii	
iii thru v	
vi thru viii	
ix and x	4
1-1	4
1-2 thru 1-4	0
1-5 and 1-6	5
1-7 thru 1-18	0
1-19 and 1-20	5
1-21	3
1-22 (Blank)	0
2-1 and 2-2	0
2-3	3
2-4	2
2-5 thru 2-16	0
2-17/2-18	5
2-19 thru 2-21	0
2-22	1
2-23	0
2-24	1
2-25 thru 2-36	0
2-37	1
[illegible] thru 2-49	0
	1
[illegible]u 2-65	0
	1
	0
	1
thru 2-73	0
74	1
2-75 thru 2-80	0
2-81 thru 2-85	5
2-86	2
2-87	1
2-88 and 2-89	4
2-90 thru 2-96	0
2-97 and 2-98	5
2-98A and 2-98B	5
2-99 and 2-100	4
3-1 and 3-2	0
Appendixes	
A-1 thru A-3	0
A-4 (Blank)	0
B-1 thru B-5	0
B-6 (Blank)	0
C-1 thru C-4	
D-1 thru D-4	0

* Zero in this column indicates an original page.

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The information in this manual has been reviewed and is believed to be entirely reliable, however, no responsibility is assumed for any inaccuracies. All material is for information purposes only and is subject to change without prior notice.

NOTICE REGARDING FCC COMPLIANCE

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

APPENDIX A
SERIES 658 HARDWARE AND SOFTWARE ERROR MESSAGES

APPENDIX B
EXAMPLE WAVEFORM DISTURBANCES

APPENDIX C
MAIN AND SENSOR (TRANSDUCER) CHANNEL SETUP SCREENS

APPENDIX D
HARMONIC DISTORTION ANALYSIS

LIST OF ILLUSTRATIONS

LIST OF TABLES

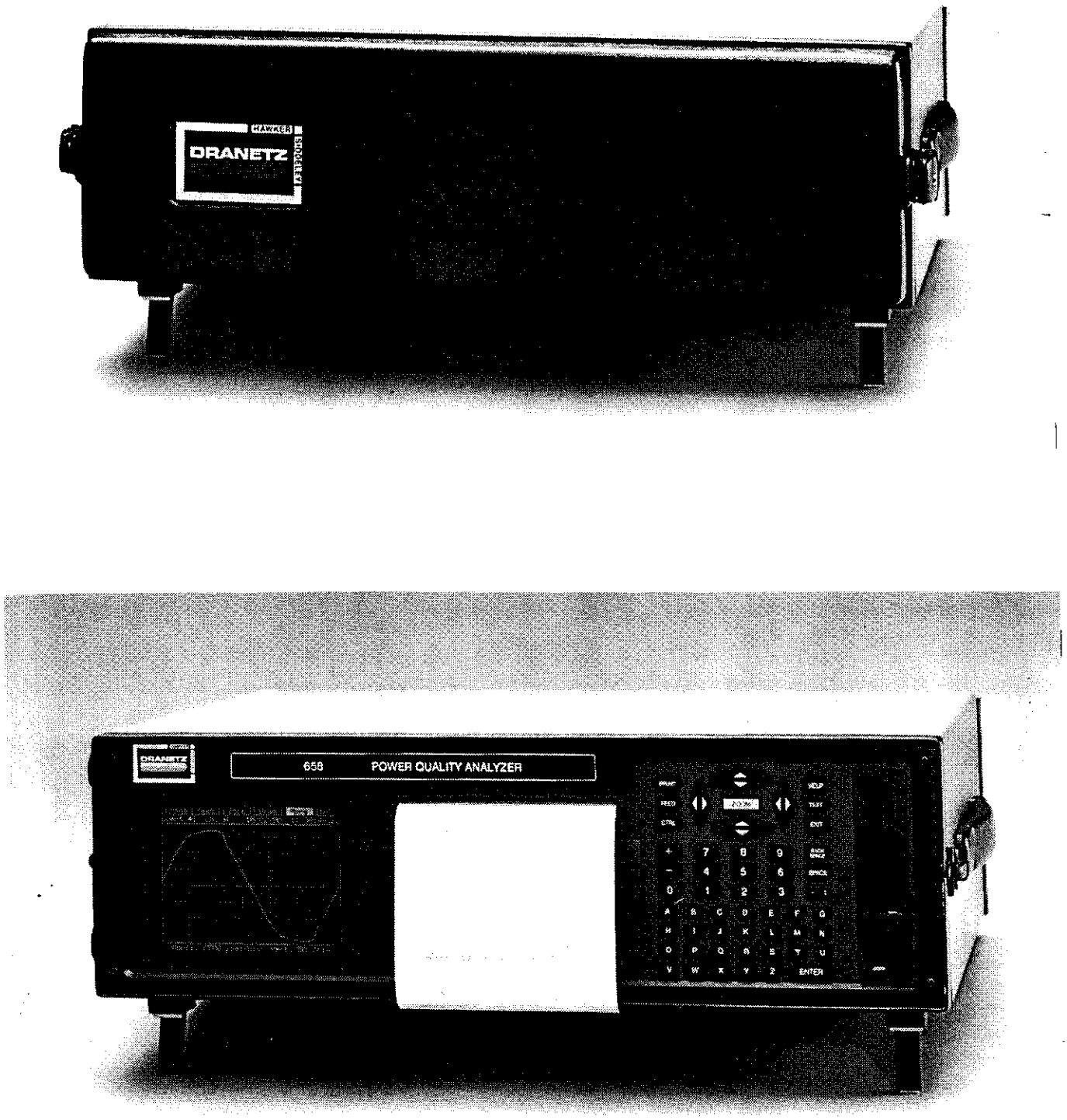


Figure 1-1. POWER QUALITY ANALYZER, Model 658

VOLUME 1
OPERATOR'S MANUAL

658 POWER QUALITY ANALYZER

SECTION I
GENERAL INFORMATION

1.1 SCOPE

The complete manual for the Model 658 consists of two volumes. You are reading Volume 1, the Operator's manual, which is divided into three main sections:

I. GENERAL INFORMATION
II. INSTALLATION AND OPERATION
III. OPERATIONAL TESTS

The appendices in the back of this manual provide further information on the hardware/software error messages, example waveforms, and Setup screens.

Volume 2, the Service/Maintenance manual, contains four sections (refer to subsection 1.10 for information on obtaining Volume 2):

IV. THEORY OF OPERATION
V. MAINTENANCE AND CALIBRATION
VI. REPLACEABLE PARTS
VII. SCHEMATICS AND ASSEMBLIES

1.1.1 General Conventions when Reading this Manual

Buttons and switches are capitalized; single keystroke commands and function keys such as *<ENTER>*, *<BACK SPACE>*, *<A>*, *<T>* and so forth, are italicized and displayed in brackets. Screen displays of printouts and graphs are indented from the margins.

1.2 INTRODUCTION

Congratulations on your purchase of the Dranetz 658 Power Quality Analyzer, Figure 1-1. We are confident you will be delighted with the unit's unique analyzing capabilities, as well as its ability to download events to a disk for permanent storage and later recall. The 658 is a powerful, self-contained, portable instrument that captures, records, analyzes, and displays AC and DC power line disturbances on four power acquisition channels. The 658 monitors current as well as voltage, and has the ability to calculate the total harmonic distortion (THD) of input signals. With available options installed, the 658 also monitors radiated and conducted RF (radio frequency) energy levels and environmental temperature and humidity changes using its Sensor (transducer) channels.

1.3 APPLICATIONS AND PURPOSE

The 658 captures, records, stores, analyzes, and displays power line disturbances affecting reliable operation of sensitive electronic, computer-based equipment. With its options installed, you can also capture, record, store, analyze, and display environmental parameters such as temperature and humidity changes, conducted radio frequency interference, and radiated radio frequency interference.

You preset the 658 to record events exceeding your threshold criteria. Once recorded, these disturbances and changes can be analyzed on screen, saved to a disk, printed for hard copy analysis, transmitted to another 658 through a modem or direct RS-232C connection, and analyzed on a PC using Dranetz 658 Graphical and Harmonic Analysis Software (P/N 658-OS-2001).

You can perform broad or detailed event analysis right on the 658 screen. For broad analysis you can display a series of related events. For detailed analysis you can display a high-resolution view of an individual event, or a harmonic analysis up to the 50th harmonic can be performed on any complete line frequency (50/60 Hz) cycle in a recorded waveform event.

The 658 Power Quality Analyzer can be used to view all data recorded on a Model 656 or 656A. However, the reverse is not true, unless the 656A is operating with version 3.0, or greater, of the Operating System.

1.4 FEATURES

The 658 operates on microprocessor based hardware, is self-contained and portable, and has the following features:

- Two MC68000 microprocessors: 16/32-bit architecture
- Menu prompts with available "Help" screens
- Four Main input channels for graphical disturbance recording
- Eight Sensor input channels for environmental monitoring (Optional)
- Monitoring of 50/60Hz signals (400Hz optional)
- Two RS-232C compatible serial ports (1 PC or modem interface, 1 Printer interface)
- High-resolution electroluminescent display
- Built-in high-resolution thermal printer
- Single 3.5 inch disk drive
- Built-in real-time clock with 10 mS resolution
- Built-in UPS for continued operation during power outages
- Zoom feature for enlarging any portions of waveforms and digital measurements
- Non-volatile memory of 1/2 Mbyte for long-term monitoring and data storage
- Optional internal 2400 baud Hayes compatible modem

- Harmonic distortion analysis (50/60Hz only)
- Real-time display (Scope Mode) of any voltage or current input

1.4.1 Using the Cursor Keys, Dedicated Keys, Alphanumeric Keys, and Zoom Feature

The cursor keys, dedicated keys, and alphanumeric keys are used to select menus and menu options throughout the operation of the 658.

The cursor keys are primarily used to select menu and menu options due to their simplicity in movement to select either horizontal or vertical items. In addition, the cursor keys control zoom window dimensions.

Some of the more frequently used functions have dedicated keys such as *<PRINT>*, *<FEED>*, *<EXIT>*, *<HELP>* etc. Each of these keys is described in detail in that functional operation where it is used.

Alphanumeric keys are used for entering site information as well as selecting commands and options. One key, designated period (.) and semicolon (:), is software selectable dependent on the text being changed.

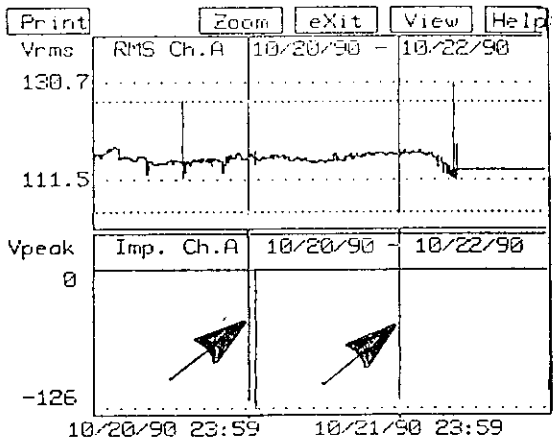
Menu Selection

Menu selections are made either through selection of the corresponding line number by a keyboard numeric key or by using the cursor for highlighting the line (up/down cursor) or option (left/right cursor) and then pressing ENTER. The cursor keys let you make selections in four axes; up, down, left, and right. By applying gentle pressure with your index finger and pivoting it while pressing any one cursor, provides two axes control of that cursor. Position of the cursor in menu selection is only in the vertical axis to highlight a selection. The cursors provide for left/right movement for option selection; whereas up/down movement provide for increasing/decreasing a range of values.

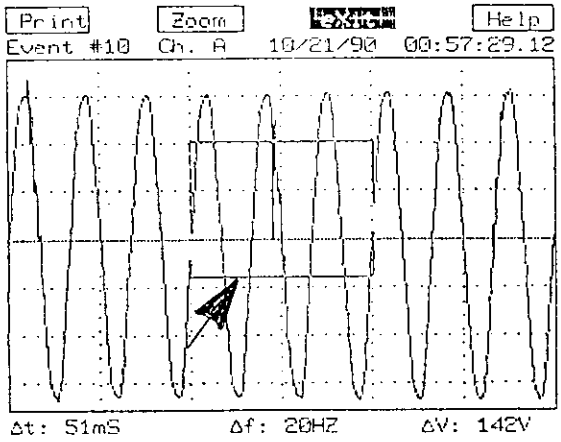
If you feel more comfortable using the alphanumeric keys to make selections and entries, use them instead (you are prompted on the screen with the corresponding number key to enter, or by the capitalized letter in each option or command).

Zoom Feature

The *<ZOOM>* key enables the Zoom feature to let you enlarge any portion of a graphic summary or displayed waveform event (see figures on next page). When selecting zoom in a graphic summary, two vertical lines (zoom markers) appear; when selecting zoom in a waveform event, a square box (zoom box) appears. The area enclosed by the zoom box or markers (referred to as the Zoom Window) expands to the full size of the waveform or graph portion of the screen when Zoom is selected a second time. The Zoom feature is explained in detail in those functional operations where it is used.



Zoom Markers



Zoom Box

1.4.2 Distinctive Operation

Most data analyzers print events on paper as they occur, often resulting in a lot of wasted paper. The 658 is distinct in that it internally stores large amounts of event data without necessarily printing or displaying it. When you want a graphic summary of the events that have occurred, you can go through the GRAPHIC SUMMARIES MENU to display all of the events or only the ones you want. You can also go to the VIEW EVENTS MENU to view a particular event. If you want a paper printout (for reports, analysis, and so forth), the internal or an external printer can print a copy of the individual event or a graphic summary of a series of events. You can then use this information for fast and easy solutions to your most intricate power problems.

Another distinctive feature of the 658 is that it monitors RMS disturbances on a cycle by cycle (50/60 Hz) basis, rather than averaging multiple cycles as other waveform analyzers might do. And it saves raw data sample points to the disk (not just graphic picture files) allowing later post-processing and analysis.

1.4.3 Overview of Operation

The 658 is designed for easy operation. All selections and entries are prompted by the display, and the Operator is never more than a keystroke away from a "Help" screen. This lets you run the 658 without having to continually refer to this manual for instructions.

Main Input Channel Monitoring

There are four Main input channels (A, B, C, and D). Each Main input channel can monitor AC voltage, neutral-to-ground voltage, or DC voltage on either a low (0 to 60 V RMS) or high (0 to 600 V RMS) range. Channels B, C, and D can also monitor current on ranges of 0 to 5, 0 to 30, 1 to 300, or 10 to 3000 A RMS. RMS for both voltage and current is monitored on a cycle by cycle basis for deviation from user set limits.

NOTE: *Most example screens in this manual illustrate voltage displays. In current displays, "Arms" and "Apeak" would replace "Vrms" and "Vpeak".*

WARNING

Before attempting Main input channel monitoring, ground channel A to a verified safety ground (using the grounding lug on the rear panel).[1]

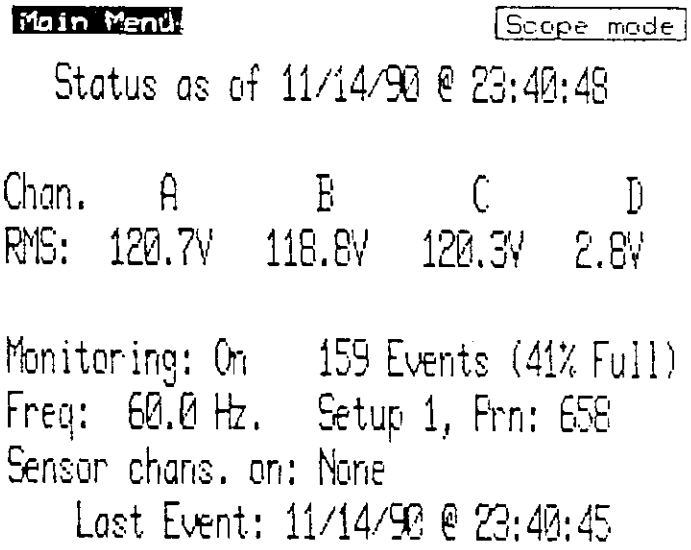
Sensor Channel Monitoring (Optional)
The Sensor channels are used for environmental monitoring. Options are available to monitor environmental temperature and humidity changes, conducted RF (radio frequency) energy, and radiated RF energy.

Primary Synchronization
By convention, channel A is the primary synchronization channel.[2] If a synchronization signal is not available on channel A, synchronization automatically switches to the next active channel (B then C then D).

NOTE: *The synchronization signal should be referenced to an AC voltage waveform, not a current waveform.*

Monitoring Status Screen and the Initial Reference Readings
When you turn on the 658, you'll hear beeps indicating that the power on event, main channel waveform(s), RMS, and frequency events have been recorded.

The first display shown after power turn-on is the Status Screen shown below. This screen provides the current date and time and monitoring information on the RMS values and frequency of the four main channels; A, B, C, and D. This information is updated once per second. In addition, the screen provides information on the number of events currently in memory and the memory capacity; monitoring set-up number (1 out of 16); printer being used (658 is the internal printer); and the monitoring condition of the sensor channels, if used (optional). The last item of information is the last event recorded and its date and time to the second. From the Status Screen you may select to view the current main channel waveforms, or set-up monitoring, review previously recorded events, or many other functions available by selecting the Main Menu.



[1] This grounding lug is common with the instrument frame and the power cord ground. See subsections 2.4.3, 2.4.5, and 4.5.2 for further details.

[2] If the synchronization channel drops out, the RMS calculation window defaults to a length of approximately four 45 Hz periods until re-synchronization occurs.

Selecting Scope Mode will allow real-time viewing of the active main input channel waveforms. The display is updated once a second. Any or all channels waveforms may be viewed simultaneously, and may be saved for future reference and analysis.

Event Recording

Other than the standard events recorded when the 658 is first turned on, events are also recorded with any of the following occurrences:

NOTE: *RMS voltages and currents are calculated on a single cycle basis from one positive zero crossing to the next positive zero crossing.*

- When the monitored waveform for a channel deviates by more than the programmed RMS sensitivity from the last cycle of the last event for that channel.[3]
- When an impulse on a channel exceeds the impulse sensitivity threshold (V peak or A peak) for that channel.[3]
- When the Synchronization channel's frequency (averaged over 20 cycles) changes from the last recorded frequency by more than the programmed sensitivity for that channel.
- When a Sensor channel's input changes from the previous reading by more than the programmed sensitivity for that channel.
- When the RMS of any cycle goes above or below the user set limits.
- When the RMS of any cycle changes by more than the user set sensitivity from the previously recorded RMS while out of limits.
- When the RMS of any cycle returns to the user set limits.
- If no RMS or waveform event described above is recorded, a pseudo event is recorded every fifteen minutes (default time). These pseudo-events are not given event numbers (and therefore are not viewable), but are used to increase the number of plot points on long-term Graphic Summaries, thereby increasing accuracy of the information presented on these plots. The time period of the pseudo events is selectable and is described in subsection 2.14 under 658 System Tools Menu, Selection 4 - Pseudo-event timer.
- When the <A>ctivate option is selected from the Main Channel Setups screen, an initial event is recorded and all setup information is saved.

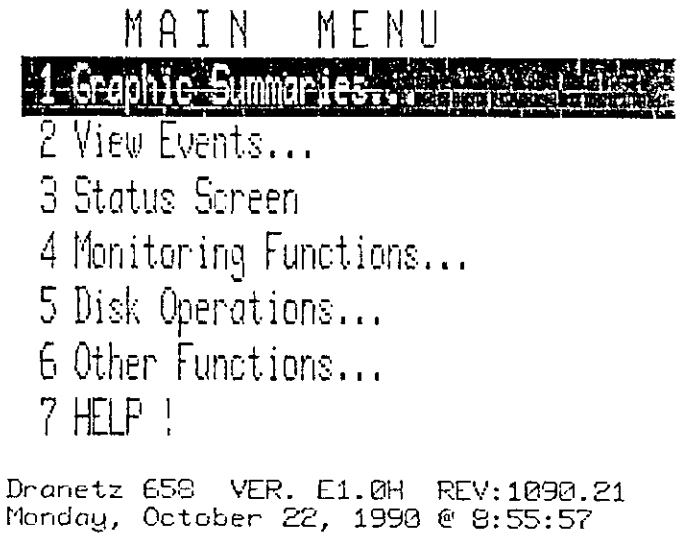
Diagnosing Power Problems

Refer to Section II of this manual for detailed instructions of the following menus. These menus are provided as an example to get you acquainted with diagnosing power problems.

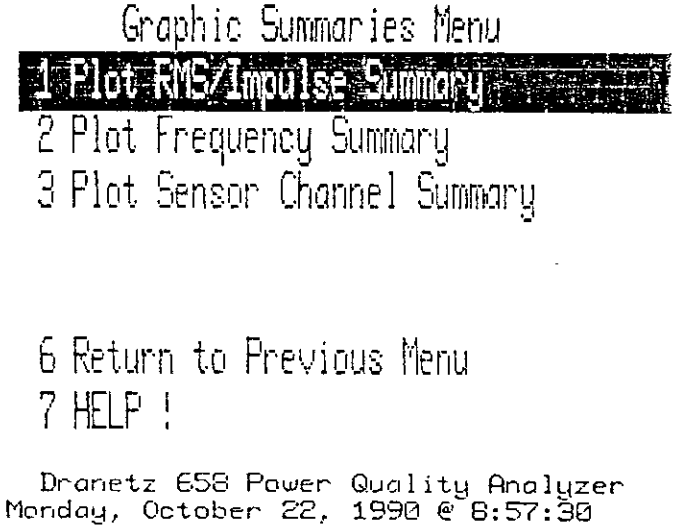
[3] When this type of event occurs, a "snapshot" of each monitored main channel is taken, allowing you to compare the activity on different channels at that precise instant.

Power problems can be diagnosed as follows:

1. Starting at the 658 MAIN MENU:

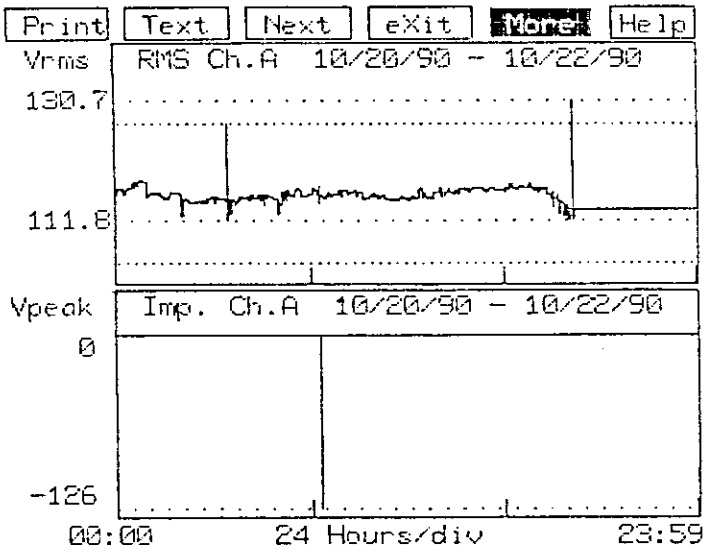


2. Press <*1*> or <ENTER> for the GRAPHICS SUMMARIES MENU:



3. Press <*1*> or <ENTER> for the PLOT RMS/IMPULSE SUMMARY MENU:

4. Pressing <*1*> or <ENTER> at this point alternates the channel from "A" to "B" to "C" to "D" to "A", and so forth. Once the proper channel is displayed, you could select <*2*>, <*3*>, <*4*>, or <*5*>, depending on the time span you want to examine. For example: If you selected <*2*> to plot multiple days, you would be prompted for a starting date and an ending date. An RMS/Impulse plot of events in memory between the dates you enter is displayed:



The above display illustrates RMS voltage changes (top) and impulses (bottom) recorded between 10/20/90 and 10/22/90.[4]

[4] A detailed description of the available menu options is located in subsection 2.8.1.5.

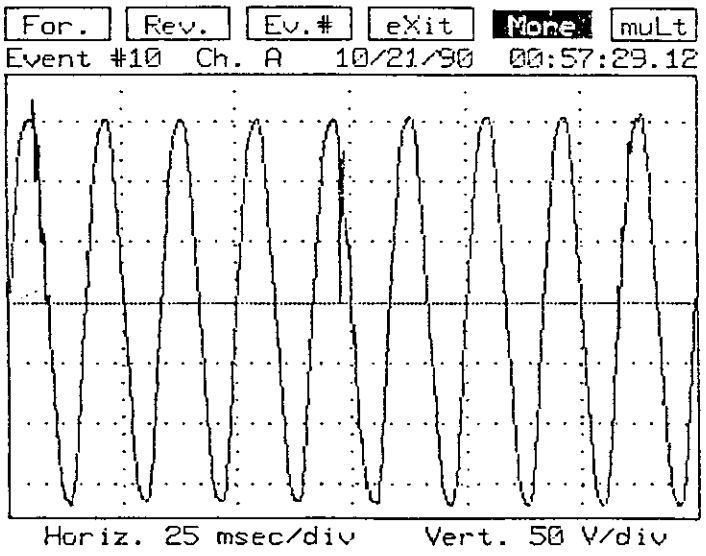
5. If desired, you could press <7EXT> for a description of the display. The following display describes the RMS/Impulse Plot summary above:

```
Print        eXit        Help

        Ch. A RMS/Impulse Plot Summary

    DRANETZ 658 Power Quality Analyzer

      Start Time: 10/20/90  00:00:00
      End Time:   10/22/90  23:59:59
            Worst RMS Events
   Max Value = 130.7 Vrms  Ev # 17
   Min Value = 111.8 Vrms
   High Limit = 127.0 Vrms
   Low  Limit = 105.0 Vrms
          # Impulse Events = 1
Worst Pos Value = 0 Vpeak
Worst Neg Value = -126 Vpeak  Ev # 10
```

The High and Low Limits reported here are the settings which were active for the most recent event in the plot, regardless of how many times these limits may have been changed.

The event numbers for the events where the summary begins and ends, as well as for the events containing the minimum and maximum RMS values are indicated unless the event was a "pseudo-event" (explained under "Event Recording" in subsection 1.4.2).

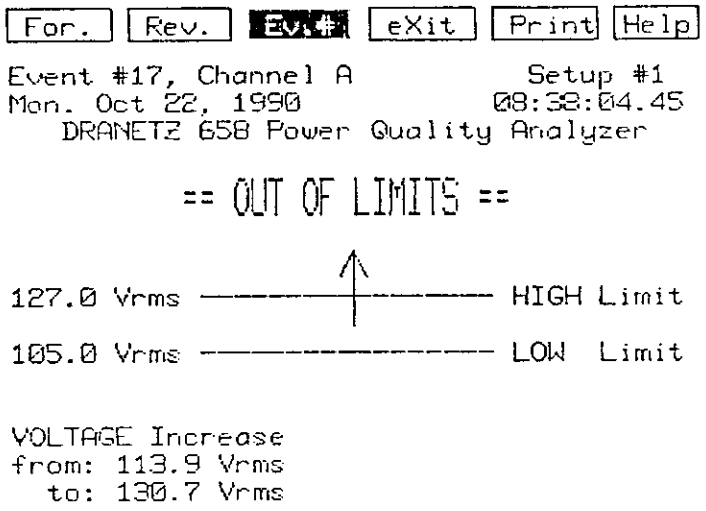
6. Once you have a general idea of the events which have occurred, you can narrow the interval to be searched or you can view individual events (refer to subsection 2.10.2). When viewing individual events, you can page forward or backwards through all events in Memory. These include RMS events (triggered by the RMS HI/LO/SENS thresholds); waveform events (triggered by the Wave or Impulse thresholds); or other events such as frequency or sensor channel changes. A sample waveform event appears below[5].



[5] If current was recorded instead of voltage, "A/div" would replace "V/div".

7. When viewing waveform events, you can zoom in on a smaller segment of the waveform, view a textual description of the display, perform a harmonic analysis or print the display.

8. When viewing RMS events, you can quickly see if the event was caused by the RMS going above or below the user-set limits, by a change in the RMS greater than the user-set sensitivity while out of limits, or by the RMS returning to within limits. In the display below, the RMS exceeded the user-set High Limit of 127 V:



9. When viewing individual events, the thresholds used for recording any particular event can be obtained by paging back to the most recent "Initial RMS event" prior to the individual event in question, and selecting to view Main or Sensor Channel settings.

Downward Compatibility

Version 3.x of the 658 Operating System can read in and analyze data recorded on earlier versions of the Operating System, read by a 656 Version 1.X or 656A Version 2.X.

1.5 GENERAL OVERALL DESCRIPTION

Front and rear panel views of the 658 are illustrated in FIGURES 1-1 and 1-2.

Subsections 1.5.1 and 1.5.2 list the visible parts of the front and rear panels. (For illustrative purposes, the keyboard is considered part of the front panel.) Subsections 1.6 through 1.6.10 describe the main sections of the 658, including the connecting cables.

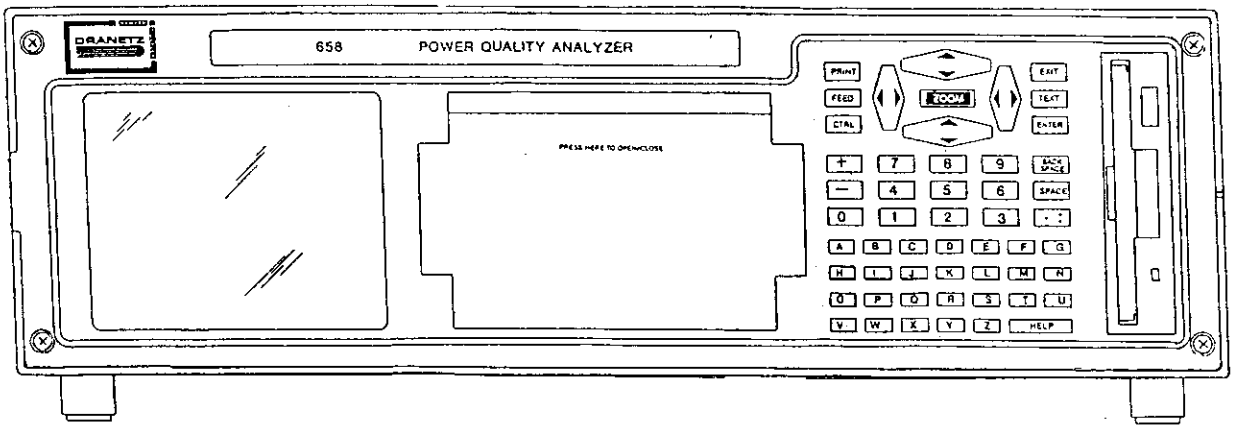
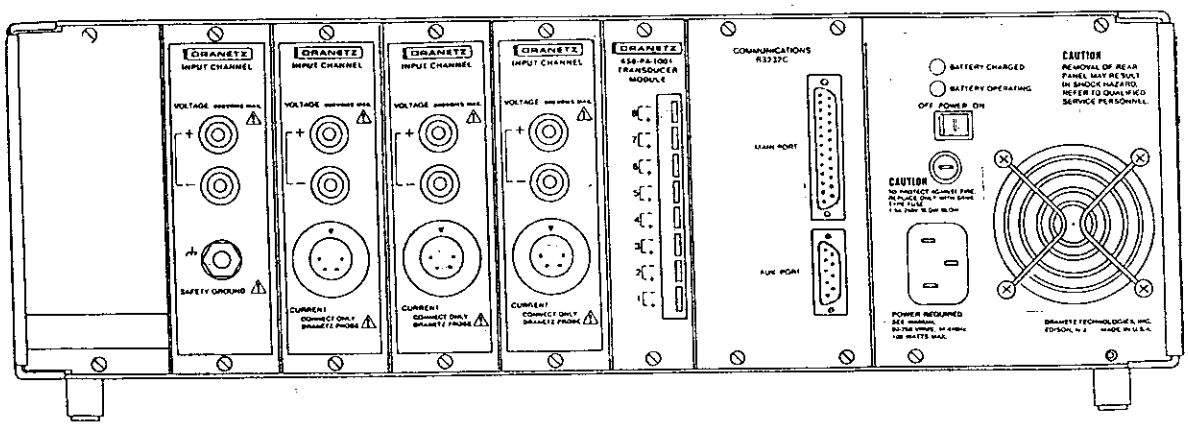


FIGURE 1-2. MODEL 658 FRONT PANEL



(Optional Transducer Module Shown)

FIGURE 1-3. MODEL 658 REAR PANEL

1.5.1 Front Panel

The front panel illustrated in FIGURE 1-2 contains the following sections:

- 5" diagonal high-resolution Electroluminescent screen
- 3.5" disk drive - Events and setups are stored and retrieved on the disk drive
- 4" wide Thermal Printer
- Dedicated keys which include the following:
  <*ZOOM*> - Selects Zoom feature for graphs and waveshapes
  <*PRINT*> - Print display information
  <*FEED*> - Advance thermal paper
  <*CTRL*> - Used with key letters to control printing of full display, lock/unlock keyboard, abort/terminate RS232C communications
  <*EXIT*> - Exit out of menus or from last function
  <*TEXT*> - Selects text mode associated with graph or waveform
  <*ENTER*> - Enter data into computer for selection or computation
  <*HELP*> - Selects HELP screen to provide additional data for understanding function or menu selection

  Cursor Keys - Also called Arrow keys (<, >, ∧, ∨). Provide 4 axes control of text, highlighted commands and zoom feature position

  Alphanumeric Keyboard - Provide capital letter keys <*A*> thru <*Z*>, <*0*> thru <*9*>, <+>, <->, <.>, </>, <:>, <*SPACE*> and <*BACK SPACE*>.

1.5.2 Rear Panel

The rear panel illustrated in FIGURE 1-3 contains the following sections:

- Power supply fan
- ON/OFF switch
- "BATTERY CHARGED" and "BATTERY OPERATING" indicators
- AC power cord receptacle
- Main Port (25-pin RS-232C female serial port)
- Auxiliary Port (9-pin RS-232C compatible female serial port)
- Four Main Channel inputs for power disturbance monitoring
- Eight optional Sensor channel inputs for environmental monitoring
- Fuse

1.6 INPUT AND OUTPUT SECTIONS

The following subsections contain information on the input and output portions of the 658.

1.6.1 Thermal Printer

NOTE: *Never allow the 658 printer to operate without paper because doing so could damage the print head.*

The 658 thermal printer provides paper printouts of screen displays. Certain menus allow you to select a capitalized print option which prints out the screen display with the site descriptor replacing the menu options. You can get a printout of any screen in its entirety (including the menu options) by holding down *<CTRL>* and pressing *<P>*, or pressing *<CTRL>* *<PRINT>*.

1.6.1.1 Changing a Roll of Thermal Paper

1. Stand the Mainframe in its operating position on a flat surface.
2. Press and hold the FEED button to eject any paper left in the printer.
3. Open the printer compartment by pushing the door and quickly releasing it. A light pull on the top of the door will release it from its catches. The bottom hinged door may now be flipped down.
4. Hold the empty spool with one hand and push outwards on either side spring clip to release spool, then pull out spool.
5. Slide empty spool off plastic shaft.
6. Reinsert the shaft in a new roll of paper.
7. Orient the roll so the paper feeds from the back of the roll going up. Gently insert the roll into the compartment until the shaft engages the holes in the spring clips
8. Using scissors, make a straight cut across the leading edge of the paper.
9. Feed the paper about 1/4 inch into the lower "in" feed slot (just above the roll).
10. While gently working the paper into the printer, press and hold the FEED button until the paper goes through the print head and reappears at the "out" feed slot just below the tear-bar (3/4 of an inch above the "in" slot). MAKE SURE THE PAPER FEEDS EVENLY.
11. Push the printer door in until it locks. The paper should be visible just below the tear-bar. If not, press and hold the FEED button until it comes into view.

NOTE: *If the thermal paper is installed backward, the thermal printer will not print an image on the paper.*

1.6.1.2 Reordering Thermal Paper

Thermal paper for the 658 thermal printer may be ordered from your authorized Dranetz representative or directly from Dranetz (P/N 110888-G1) by calling or writing:

Dranetz Technologies, Inc.	Tel:	(908) 287-3680
1000 New Durham Road	FAX:	(908) 287-8627
Edison, NJ 08818-4019	TWX:	(710) 997-9553
	Telex:	499-7808
Attention: Order Entry	Cable:	DRANETZ

1-800-372-6832

CAUTION

Using thermal paper other than that supplied by Dranetz Technologies, Inc. or its authorized representatives may damage the print head.

1.6.2 Electroluminescent (EL) Display

The glare resistant EL Display provides menu displays for guiding you through operations, lists "Help" screens describing menu choices and what they mean, and displays high-resolution pictures of waveforms and text displays. When a waveform is displayed, you can zoom in any portion of a waveform to take a closer look at it.

658 units have a screen blanking feature. If the keyboard is not used for a period of five minutes, the screen goes blank. The image resumes as soon as any key on the keyboard is pressed This feature helps to preserve screen life and save power consumption. The screen is also blanked when the unit is running on its internal battery.

1.6.3 Disk Drive

The 658 has a 3.5 inch disk drive. The drive is used for saving and loading system setups and recorded events.

1.6.3.1 Disks

The 658 is shipped with one blank (unformatted) disk. For best results, always use high quality, double sided, double density (DS-DD) disks. If you need additional disks, see subsection 1.10.

To write protect a disk, open the tab at the bottom corner of the disk. When the slot is open, you cannot write to the disk. To write to a disk, close the slot.

1.6.3.2 Cleaning the Disk Drive

After extended use, the disk drive will become dirty and requires cleaning. Only use a quality 3.5 inch disk drive cleaning kit and follow its directions for preparing the cleaning disk. To clean the disk drive, follow the procedure for initializing a disk (subsection 2.11.3), but use the cleaning disk and ignore the error messages that appear on the screen.

1.6.4 Keyboard

The keyboard allows you to select menu items, enter data, and type commands.

NOTE: *The keyboard contains a "locking" function, which locks-out commands to the keyboard.. Refer to Subsection 2.7 for information on this feature.*

1.6.5 Power Supply

The Power Supply module in the rear of the Mainframe allows operation within 90 to 250 V RMS at 50 to 400 Hz. The power cord attaches to the power cord receptacle. The module is cooled by an internal fan and an ON/OFF rocker switch turns the 658 on and off.

1.6.6 Battery Pack

When the 658 is on, the "BATTERY CHARGED" LED indicates that the internal UPS (Uninterruptable Power Supply) battery pack is charged. If line voltage fails, the "BATTERY OPERATING" LED lights to indicate UPS operation. The UPS maintains operation for about 5 minutes if power is temporarily lost. The display is blanked during this time to save power.

1.6.7 Communication Ports

The rear panel contains two serial communication ports: A Main Port and an Auxiliary Port. (Refer to subsections 2.12.1.1 and 2.12.1.2 for Main Port description and cable connection information. Refer to subsections 2.13.1.1 and 2.13.1.2 for Auxiliary Port description and cable connection information.)

1.6.8 Main Input Channels for Power Line Disturbance Monitoring

Refer to TABLE 1-1 for technical specifications. Four rear panel voltage inputs and 3 rear panel current inputs allow the 658 to analyze synchronous, multiphase AC power lines of up to 600 V RMS and 30, 300, or 3000 A RMS (depending on your choice of current probes).

WARNING

To avoid serious injury, only use the safety plugs provided with the instrument.

Below is an illustration of the four Main input channels:

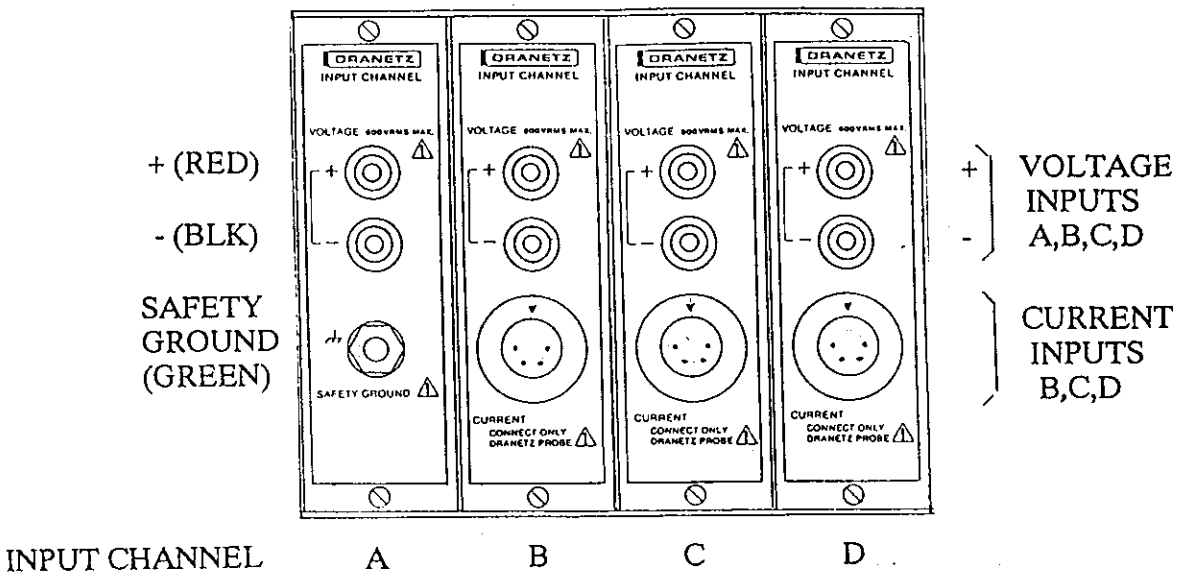


Figure 1-4. Main Input Channels

1.6.9 Sensor Input Channels for Environmental Monitoring (Optional)

A single 16-position removeable terminal block is provided for wiring up to eight Sensor input channels.[6] The terminal block is labelled "Transducer Channels", although the menus and other references commonly refer to "Sensor channels". It is much easier to wire this connector before inserting it into the Mainframe than once it's in the Mainframe. The channels applying to each available Sensor input channel option are illustrated in FIGURE 1-5.

NOTE: *DO NOT remove the installed shorting jumpers unless connecting a transducer to that channel, otherwise input voltage for that sensor channel could float above 0 and spurious events could result. If the transducer is disconnected at a later time, re-connect the jumper between the "+" and "-" terminals for that channel.*

[6] Refer to subsection 2.4.6 for information on connecting the Sensor Channels.

NOTE: *All eight Sensor channels are factory preset for 0-10 V input. To change any input to 0-40 mA, contact Dranetz Customer Service Department for instructions (see subsection 1.11).*

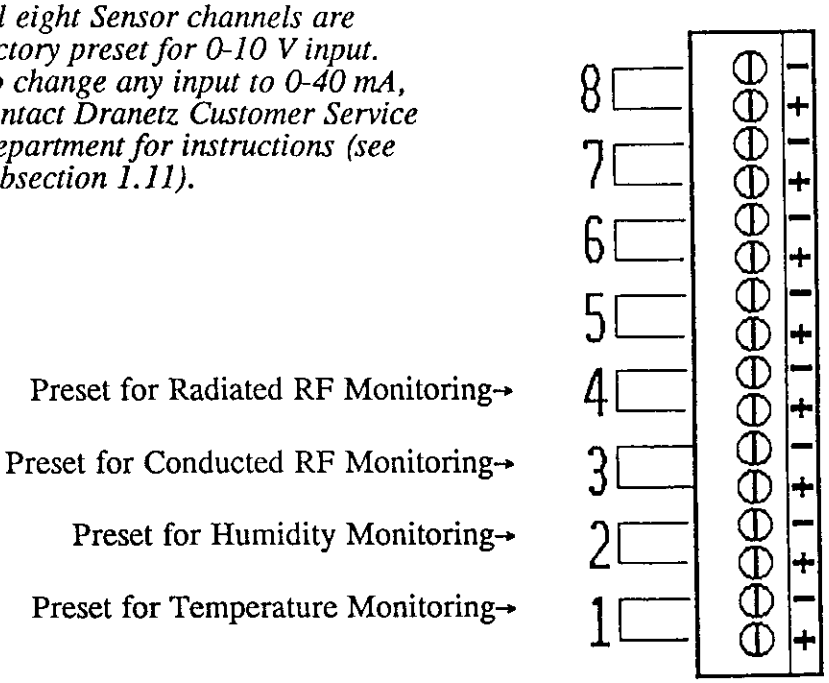


Figure 1-5. Sensor Input Channel Strip with Corresponding Sensor Options

1.6.10 Real-Time Clock

A crystal controlled real-time clock is built into the Mainframe. The clock is battery backed with an estimated 10-year life. Time appears in 24-hour military format (hours, minutes, seconds, and hundredths of seconds) with a 10 mS resolution.

1.6.11 Beeper

The 658 produces a beep at power-on and whenever a new event occurs. The beeper can be turned on and off under the Other Functions Menu.

1.7 REMOTE OPERATION[7]

Event data and system setups can be transferred between two 658 Mainframes[8], or, using applicable software, between a 658 and a personal computer. The transfer can take place in one of two ways:

1) over the telephone lines using a modem at each site; or

2) through an RS-232C direct connection if the two sites are within 50 feet of each other.

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[7] Refer to subsections 2.12 through 2.12.3 for more information on Remote Operation.

[8] A 658 running on version 3.0 (or higher) of the Operating System can retrieve data from a 656 or from a 658 running on an earlier version of the Operating System, although the reverse is not true (due to the more complex data structure of the later versions of the Operating System). In addition, not all remote functions are available for the older models.

1.8 SPECIFICATION SUMMARY

TABLE 1-1 contains a summary of the 658 specifications.

TABLE 1-1. 658 TECHNICAL SPECIFICATIONS

OPERATION	Menu-driven with accessible "Help" screens
DIMENSIONS	
Package	Rugged, portable case
Size	5.8" high by 17" wide by 14.5" deep (14.7 x 43.2 x 36.8 cm)
Weight	23.2 pounds (10.6 kg)
ENVIRONMENTAL SPECIFICATIONS	
Operating	5° to 40°C (41° to 104°F operating)
Storage	-20° to 55°C (-4° to 131°F)
Humidity	10% to 90% (non-condensing)
TIME CLOCK	Crystal controlled, 25 PPM stability, 10 mS resolution. Lists time in HH:MM:SS:ms format and date in MM:DD:YY format, including day of week. Accurate to within 2 seconds per day.
MAIN INPUT CHANNELS	Four 2-wire differential Main input channels for power line monitoring.
AC Voltage Ranges	0 to 60 V RMS [V_L (low) range]
	0 to 600 V RMS [V_H (high) range]
AC Current Ranges	0 to 5 A RMS, 0 to 30 A RMS, 1 to 300 A RMS, and 10 to 3000 A RMS
Frequency	45 to 65 Hz (310-445 Hz Optional)
Input Impedance	40 Megohms (voltage)
	120 Ohms (current)
Accuracy	Voltage: ±1% reading, ±0.2% full scale (6 V to 600 V)
	Current: ±2% reading, ±0.2% full scale (6 A to 300 A)
Resolution	Voltage: 0.1 V (0 to 72 V low range); 1 V (0 to 600 V high range)
	Current: 0.1 A resolution using 30 A current probe
	1 A resolution using 300 A current probe (TR-2019A)
	10 A resolution using 1000 A or 3000 A current probe
Sampling Rate	7.2 kHz
Impulse Voltage Range	2.4 to 6120 V pk
Impulse Current Range (Probe Dependent)	2.4 to 6000 A pk
Impulse Duration	> 1 μS
Impulse Sampling Rate	1.8432 MHz
Impulse Accuracy	±10% reading ±1% full scale
Impulse Resolution	[V_H (high) range] 12 V at or below 1536 V, 24 V above 1536 V
	[V_L (low) range] 1.2 V at or below 153.6 V, 2.4 V above 153.6
	(I300 range) 12 A at or below 1536 A, 24 A above 1536 A w/300 A probe
	(I30 range) 1.2 A at or below 153.6 A, 2.4 A above 153.6 A w/300 A probe
OPTIONAL SENSOR INPUT CHANNELS FOR ENVIRONMENTAL MONITORING	Eight input channels, configurable as fused current or voltage inputs
DC Input Ranges	0 to 10 V DC (voltage input) or 0 to 40 mA DC (current input)
Input Impedance	>2.0 Megohms (voltage); 250 Ohms (current loop)
Sampling Rate	12.5 Hz
Accuracy	±0.5% reading ±0.2% full scale
MEMORY	512 Kbytes of non-volatile event RAM; 128 Kbytes of program ROM;
	64 Kbytes of system RAM; 64 Kbytes of system ROM
Disk Drive	Single 3.5 inch, double sided, double density disk.
PRINTER	High-resolution graphics printer, 320 dots/line,
Paper	Thermal, 4.33 " wide
USER INTERFACES	
Screen	5-inch diagonal electroluminescent
Keyboard	Elastomeric, full travel
Serial Ports	One 9-pin Female (DCE) printer port
	One 25-pin Female (DCE) RS-232C port
OPTIONAL MODEM	2400 bps internal (Hayes compatible)
POWER REQUIREMENTS	90 to 250 V RMS, 50/60/400 Hz, 100 watts typically
UNINTERRUPTABLE POWER SUPPLY (UPS)	Provides approximately 5 minutes of uninterrupted operation if power goes out. (Sixteen hours is the typical recharge time for the UPS.)

1.9 STANDARD ACCESSORIES

Part Number	Quantity	Description
TM-115000-G1	1	Model 658 Operator's Manual
110888-G1	1	Thermal Paper
114012-G2	1 Set	Measurement Cable Kit
105411-G2	1	Event Diskette
110727-G3	1	Power Cord, Shielded (115VAC) U.S.A.
113255	1	Key Ring
BT-14N	1	Cable Tie

1.10 OPTIONAL ACCESSORIES

See step (3) of subsection 1.11 for information on obtaining the Service/Maintenance manual (Volume 2) listed below. To purchase any of the other options, contact:

Dranetz Technologies, Inc.
1000 New Durham Road
Edison, New Jersey 08818-4019

Attn: Order Entry

Tel: (908) 287-3680
FAX: (908) 248-9240
TWX: (908) 977-9553
Telex: 499-7808
Cable: DRANETZ

1-800-372-6832

Part Number	Quantity Required	Description
TM-115000-G1 Vol. 2	1	Model 658 Service Manual

Accessories for Environmental Monitoring

112935-G1	1	656-PA-1001 8-Channel Transducer Board
656-XD-1001[9]	1	Temperature & Humidity Monitor[10]
113804-G1	1	90' extension cable for 656-XD-1001
656-XD-1002[9]	1	Conducted RF Monitor[11]
656-XD-1003[9]	1	Radiated RF Monitor[11]

[9] Requires 656-PA-1001 installed.
[10] Included is a 1' signal cable, 113802-G1, and an attached 9' extension cable.

Part Number	Quantity Required	Description
Current Probes and CT Termination Box		
TR-2019B	1-3	TR-2019A, 300 A current probe
TR-2021	1-3	TR-2021, 30 A current probe
TR-2022	1-3	TR-2022, 1000 A current probe
TR-2023	1-3	TR-2023, 3000 A current probe, internally terminated
115550-G2	1-3	0-5 A Isolated CT Termination Box

NOTE: *See Table 1-2 for current probe specifications.*

Miscellaneous		
115038-G1	1	Soft carrying case with probe pallet
115039-G1	1	Reusable hard shipping container
113070-G1	As Required	Box of ten 3.5" double sided, double density disks
658-2400M	1	2400 baud Hayes compatible internal modem
113445-G1	1	Main Port Cable (male 25-pin to female 25-pin connectors)
113446-G1	1	Main Port Null-Modem Cable (male 25-pin to male 25-pin connector)
113447-G1	1	Auxiliary Port Cable (male 9- and 25-pin connector)
113448-G1	1	Auxiliary Port Cable (male 9-pin to female 25-pin connector)
115022-G1	2	Rear Extension Bracket (2 req'd to stand 658 on-end)
115024-G1	1	Rack Mount Kit
115090-G1	1	658-OS-2001, Graphical and Harmonic Analyzer P.C. Software
HB114415	1	Dranetz Field Handbook for Power Quality Analysis

[11] Included is a 1' signal cable, 113814-G1, and an attached 9' extension cable.

Table 1-2. Optional Current Probe Specifications

Model	Type	Current Rating	Transient Response	Jaws Opening	Frequency Response
TR-2015A[12]	Clamp-on	10-3000 ARMS (10-3000 A ±0.5%)	N/A	2.56" cable, 1.97"X5.31" Bus Bar	48-5000 Hz
TR-2019A	Clamp-on	1-300 ARMS (1-300 A ±<1%)	2 usec	2.0"	45 Hz-50 kHz
TR-2021	Clamp-on	0-30 ARMS (0.2-30 A ±<1%)	2 usec	0.47"	45 Hz-10 kHz
TR-2022	Clamp-on	10-1000 ARMS (10-1000 A ±0.9%)	5 usec	2.17"	30 Hz-20 kHz
TR-2023	Clamp-on	10-3000 ARMS (10-3000 A ±0.5%)	N/A	2.56" cable, 1.97"X5.31" Bus Bar	48-5000 Hz
110635-G2	Isolated CT Terminal Box	0-5 ARMS	2 usec	None	50-5000 Hz

1.11 FACTORY REPAIR

When factory repair is required, proceed as follows:

1. Contact Dranetz Customer Service Department to obtain an authorization number for factory repair:

   Tel: (908) 287-3680 1-800-372-6832 Telex: 499-7808
   FAX: (908) 248-9240 Cable: DRANETZ
   TWX: (908) 997-9553

2. Fill out the REPAIR/SERVICE ORDER form in this manual and ship it along with the malfunctioning equipment to Dranetz Customer Service Department. If this form is missing, contact Dranetz to request a replacement.

3. You have been supplied a Control Form in this manual with a Control Number. This form is used if you want the Volume 2 of this manual (for Service and Maintenance). If this form is missing, contact Dranetz to request a replacement.

[12] Must be used with Isolated CT Terminal Box, 110635-G2.

SECTION II
INSTALLATION AND OPERATION

2.1 GENERAL

This section contains the installation, setup, and operating instructions for the 658 Power Quality Analyzer.

2.2 UNPACKING

For maximum protection against possible shipping damage, the 658 has been sealed in a two-piece, pre-molded urethane foam pack, encapsulated within a durable shipping carton.

Unpack the unit from the carton as follows:

1. Remove any remaining literature inside the top of the carton.

2. Carefully remove the unit from its shipping carton.

3. Remove the power cord and any additional parts inside the carton.

4. Place all of the shipping materials back into the carton, close its flaps, and store it away. **DO NOT throw away the carton and packing materials. Save the carton and packing materials in case you have to return the unit to Dranetz Customer Service Department for maintenance, repair, or calibration.**

2.2.1 Shipping Damage Inspection

Visually inspect the unit for possible shipping damage. If any damage exists, first notify and file an insurance claim with your carrier or underwriter or both. Then notify Dranetz Customer Service Department[1] (refer to the REPAIR/SERVICE ORDER form enclosed in this manual) of your intentions to return the unit. **DO NOT** return the unit without prior instructions from Dranetz Customer Service Department.

2.2.2 Repacking the 658 for Return Shipment

If you have to return the 658 to Dranetz Customer Service Department, repack it in its original packing materials. **DO NOT RETURN THE 658 IN AN UNPACKED BOX. DRANETZ TECHNOLOGIES, INC. WILL NOT BE RESPONSIBLE FOR DAMAGE INCURRED DURING TRANSIT DUE TO INADEQUATE PACKING ON YOUR PART.**

[1] Dranetz Customer Service Department can be reached at (908) 287-3680 or 1-800-DRANTEC.

2.3 INSTALLATION WARNING

WARNING

Be sure that the 658 is turned off before proceeding with any installation. Because of possible shock or fire hazards, connection of this instrument should be performed in compliance with the National Electric Code (ANSI C1) and any other requirements which are applicable to your installation. Installing, operating, and maintaining this instrument should be performed ONLY by qualified personnel.

2.4 SETTING UP THE 658

Initial setup of the 658 involves:

- positioning the unit,
- grounding the unit,
- making any required communication connections,
- connecting the Main input channels,
- connecting the Sensor input channels (if applicable),
- inserting the event disk (if desired),
- applying power, and
- programming the desired settings[2].

2.4.1 Positioning the 658

1. Stand the 658 on its rubber feet in its desired location.
2. Flip-up feet connected to the front underside of the unit are used to elevate the front of the 658. Raise the front of the 658, reach underneath and flip each foot forward until it locks in place. Lower the 658 to rest on the front feet.
3. Two latches hold the front cover in position to protect the front panel of the 658. Flip the back edge of each latch forward to release the latch. With both latches released, remove the front cover.

CAUTION

If you are going to operate the 658 in a "dirty" environment, leave the front cover in-place when you are not using the printer, display, or keyboard. This will help protect the inside of the instrument from dust or other airborne contaminants.

[2] Refer to subsections 2.8 through 2.8.8 for information on programming settings.

2.4.2 Grounding the 658

Connect the grounding lug of channel A to a suitable earth safety ground using the green ground cable provided. This lug is connected to the chassis ground of the instrument, as is the third wire safety ground of the power cord. The ground connection to the grounding lug of Channel A ensures operator's safety if the power cord is accidently disconnected.[3]

2.4.3 Connecting RS-232C Cables

Connection to the Main Port lets the 658 communicate with another 658[4] or a personal computer during remote operation. All aspects of Remote Communication, including cable and modem connections are covered in the Remote Communication section of this manual (subsection 2.12, page 2-86).

Connection to the Auxiliary Port lets the 658 print to an external printer. See subsection 2.13, page 2-95, for information on the use of external printers, including cable information.

2.4.4 Connecting the Power Cord

Plug the female end of the power cord[5] into the 658 rear panel receptacle; plug the male end into an appropriate 3-pronged AC power outlet.

2.4.5 Connecting the Main Input Channels

The 658 has four Main input channels: A, B, C, and D (see figure 2-1). Each channel consists of a pair of "+" and "-" voltage input jacks, but only channel A contains a grounding lug; channels B, C, and D contain a "CURRENT" input connector. Connect these channels as follows:

1. Make sure the 658 is turned OFF, but leave its power cord plugged in to maintain a safety ground connection.

2. Turn off the power to the line(s) that are going to be monitored.

3. Read the circuit connection guidelines and circuit applications in subsections 2.4.5.1 through 2.4.5.3 before continuing.

4. Connect the applicable voltage lines in your Measurement Cable Kit (114012-G2) to the "+" and "-" input jacks. Refer to the illustrations under subsection 2.4.5.3 (figures 2-2 through 2-10) for the connection guidelines.

WARNING

When using the TR-2021 current probe, DO NOT connect the probe jaws around an uninsulated wire. This probe is used to monitor insulated wire only.

5. If you are using a current probe (TR-2019A, TR-2021, TR-2022, or TR-2023) with the 658, plug the connector end of the probe into the "CURRENT" input jacks of the channel(s) you are using. If you are using the TR-2015A current probe with the CT Termination Box, see subsection 2.4.5.1 for instructions.

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[3] Refer to Subsection 2.4.5.2 for more information on the safety ground.

[4] Connection is also possible to a 656, although not all remote functions are available for the older models.

[5] When operating from 115 VAC, use power cord P/N 110727-G3 (supplied with all shipments to the U.S.); when operating from 230 VAC, use power cord P/N 110726.

NOTE: *You cannot monitor voltage and current at the same time on one channel. The Main Channel Setups Menu allows you to switch between voltage and current monitoring. Once voltage monitoring is selected, current monitoring is disabled; once current monitoring is selected, voltage monitoring is disabled.*

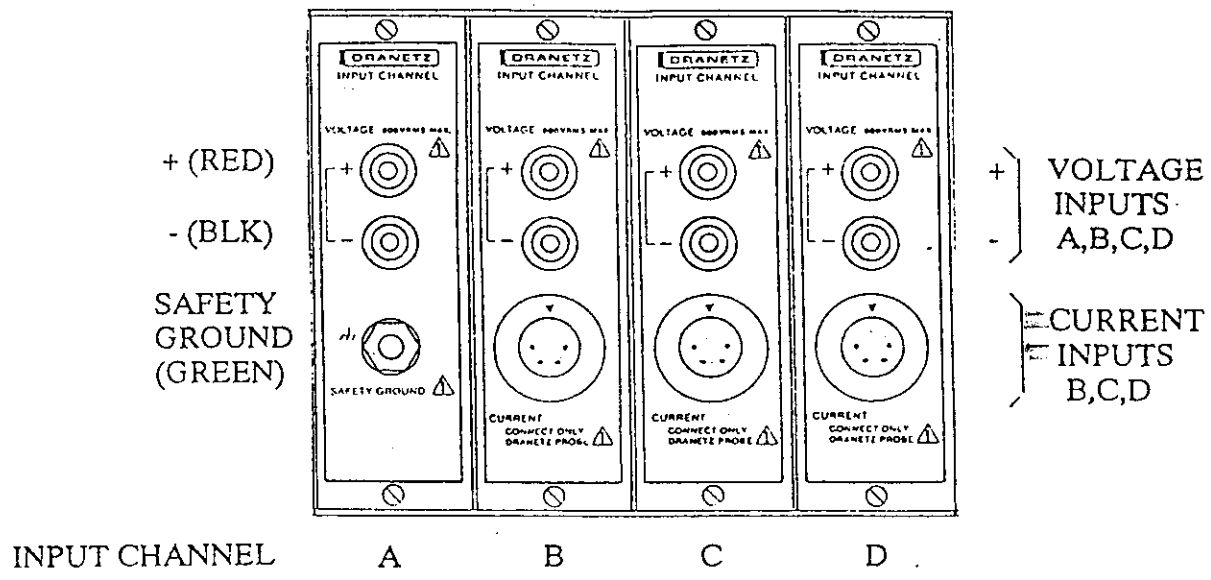


Figure 2-1. Main Input Channel Connections

2.4.5.1 Using Current Probes

The "CURRENT" input jacks are specifically designed for use with the Dranetz current probes. If you are monitoring currents of 300 A RMS or less, use current probes TR-2019A or TR-2021. The TR-2022 is designed to monitor currents up to 1000 A RMS. For monitoring currents up to 3000 A RMS, use either the TR-2023 (which is terminated internally) or the combination of the TR-2015A current probe and CT Termination Box.

CT Termination Box

The CT Termination Box can be purchased separately (P/N 110635-G2), or as a kit (P/N 110639-G1) with the TR-2015A current probe. The CT Termination Box reduces the input from the current probe to a range acceptable to the 658. The TR-2015A current probe is rated at 3000 A RMS and contains a 5 A secondary for use with the CT Termination Box. To make the connection, plug the connector end of the CT Termination Box into the applicable current connector and hard wire the box's screw terminals to the current probe cable.

WARNING

When using the CT Termination Box, be sure to replace its terminal cover on the barrier block as soon as the current probe wires are connected. Also, remove the current probe from the line being monitored before attaching or removing the wires of the current probe secondary to or from the barrier block on the Box.

2.4.5.2 Circuit Connection Guidelines for the Main Input Channels

Proper monitoring and analysis of AC and DC disturbances requires careful attention to the method of connection between the 658 Main input channels and the monitored circuits. To obtain the most accurate and relevant monitoring data, we suggest the following guidelines:

- Be aware that frequency information is measured from the Synchronization Channel (usually channel A). If the line on channel A drops out, frequency is measured on the next available channel: B then C then D. Never connect channel A from Neutral-to-Ground and never try to synchronize from a current waveform (current is unreliable for synchronization).

- The safety ground lug on channel A acts as a common grounding point and is internally tied to the 658 frame ground--which is connected to the line cord earth ground. Make sure that the grounding lug is connected to a verified safety ground using the green grounding cable provided. Whenever possible, use a grounding point at the same potential as the AC power cord ground, to avoid inducing current flow due to different ground point potentials.

- Whenever possible, power the 658 from a separate line other than the one you are monitoring. This prevents the 658 from affecting the disturbances you are trying to monitor, due to the additional load of the 658 circuit.

- To minimize spurious impulse transients and interchannel coupling, always use the Dranetz Main Input Channel cables contained in your Measurement Cable Kit (114012-G2).

- If you are monitoring a power line connected to critical, sensitive load equipment, the test cables should be connected as close as possible to the load. For 3-phase loads, connect the 658 in the same way as the load equipment is connected, for example, Line-to-Line or Line-to-Neutral.

2.4.5.3 Circuit Applications for the Main Input Channels

- The 658 can monitor Line-to-Neutral and Neutral-to-Ground voltage in a 120 VAC single-phase system (illustrated in figure 2-2). This application requires two Main channels (A and B in the illustration). In such an application, one of the two remaining channels could be used to monitor current (illustrated in figure 2-3 using channel C).

- The 658 can monitor Line A-to-Line B, and current (on one of the three remaining channels) in a 208 VAC split-phase system (illustrated in figure 2-4). This application requires two Main channels (A and B in the illustration). You could also monitor current on channels C and D while using channel A as the synchronization channel and channel B for 3-phase "delta" voltages (illustrated in figure 2-5).

- The 658 can monitor Line A-to-Line B, Line B-to-Line C, and Line C-to-Line A voltages in a 3-phase "delta" system (illustrated in figure 2-6). This application would use three of the four Main channels (channels A, B, and C in the illustration). You could also monitor 3-phase current on channels B, C, and D while using channel A as the synchronization channel (illustrated in figure 2-7).

- The 658 can monitor Line A-to-Neutral, Line B-to-Neutral, Line C-to-Neutral, and Neutral-to-Ground voltages in a 3-phase "wye" system (see figure 2-8). This application would use all four Main channels. You could also monitor 3-phase current on channels B, C, and D while using channel A as the synchronization channel (illustrated in figure 2-9).

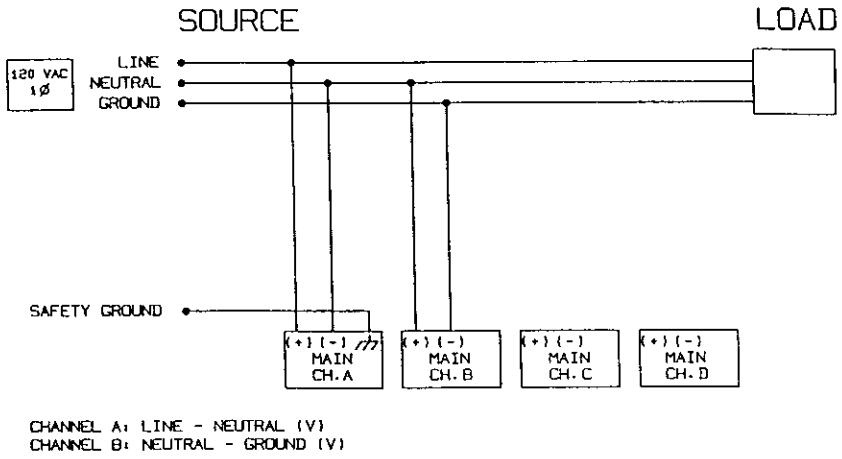


Figure 2-2. 120 VAC Single-Phase Circuit with Neutral-to-Ground Connection

Below is an example of Main Channel settings that correspond to the above configuration:

1 Setup #01	A	B	C	D
2 Range	VH	VL	Off	Off
3 Hi Lim	127	02.0	72.4	72.4
4 Lo Lim	105	00.0	00.0	00.0
5 Sens.	003	01.0	72.4	72.4
6 Imp.	0100	025.0	612.0	612.0
7 Wave	010	05.0	72.4	72.4
8 Freq.	Sens: 0.5	Range: 45-65 Hz		
Activate	Print	eXit	Help	

NOTE: *The example above displays the system default settings of Main Channel Setups screen number 1. The default settings of Main Channel Setups screen number 2 are also valid for this type of configuration. See Appendix C for a listing of all default setup screens.*

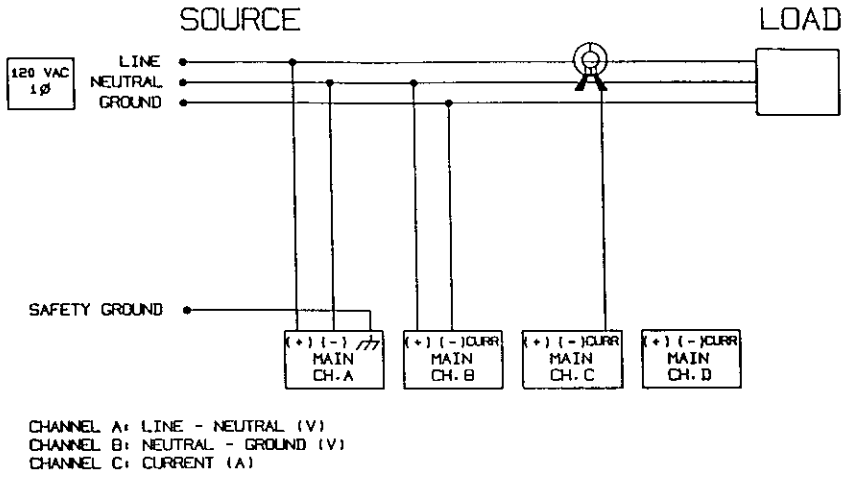


Figure 2-3. 120 VAC Single-Phase Circuit with Neutral to Ground and Phase Current Connections

Below is an example of Main Channel settings that correspond to the above configuration:

1 Setup #03	A	B	C	D
2 Range	VH	VL	I300	Off
3 Hi Lim	127	03.0	005	72.4
4 Lo Lim	105	00.0	000	00.0
5 Sens.	005	01.0	005	72.4
6 Imp.	0100	024.0	0050	612.0
7 Wave	010	05.0	015	72.4
8 Freq.	Sens: 0.5	Range:	45-65	Hz
Activate	Print	eXit		Help

NOTE: *The example above displays the system default settings of Main Channel Setups screen number 3.*

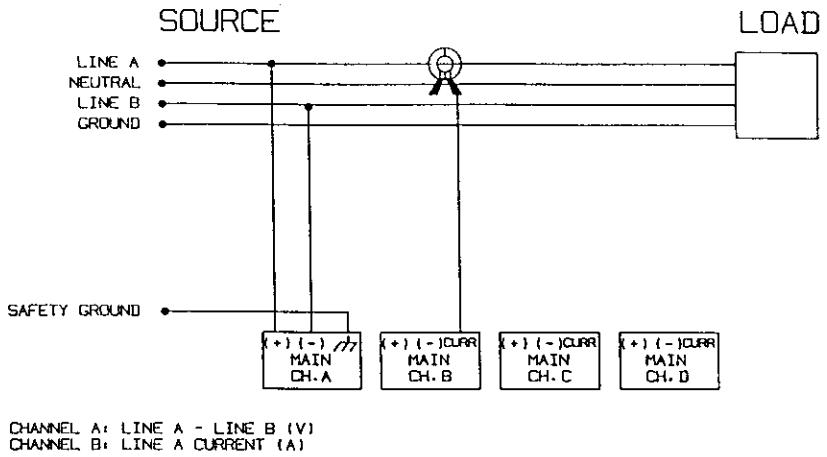


Figure 2-4. 208 VAC Single-Phase Circuit with Line Current Connection

Below is an example of Main Channel settings that correspond to the above configuration:

1 Setup #04	A	B	C	D
2 Range	VH	I300	Off	Off
3 Hi Lim	221	005	72.4	72.4
4 Lo Lim	181	000	00.0	00.0
5 Sens.	005	005	72.4	72.4
6 Imp.	0150	0050	612.0	612.0
7 Wave	020	020	72.4	72.4
8 Freq.	Sens: 0.5	Range:	45-65	Hz
Activate	Print	eXit		Help

NOTE: *The example above displays the system default settings of Main Channel Setups screen number 4.*

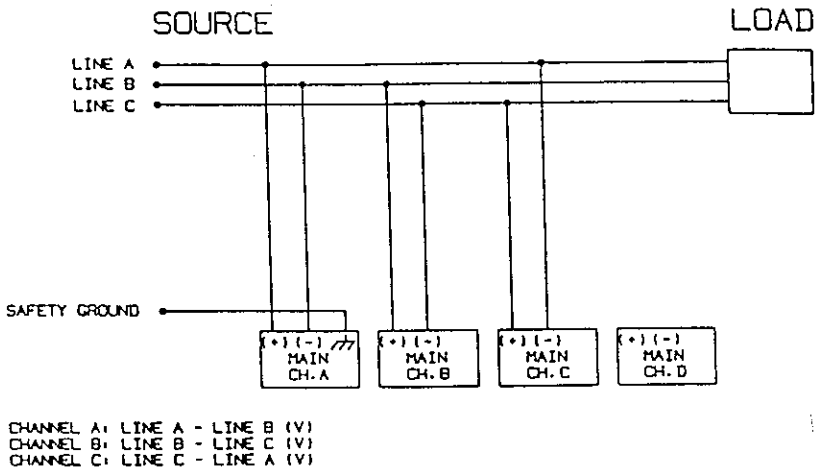


Figure 2-5. 240 VAC Three-Phase Delta with Phase to Phase Connections (5% Tolerance)

Below is an example of Main Channel settings that correspond to the above configuration:

1 Setup #13	A	B	C	D
2 Range	VH	VH	VH	Off
3 Hi Lim	252	252	252	72.4
4 Lo Lim	228	228	228	00.0
5 Sens.	005	005	005	72.4
6 Imp.	0200	0200	0200	612.0
7 Wave	050	050	050	72.4
8 Freq.	Sens: 0.5	Range:	45-65	Hz
Activate	Print	eXit		Help

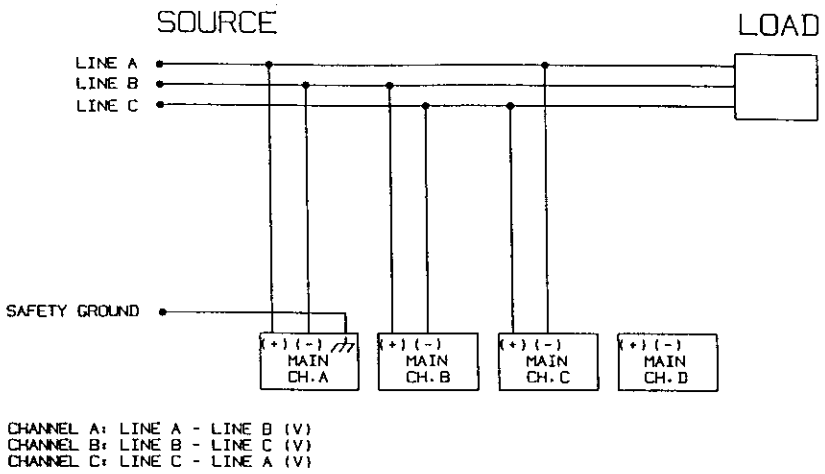


Figure 2-6. 480 VAC Three-Phase Delta with Phase to Phase Connections (5% Tolerance)

Below is an example of Main Channel settings that correspond to the above configuration:

1 Setup #14	A	B	C	D
2 Range	VH	VH	VH	Off
3 Hi Lim	504	504	504	72.4
4 Lo Lim	456	456	456	00.0
5 Sens.	010	010	010	72.4
6 Imp.	0400	0400	0400	612.0
7 Wave	080	080	080	72.4
8 Freq.	Sens: 0.5	Range:	45-65	Hz
Activate	Print	eXit		Help

NOTE: *The example above displays the system default settings of Main Channel Setups screen number 14. The default settings of Main Channel Setups screen number 13 are also valid for this type of configuration.*

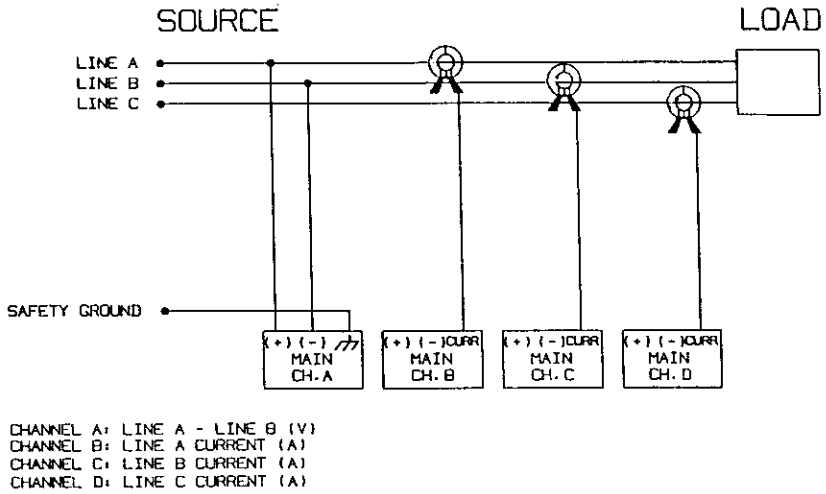


Figure 2-7. 240 VAC Three-Phase Delta with Three Phase Current Connections (0.5 Amp Isolated Termination Box)

Below is an example of Main Channel settings that correspond to the above configuration:

1 Setup #16	A	B	C	D
2 Range	VH	I5	I5	I5
3 Hi Lim	252	1.00	1.00	1.00
4 Lo Lim	228	0.00	0.00	0.00
5 Sens.	005	0.10	0.10	0.10
6 Imp.	0200	25.00	25.00	25.00
7 Wave	050	2.00	2.00	2.00
8 Freq.	Sens: 0.5		Range:	45-65 Hz
Activate	Print		eXit	Help

NOTE:
The example above displays modified settings of Main Channel Setups screen number 16.

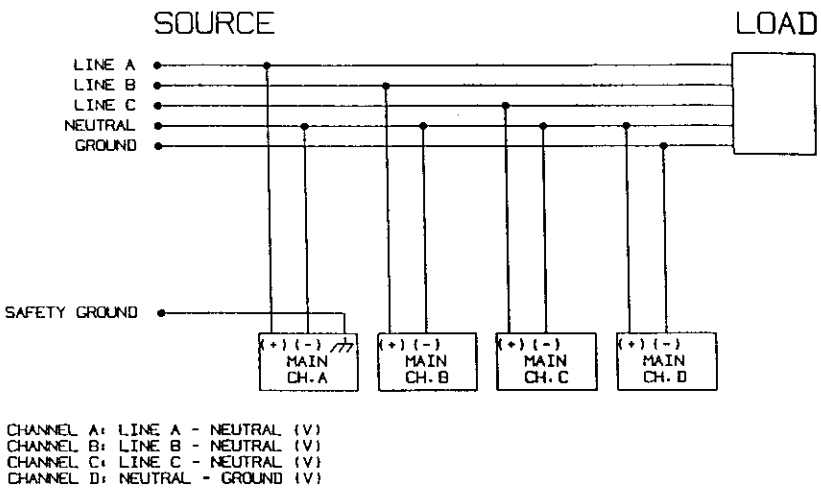


Figure 2-8. 277 VAC Three-Phase Wye Circuit with Neutral-to-Ground Connection

Below is an example of Main Channel settings that correspond to the above configuration:

1 Setup #09	A	B	C	D
2 Range	VH	VH	VH	VL
3 Hi Lim	293	293	293	03.0
4 Lo Lim	241	241	241	00.0
5 Sens.	005	005	005	01.0
6 Imp.	0200	0200	0200	024.0
7 Wave	030	030	030	05.0
8 Freq.	Sens: 0.5	Range:	45-65	Hz
Activate	Print	eXit		Help

NOTE: *The example above displays the system default settings of Main Channel Setups screen number 9.*

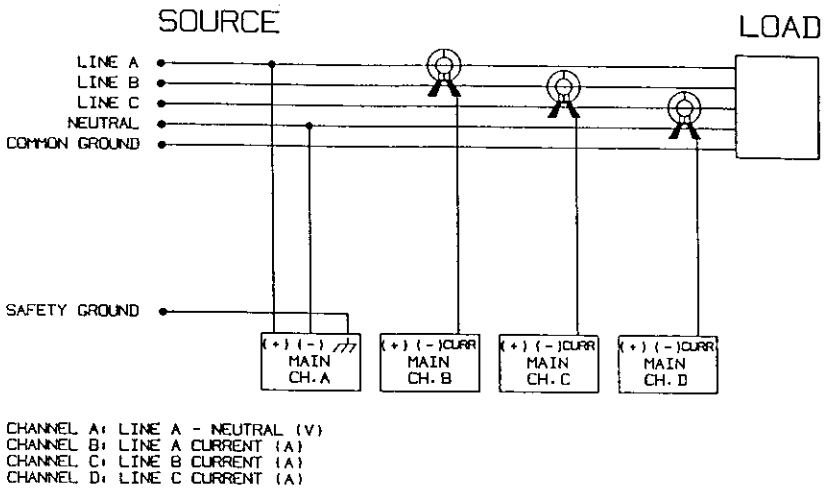


Figure 2-9. 120 VAC Three-Phase Wye Circuit with Three Phase Current Connections (0-5 Amp Isolated Termination Box)

Below is an example of Main Channel settings that correspond to the above configuration:

1 Setup #16	A	B	C	D
2 Range	VH	I5	I5	I5
3 Hi Lim	127	1.00	1.00	1.00
4 Lo Lim	105	0.00	0.00	0.00
5 Sens.	003	0.10	0.10	0.10
6 Imp.	0100	25.00	25.00	25.00
7 Wave	010	2.00	2.00	2.00
8 Freq.	Sens: 0.5	Range:	45-65	Hz
Activate	Print	eXit	Help	

NOTE: *The example above displays the system default settings of Main Channel Setups screen number 16. These settings are also valid for the configuration in Figure 2-7.*

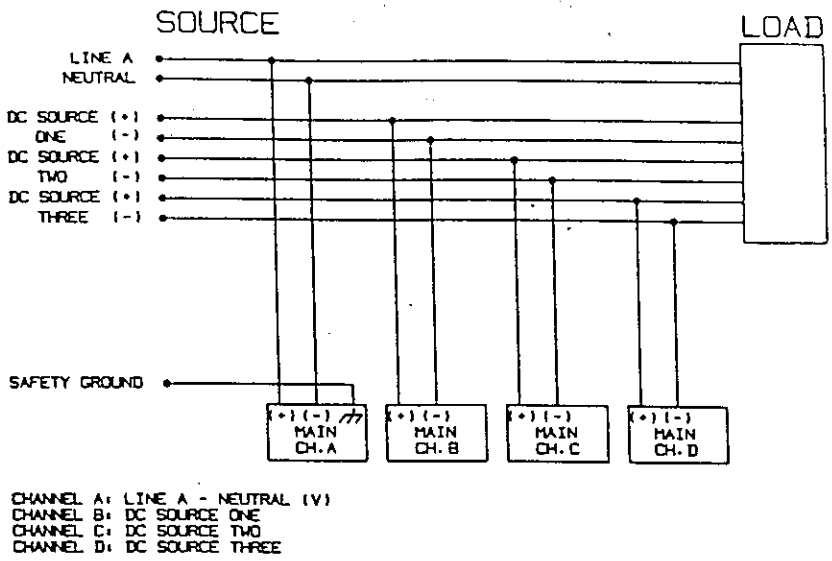


Figure 2-10. Typical Single-Phase Input and Three 48 VDC Telephone Station Battery Supply Output Monitoring Connections

Below is an example of a Main Channel Setup Screen that is modified from the preset condition of setup No.1 to correspond with the above configuration.

1 Setup #01	A	B	C	D
2 Range	VH	VL	VL	VL
3 Hi Lim	130	52.0	52.0	52.0
4 Lo Lim	090	44.0	44.0	44.0
5 Sens.	005	05.0	05.0	05.0
6 Imp.	0100	050.0	050.0	050.0
7 Wave	020	30.0	30.0	30.0
8 Freq.	Sens: 0.5	Range:	45-65	Hz
Activate	Print	eXit		Help

NOTE: *Voltage thresholds for setting 7 (Wave) are set for AC RMS changes. For DC changes, you must remove the RMS factor of 1.414 (square root of 2). Do this conversion by multiplying the DC value you want by 0.707 (1/1.414). For example: If you want 7 VDC as the trip point value, set the threshold setting to 7 X 0.707 = 5 (4.949) VDC.*

2.4.6 Connecting the Sensor (Transducer) Channel Options

To use any of the Sensor channel options, 656-PA-1001 (Transducer Channel Board) must be installed in the Mainframe. If you do not have this board but would like to use the Sensor Channel options, contact Dranetz Order Entry Department (see subsection 1.10).

As of this writing, there are three Sensor channel options available for the 658:

1.	Temperature and Humidity Monitor	(656-XD-1001)
2.	Conducted RF Monitor	(656-XD-1002)
3.	Radiated RF Monitor	(656-XD-1003)

Information on the connections, setup, operation, and specifications for these options is contained in separate technical manuals related as follows:

1.	T & H Monitor	(656-XD-1001)	TM-113800 Volume 1
2.	Conducted RF Monitor	(656-XD-1002)	TM-113810 Volume 1
3.	Radiated RF Monitor	(656-XD-1003)	TM-113900 Volume 1

For information on purchasing any or all of these options, and their related technical manual, contact Dranetz Order Entry Department (see subsection 1.10).

Figure 2-11 below illustrates the Sensor (Transducer) Channel inputs for the available options:

Note: All eight Sensor channels are factory preset for 0-10 V input. To change any input to 0-40 mA, contact Dranetz Customer Service Department for instructions (see subsection 1.11).

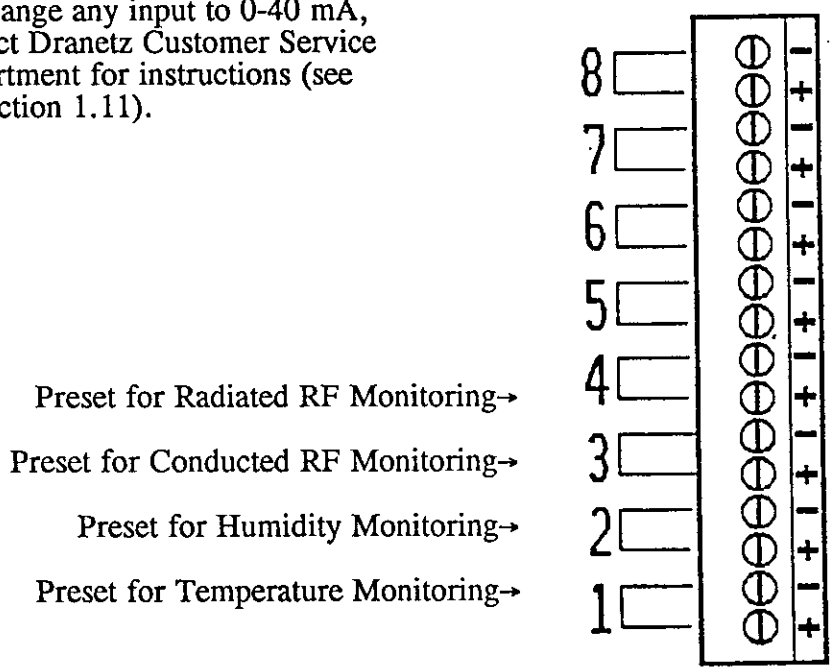


Figure 2-11. Sensor (Transducer) Channel Inputs

2.5 OPERATING PROCEDURES

Once the necessary monitoring and communication connections are made, you are ready to operate the 658. Basic 658 operation consists of the following steps:

- Turn the unit on,
- program the desired parameters and settings,
- allow the unit time to monitor the power line and record events, and
- view and analyze recorded events.

Several disk operations are available, including initializing (formatting) a disk, saving data to a formatted disk, and retrieving data from a disk.[6]

Information pertaining to remote operations, including communication connections and procedures, are located in subsections 2.12 through 2.12.3.

Information pertaining to using an external printer with the 658, including connections and procedures, is located in subsections 2.13 through 2.13.3.

The 658's menu structure, illustrated in figure 2-12, is several levels deep. Commands and operations are performed through the various menu prompts.

2.6 BEGINNING OPERATION

NOTE: *If you are installing the 658 for the first time, or if you have not operated it for two weeks or longer, plug it in, turn it on, and let it sit for 24 hours to allow the internal UPS batteries to fully charge. Once the batteries are charged, the BATTERY CHARGED indicator on the rear panel will light. Turn the unit off before proceeding with the steps in this subsection.*

At this point it is assumed the 658 has been properly connected and is ready for operation.

Turn on the 658. The instrument will automatically perform a series of self-diagnostic tests to verifying the integrity of its various subsystems. (Refer to Section III in this manual for more information on the operational test.)

2.6.1 Using the Cursor Keys, Dedicated Keys, and Keyboard

The cursor keys, dedicated keys, and alphanumeric keys are used, in that general use order, to select menus and menu options throughout the operation of the 658. The cursor keys and ZOOM key are associated with graph or waveform area selection and enlargement to enhance area for greater information interpretation in the zoom feature.

<u>Cursor Keys</u>
The cursor keys are primarily used to select menu and menu options due to their simplicity in movement to select either horizontal or vertical items. In addition, the cursor keys control zoom window dimensions.

[6] Refer to subsections 2.11 through 2.11.4 for more information on these functions.

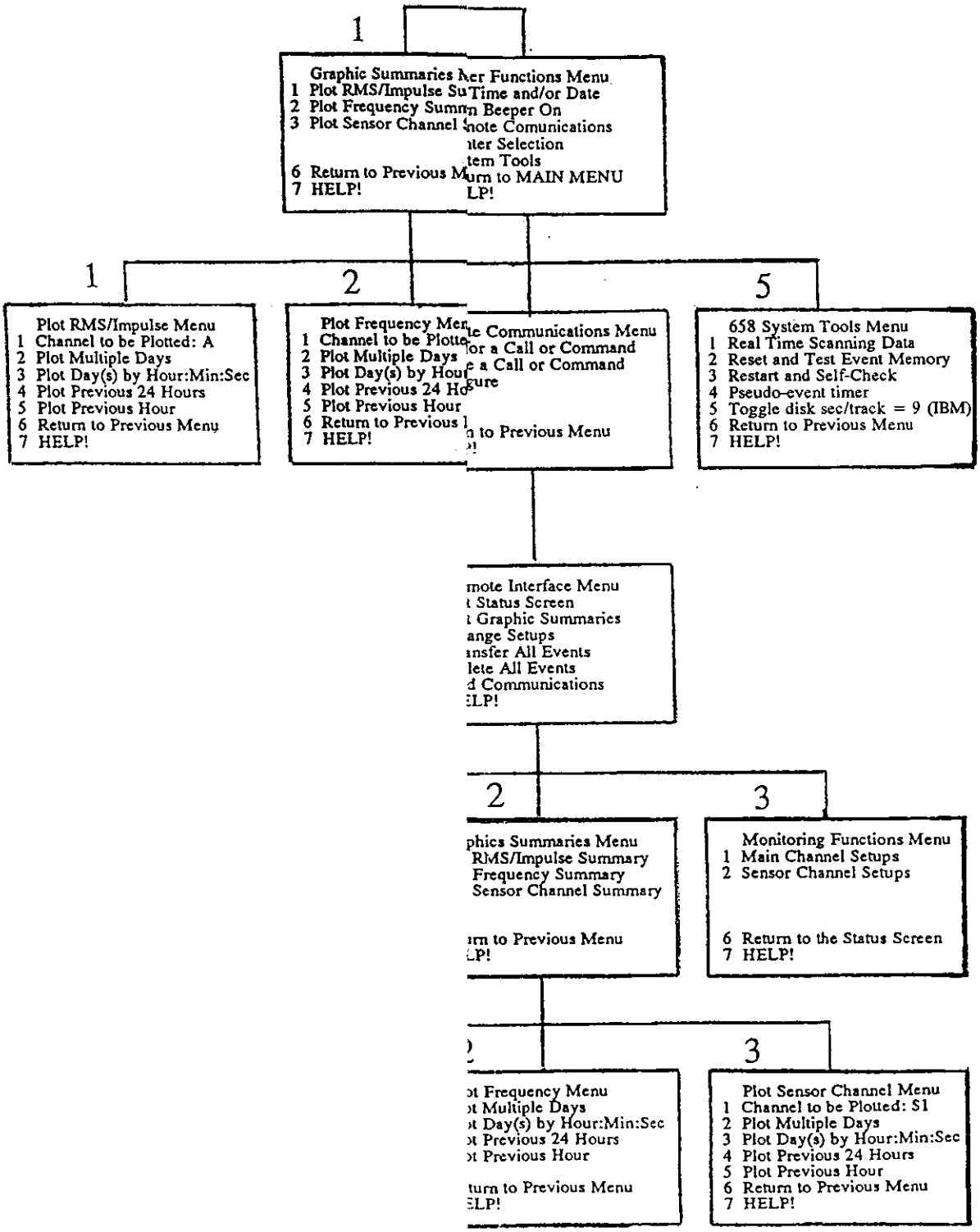


Figure 2-12. 658 Menu Structure

Dedicated Keys
Some of the more frequently used functions have dedicated keys such as *<PRINT>*, *<FEED>*, *<EXIT>*, *<HELP>* etc. Each of these keys is described in detail in that functional operation where it is used.

Keyboard
Alphanumeric keys are used for entering site information as well as selecting commands or options. One key, designated period (.) and semicolon (:), is software selectable dependent on the text being changed.

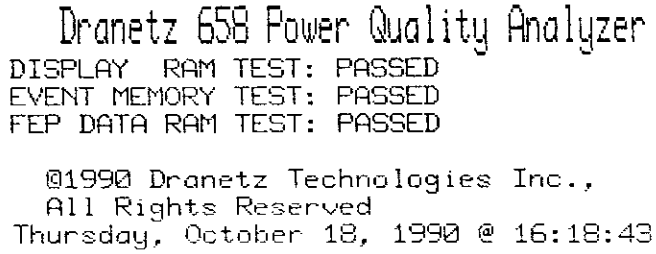
2.6.2 Menu Selection

Menu selections are made either through selection of the corresponding line number by a keyboard numeric key or by using the cursor for highlighting the line (up/down cursor) or option (left/right cursor) and then pressing ENTER. The cursor keys let you make selections in four axes; up, down, left, and right. By applying gentle pressure with your index finger and pivoting it while pressing any one cursor, provides two axes control of that cursor. Position of the cursor in menu selection is only in the vertical axis to highlight a selection. The cursors provide for left/right movement for option selection; whereas up/down movement provide for increasing/decreasing a range of values.

If you feel more comfortable using the keyboard to make selections and entries, use it instead (you are prompted on the screen with the corresponding number key to enter the number of the corresponding line selection or by the highlighted capitalized letter in each option or command).

2.6.3 Start-Up Screen

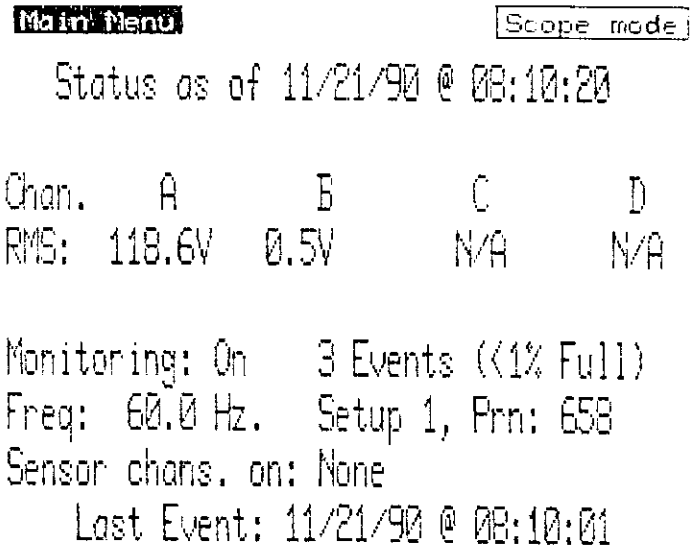
If all tests are passed, the Start-Up Screen appears:



Any malfunction detected during the start-up routine will be listed. See Section III for further instructions if this occurs. Also, when the 658 is first turned on, a power on event and reference events are recorded (when the 658 is turned off, a power off event is recorded).

2.6.4 Status Screen

The Status Screen is displayed immediately after the start-up screen has indicated that all tests have passed. The Status Screen provides a composite reference of the Main Channel and Sensor inputs, and an event memory summary.



The messages displayed on the Status Screen indicate the following conditions:

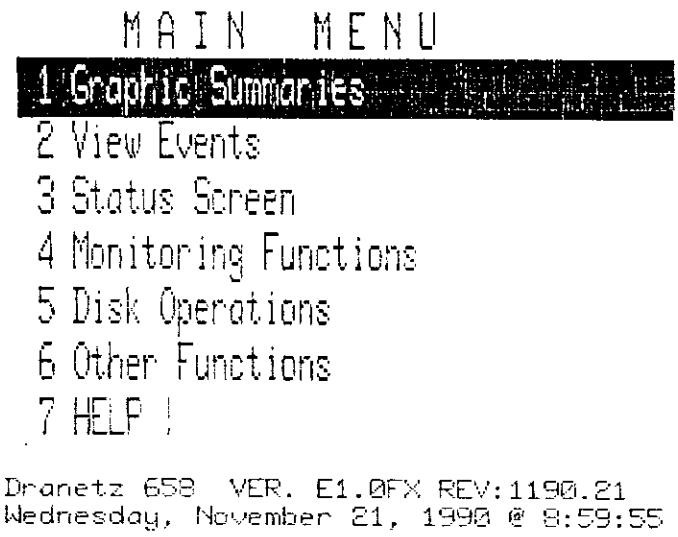
- monitoring status as of the current date and time,
- channels A and B are on (channels C and D are off, N/A),
- RMS values of channels A and B,
- monitoring is on,
- 3 events[7] are in memory and memory is less than 1% full,
- the current frequency of the Synchronization channel is 60 Hz,
- the active setup is "1",
- the active printer is the internal 658 printer[8],
- Sensor (Transducer) channels are off, and
- the last event[9] recorded was on 11/21/90 at 08:10:01

Use left or right cursor keys to toggle between highlighting MAIN MENU or SCOPE MODE then press *<ENTER>*, or use keyboard to select *<M>* or *<S>*. Refer to subsection 2.6.6 for a brief discussion of the Scope Mode.

[7] This includes a main channel waveform event, an initial RMS event, and initial frequency event. These events follow a memory delete of all events.
[8] See subsection 2.13 through 2.13.3 for information on the use of external printers.
[9] This was an initial event, recorded when the unit was turned on.

2.6.5 Main Menu

The MAIN MENU is the top menu in the 658 menu structure:



From the MAIN MENU you can work your way down to any menu in the structure.

Possible Selections and What They Mean
Brief descriptions of the Main Menu selections are given below and on the following page.

Selection: **1 Graphic Summaries**

Application: Selection 1 puts you in the GRAPHIC SUMMARIES MENU where you can plot RMS, impulse, sensor, and frequency summaries. Summaries can be plotted in multiple days, specific days and times, previous 24 hours, or previous hour. Summaries can be graphical illustrations, text descriptions, or both.

Once you are viewing a graphic summary, you can zoom in on a more specific time frame or view individual events. Once you are viewing individual events, other menu options are available to you depending on the type of event being viewed.

Selection: **2 View Events**

Application: Selection 2 puts you in the VIEW EVENTS MENU where you can view events according to their sequential order in memory or according to the time and date they occurred.

Once you are viewing individual events, other menu options are available to you depending on the type of event being viewed.

Selection: **3 Status Screen**

Application: Selection 3 brings up the STATUS SCREEN previously described in subsection 2.6.4. The Status Screen indicates the monitoring status, Main and Sensor channel status, Synchronization channel frequency, number of events in memory, percentage of memory used, the active setup, the time and date of the last event recorded, and the printer output selection.

If an automatic transfer of event memory to disk has occurred, it will also be reported on the Status Screen.

The MAIN MENU or SCOPE MODE may be selected from the Status Screen.

Selection: **4 Monitoring Functions**

Application: Selection 4 puts you in the MONITORING FUNCTIONS MENU where you can view or change the 16 Main channel setups, view or change the 8 Sensor (Transducer) channel setups, delete all events in memory, turn monitoring on and off, and change site descriptions.

Selection: **5 Disk Operations**

Application: Selection 5 puts you in the DISK OPERATIONS MENU where you can load stored disk information to the 658, save recorded 658 information to a disk, initialize a new disk, and toggle the auto-transfer mode between "once" and "multi-" transfer modes..

Selection: **6 Other Functions**

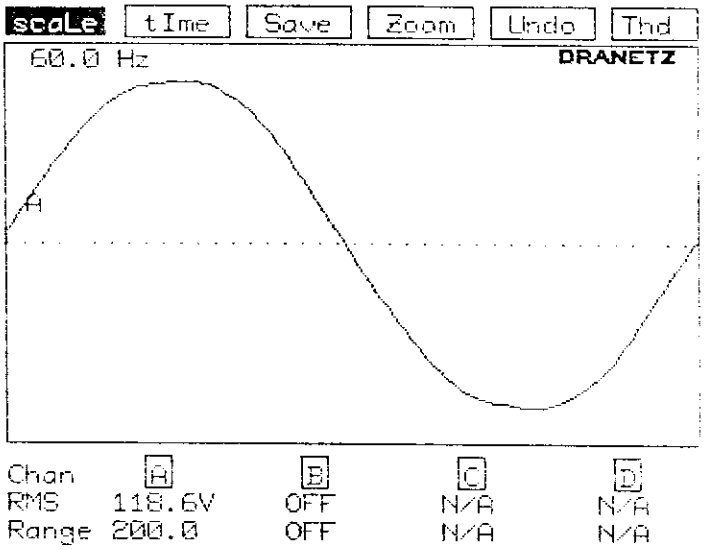
Application: Selection 6 puts you in the OTHER FUNCTIONS MENU where you can set the internal clock's time and date, turn the beeper on and off, access remote communication, change the active printer, and access the 658 system tools (to test memory, and restore factory preset values for the setups).

Selection: **7 HELP !**

Application: Selection 7 brings up a HELP Screen which briefly describes the functions of selections 1 through 6.

2.6.6 Scope Mode

The SCOPE MODE provides you with a single or multiple waveform presentation of the Main Channel input signals in a real-time environment. This display, shown below for setup 001, quickly provides a visual means of determining the condition of the connected input channels. The first channel connected in this setup - channel A, is displayed by itself. Other connected channels, channel B in this case, must be enabled to be displayed.



The display tells you the monitoring signals amplitude and phase relationships, and RMS values updated at one second intervals. During the time the scope mode is operational, monitoring and storage of events to memory is temporarily stopped. Waveforms viewed in Scope Mode may be saved in memory as events by selecting the <SAVE> option.

Options are selectable to provide you with the selected channel amplitude scaling, zoom, and Total Harmonic Distortion (THD) analysis. Since event scanning is turned off in Scope Mode, the time option allows you to preset how long the event scanning will be off before returning to on. While viewing the display a zoom feature is available to permit you to determine unknown interference frequencies, and amplitude and time characteristics of the displayed waveforms. Harmonic analysis is provided for fundamental frequencies of 45 to 65 Hz with graphs displayed of harmonic distribution and harmonic relative content. When viewing any waveshape or harmonic graph you may print out a record of that event.

Detailed description of the display and options of the Scope Mode are provided in subsection 2.10.2.3.

2.7 LOCKING KEYBOARD

The keyboard can be "locked" to discourage tampering with the unit. This feature locks-out commands to the unit from the keyboard.

To Lock The Keyboard
To activate this feature, press <*CTRL*> <*L*>. The following message appears briefly on the screen:

```
=KEYBOARD IS LOCKED=
```

This message is displayed when any of the keys are pressed until the keyboard is unlocked..

To Unlock The Keyboard
To unlock the keyboard press <*CTRL*> <*U*>.

2.8 PROGRAMMING SETTINGS

When initially programming the 658, the following steps are recommended:

- set time and date (subsection 2.8.1)
- change site information (subsection 2.8.2)
- turn monitoring on (subsection 2.8.3)
- set Main and Sensor Channel thresholds (subsection 2.8.4 through 2.8.4.3)
- clear memory (subsection 2.8.5)
- set auto-transfer mode (subsection 2.8.6)
- check status screen (subsection 2.8.7)
- check scope mode (subsection 2.8.8)

Setting time is through the OTHER FUNCTION MENU.

Changing the site information, clearing the 658 memory, turning monitoring on, and setting the Sensor and Main Channel thresholds are all accomplished through the MONITORING FUNCTIONS MENU (selection 4 from the MAIN MENU).

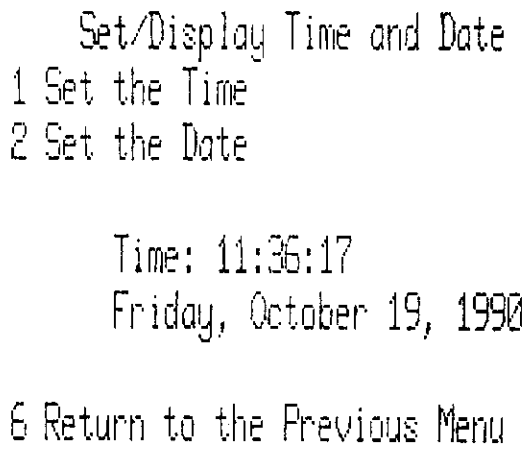
Checking the status screen is accomplished through the MONITORING FUNCTIONS MENU or the MAIN MENU.

Setting the auto-transfer mode is accomplished through the DISK OPERATIONS MENU (selection 5 from the MAIN MENU).

2.8.1 Setting Time and Date

The time and date of the 658's internal clock are set through the OTHER FUNCTIONS MENU (selection 6 from the MAIN MENU).

From the OTHER FUNCTIONS MENU select option 1, "Set Time and/or Date." The SET/DISPLAY TIME AND DATE MENU appears:



The time displayed on the screen is updated every second.

To set the time, select option 1. Time must be entered in a 24 hour format. The screen that appears explains this and gives several examples. After entering the time, press <*ENTER*> to accept the new setting and return to the SET/DISPLAY TIME AND DATE MENU.[10]

To set the date, select option 2. You are prompted to enter the date in a mm-dd-yy format. After entering the time, press <*ENTER*> to accept the new setting and return to the SET/DISPLAY TIME AND DATE MENU.[11]

2.8.2 Changing Site Information

The site information is recorded with every event that occurs. The site information is displayed on screen for RMS event screens and waveform or summary plot Text screens. When printing an event or summary screen, the site information replaces the menu options in the printout.[12]

Since event data can be transferred to a disk, to another 658, or to a PC, the site information feature is one way of keeping track of which 658 recorded the event data.

The default site information setting is "DRANETZ 658 Power Quality Analyzer". You can change this setting to indicate the location where the unit is monitoring. This is accomplished through the MONITORING FUNCTIONS MENU (selection 4 from the MAIN MENU).

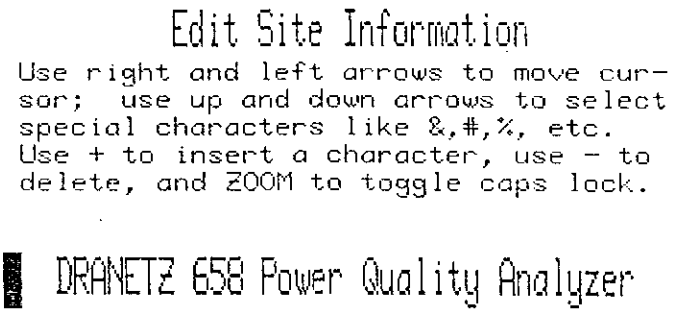
---

[10] If you press <ENTER> without entering a new time, the old time remains in effect.

[11] If you press <ENTER> without entering a new date, the old date remains in effect.

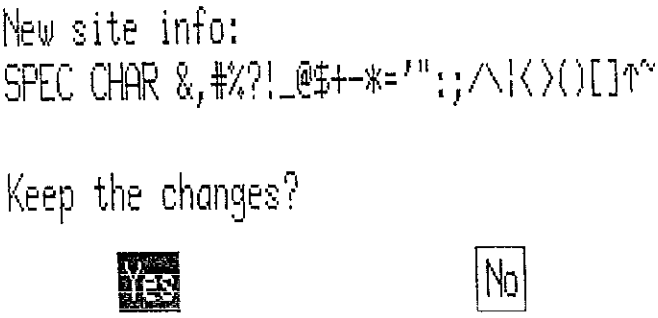
[12] This is only true when printing using the "Print" command. If printing using <*CTRL*> + <*P*>, the screen prints out in its entirety, including the menu options on the top of the screen.

From the MONITORING FUNCTIONS MENU select option 5, "Change Site Information." The site information currently in memory is displayed, along with a prompt providing Edit Site Information.



Type a new description of up to 40 characters long. The highlighted cursor displayed is moved horizontally by the left and right arrow cursors. The description can be upper and lower case letters, numbers, spaces, and up to 28 special characters. The alphanumeric keyboard is used to select the letters and numbers, whereas the up and down arrow cursors scroll through the special character selection menu. To select upper and lower case letters, position the highlight cursor on the letter to be changed and press <ZOOM> to toggle. Use <+> to insert a space and <-> to delete any character. To delete the entire line, press and hold <->.

Once the desired description is selected press <ENTER>. The site information is changed and the new description is echoed back to you.



Select Yes or No using the cursors and press <ENTER> or press <Y> or <N> from the keyboard. Select Yes to keep the changes and return to the MONITORING FUNCTIONS MENU. If you wish to make further changes, select No and the screen will return to the Edit Site Information menu.

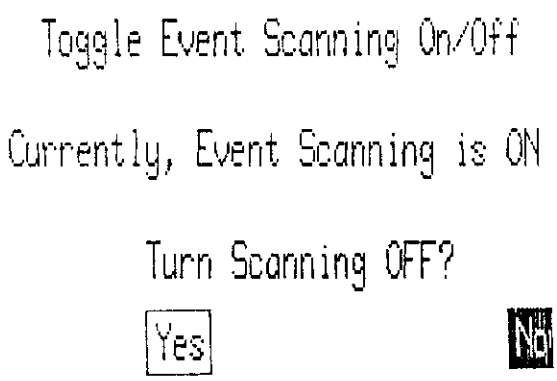
2.8.3 Enable/Disable Monitoring

In order for the 658 to monitor the connected channels, event scanning must be enabled.[13] This is accomplished through the MONITORING FUNCTIONS MENU (selection 4 from the MAIN MENU).

From the MONITORING FUNCTIONS MENU select option 4, "Turn Monitoring On/Off." The screen that appears indicates whether monitoring is presently on or off.

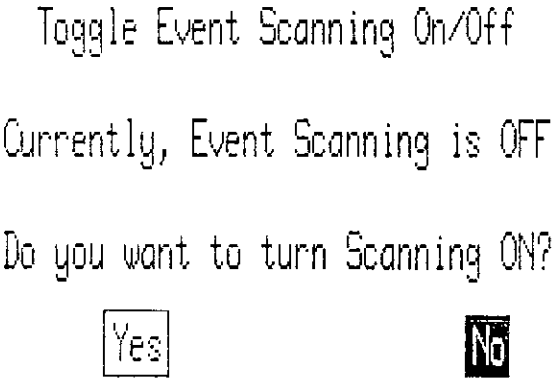
[13] The default condition for event scanning is "Enabled".

If monitoring is presently on, a screen such as the following appears:



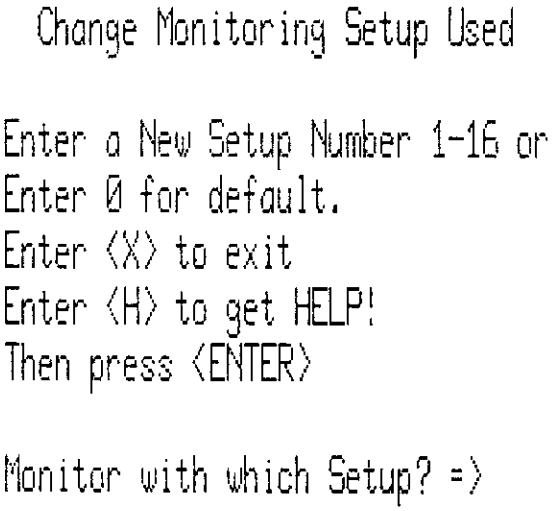
Use cursors to select highlight "Yes" or "No" and press <ENTER> or select <Y> or <N> with keyboard.

If monitoring is presently off, a screen such as the following appears:



If you select "No" you are returned to the MONITORING FUNCTIONS MENU.

If you select "Yes" the following screen appears, prompting you for the Main Channel Settings to activate.

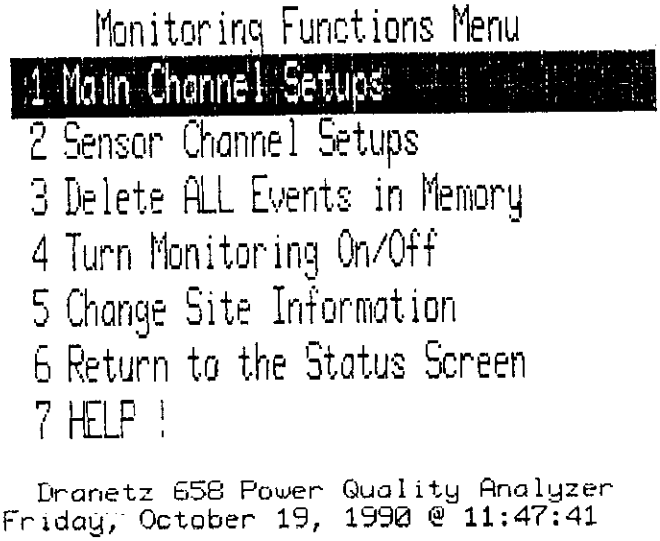


When monitoring is turned on a reference event is taken of all active channels.

NOTE: *Event Scanning is automatically turned off when 658 memory is full. Memory is full when there is not enough room to store a worst case event. If an initialized disk is in the disk drive, events are automatically dumped to disk, freeing up memory for more events.*[14]

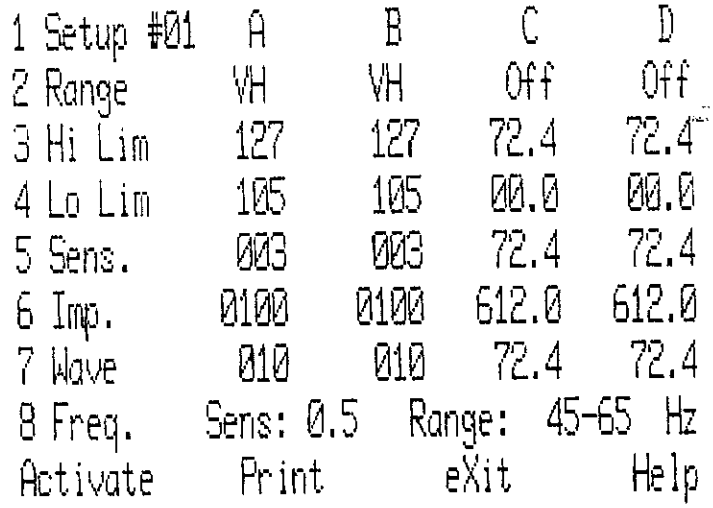
2.8.4 Setting Monitoring Thresholds

Main and Sensor Channel thresholds are set through the MONITORING FUNCTIONS MENU (Selection 4 in the MAIN MENU), which is illustrated below.



2.8.4.1 Main Channel Settings

Selection 1 from the MONITORING FUNCTIONS MENU brings up the Main Channel Setups Screen:



[14] Selection 5 on the DISK OPERATIONS MENU lets you select whether event data is dumped only once or repeatedly.

Sixteen different setup screens (numbered 1 through 16) are available. The first screen displayed is the currently active one.

These screens each have different default settings which can be changed to meet your requirements. Appendix C provides a listing of all 16 default settings.

You select individual options to change their settings. When you select an option, it is highlighted on the screen.

NOTE: *When a line or selection is highlighted, if you press <ENTER> before making any changes, nothing on the screen is affected.*

If you select options 2 through 7, the channel letters are also highlighted, indicating that you must next select the channel whose value you wish to change for that option.[15] Next, type in the new value and either press *<ENTER>* or select the next channel whose value you wish to change for that option. After making all the desired changes for that option, press *<ENTER>* to accept the changes. Then select the next option to change.

After changing the displayed settings, press *<A>* to activate the new setup, otherwise the old setup values are still active. If you forget to activate the settings a cautionary note will appear on the display reminding to return to activate the settings or continue.

NOTE: *The cursor keys are not active in the Main Channel and Sensor Setup screens.*

Help screens are available for the various options by pressing *<HELP>* while the option is highlighted. If no option is highlighted, a general help screen appears that explains how to select an option. The help screens also list the acceptable ranges when applicable.

To display a different setup, highlight option number 1, "Setup." Press <+> to sequentially advance through the screens. Press <-> to move through the screens in reverse order. To "jump" to a particular screen, type in the desired setup screen number in a 2-digit format (for example, *<0>* *<6>*).[16] Press *<ENTER>* to un-highlight the option.

To change the voltage or current range for an input channel, highlight option number 2, "Range." Each time the channel letter is pressed, the corresponding channel setting changes. The available settings for Channel A are "VH," "VL," and "OFF." For Channels B, C, and D, the available settings are "VH," "VL," "OFF", "I5," "I30," "I300," and "I3K."

"VH" (voltage high range) is used for most line-to-line or line-to-neutral voltage monitoring.

"VL" (voltage low range) is typically used for neutral-to-ground or low-voltage DC monitoring.[17]

Current settings should be used with the corresponding probe.

NOTE: *The current range is dictated by the probe used, for instance, if the TR-2019A probe is used, "I300" is the only allowable range.*

---

[15] Selecting another option before selecting a channel highlights that option instead. Selecting the same option twice without selecting a channel un-highlights the option.

[16] If only one digit is entered (for example, *<6>*), you must press <ENTER> to jump to that screen.

[17] At least one channel must be "ON" at any given time. Channel A is usually the default for synchronization. If channel A is "OFF," then at least one of the remaining channels must be set to "VH," "I5," "I30," "I300," or "I3K."

The acceptable ranges are described in TABLE 2-1 below:

TABLE 2-1 ACCEPTABLE RANGES FOR VOLTAGE AND CURRENT

V RMS Range		V pk Impulse Range		Waveform (V RMS) Envelope
VH = 0 to 724 V RMS	→	24 to 6120 V	→	2 to 724 V
VL = 0 to 72.4 V RMS	→	2.4 to 612 V	→	0.2 to 72.4 V
OFF = No Monitoring				
A RMS Range		**A pk Impulse Range**		**Waveform (A RMS) Envelope**
I5 = 0 to 7.24 A RMS[1]	→	0.24 to 25 A	→	0.02 to 7.24 A
I30 = 0 to 72.4 A RMS[2]	→	2.4 to 250 A	→	0.2 to 72.4 A
I300 = 0 to 724 A RMS[3]	→	24 to 2500 A	→	2 to 724 A
I3 K = 0 to 7240 A RMS[4]	→	240 to 25000 A	→	20 to 7240 A

[1] Use only the 0-5 A isolated CT Termination Box (110635-G2) with any 0-5 A secondary probe in this range.
[2] Use only the TR-2021 current probe in this range.
[3] Use only the TR-2019A current probe in this range.
[4] Use Dranetz P/N 110639-G1 (CT Termination Box and TR-2015A 3000 A current probe) or the TR-2023 current probe (with internal termination) in this range. If input will not be exceeding 1000 A, the TR-2022 current probe may be used.

After you have set the desired range, you can set the range for another input channel, or press <*ENTER*> to un-highlight the option.

To enter a value for the RMS High Limit, highlight option number 3, "Hi Lim," then select the channel whose High Limit you wish to set. (The acceptable RMS High Limits are listed in TABLE 2-2.) Type in the desired value.[18] Press <*ENTER*> to accept this setting and un-highlight this option, or select the next channel whose High Limit you wish to set. The 658 monitors Voltage or Current RMS values on a cycle by cycle basis, and an event is recorded when the RMS value for any cycle goes above or returns below the High Limit you set for that channel.

To enter a value for the RMS Low Limit, highlight option number 4, "Lo Lim," then select the channel whose Low Limit you wish to set. (The acceptable RMS Low Limits are listed in TABLE 2-2.) Type in the desired value.[19] Press <*ENTER*> to accept this setting and un-highlight this option, or select the next channel whose Low Limit you wish to set.

The 658 monitors Voltage or Current RMS on a cycle by cycle basis, and an event is recorded when the RMS for any cycle drops below or returns above the Low Limit you set for that channel.

To enter a value for RMS Sensitivity, highlight option number 5, "Sens," then select the channel whose RMS Sensitivity you wish to set. (The acceptable RMS Sensitivity range is listed in TABLE 2-2.) Type in the desired value. Press <*ENTER*> to accept this setting and un-highlight this option, or select the next channel whose RMS Sensitivity you wish to set.

The 658 monitors Voltage or Current RMS on a cycle by cycle basis. An event is recorded when the RMS for any cycle changes by more than the programmed sensitivity while out of the limits set for that channel.

[18] The High Limit cannot be lower than the existing Low Limit.
[19] The Low Limit cannot be higher than the existing High Limit.

Table 2-2. Legal RMS Thresholds

Range	High Limit	Low Limit	Sensitivity
I5	0.01 - 7.24 A RMS	0.00 - 7.24 A RMS	0.01 - 7.24 A RMS
I30	0.1 - 72.4 A RMS	0.0 - 72.4 A RMS	0.1 - 72.4 A RMS
I300	01 - 724 A RMS	0 - 724 A RMS	1 - 724 A RMS
I3k	10 - 7240 A RMS	0 - 7240 A RMS	10 - 7240 A RMS
VH	01 - 724 V RMS	0 - 724 V RMS	1 - 724 V RMS
VL	0.1 - 72.4 V RMS	0.0 - 72.4 V RMS	0.1 - 72.4 A RMS

To change the impulse threshold for an input channel, highlight option number 6, "Imp." Press the letter on the keyboard corresponding to the input channel you want to change. Type in the new impulse threshold. See table 2-3 for legal impulse thresholds. At this point you can change the impulse threshold for another input channel by selecting that channel, or press <ENTER> again to un-highlight the option.

Impulses, also called spikes, fast transients, or (in some disciplines) surges, are measured from their point of origin on the waveform to the maximum positive or negative amplitude point.

The example below illustrates a positive and a negative impulse.

Example "+" and "-" Impulses

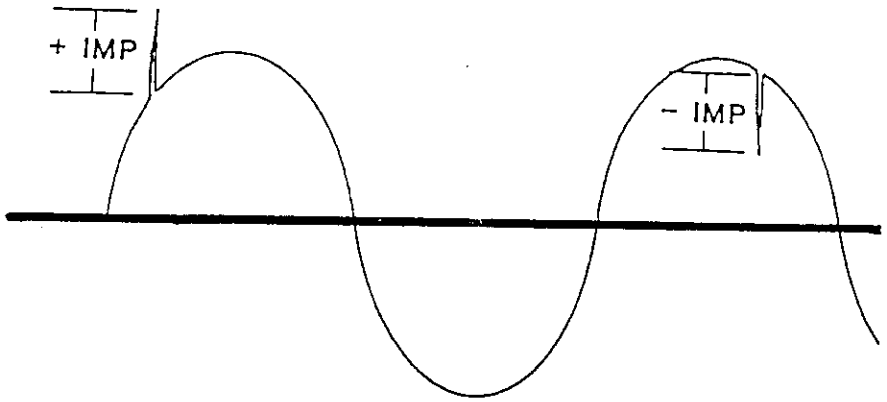


Table 2-3. Legal Impulse/Waveshape/Frequency Thresholds

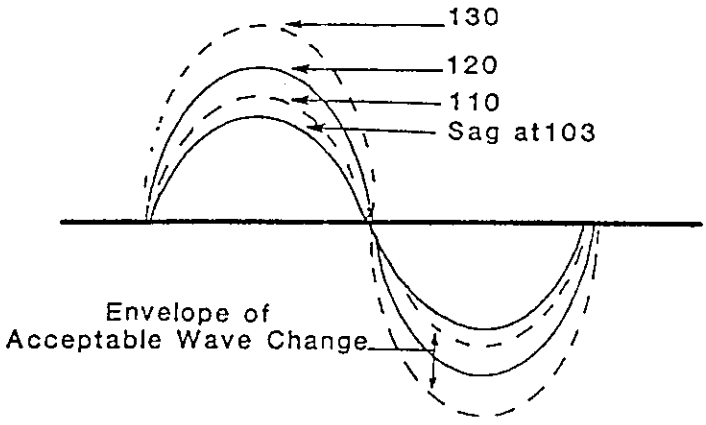
Range	Impulse Limit	Waveshape Limit	Frequency Sens
I5	00.24 - 61.20 Amps	0.02 - 7.24 ARMS	0.1 - 9.9 Hz
I30	002.4 - 612.0 Amps	00.2 - 72.4 ARMS	0.1 - 9.9 Hz
I300	0024 - 6120 Amps	002 - 724 ARMS	0.1 - 9.9 Hz
I3k	00240 - 61200 Amps	0020 - 7240 ARMS	0.1 - 9.9 Hz
VH	0024 - 6120 Volts	002 - 724 VRMS	0.1 - 9.9 Hz
VL	002.4 - 612.0 Volts	00.2 - 72.4 VRMS	0.1 - 9.9 Hz

To change the waveform envelope, highlight option number 7, "Wave." Press the letter on the keyboard corresponding to the input channel you want to change. Type in the new waveform envelope. See table 2-3 for threshold limits. At this point you can change the waveform envelope for another input channel by selecting that channel, or press *<ENTER>* again to un-highlight the option.
The envelope setting determines the amount a waveform can change before a new disturbance event is recorded. Waveform disturbances can be the result of changes in the RMS value of

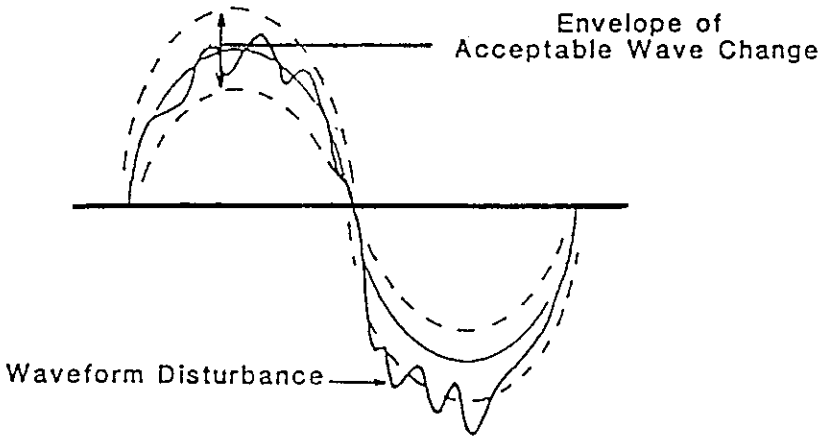
The envelope setting determines the amount a waveform can change before a new disturbance event is recorded. Waveform disturbances can be the result of changes in the RMS value of voltage or current ("sags", "surges" or "swells"), or the result of shorter sub-cycle disturbances, such as notching or harmonic distortion (see examples below). The value set for this threshold is based on the sinewave input and corresponds to the ΔV or ΔI change determining the size of the envelope.

In the two following examples, the waveform envelope is set to 10 V RMS with nominal voltage of 120. The envelope becomes 110 to 130.

Example Sag



Example Disturbance



To change the frequency sensitivity threshold and range, highlight option number 8, "Frequency." Type in the new frequency threshold and press ENTER See table 2-3 for the frequency sensitivity threshold.

The frequency threshold represents the reference or "sync" channel, which is usually channel A, and indicates the allowable change in frequency before a frequency event is recorded.[20]

If the 400 Hz option is installed you can change the frequency range. Press <R> to toggle between 45-65 Hz and 310-445 Hz.

NOTE: *Whenever you change a setup, you must press <A> to activate it. If you don't press <A>, the settings of the old Setup Screen remain active.*

[20] Changes in frequency on the reference channel are reported as frequency change events or as Graphic Summary plots of frequency vs. time. Changes of frequency on other main input channels appear as waveform events. The frequency of these waveforms can be determined using the zoom function when viewing events.

2.8.4.2 Sensor Channel Settings

Selection 2 from the MONITORING FUNCTIONS MENU brings up the Sensor Channel Setups Screen:

```
        Sensor Channel Setups
1 Channel ..... 1
2 Status ..... Off
3 Span Value ..... +00055
4 Zero Value ..... -00005
5 Units ..... Deg. C
6 Sensitivity ..... 02.0%

Print          eXit          Help
```

If the 658 is equipped with the optional Transducer board, it can monitor up to eight sensor channels. To activate a Sensor Channel, the Sensor Channel's status (line 2) must be turned ON. The channel becomes active when you exit from the Sensor Channel Setups screen. Selecting <A>ctivate from the Main Channel Setups screen will cause an initial Sensor Channel Event to be recorded for all Sensor Channels that are ON.[21]

NOTE: *Cursor keys are not active in Sensor Channel Setup screen.*

Up to eight different setup screens are available, one corresponding to each available channel. Channels 1 and 2 are preset for the T&H Monitor, channel 3 is preset for the Conducted Radio Frequency Sensor, and channel 4 is preset for the Radiated Radio Frequency Sensor.

Each has different default settings which can be changed to meet your requirements. To change a setting, you must first select the setting option. When you select an option, it is highlighted on the screen.[22] Next, type in the new value and press ENTER.

NOTE: *When a line or selection is highlighted, if you press <ENTER> before making any changes, nothing on the screen is affected.*

Help screens are available for the options by pressing *<HELP>* when the option is highlighted. If no option is highlighted when *<HELP>* is pressed, a general help screen appears.

Press *<EXIT>* or *<X>* to exit back to the REMOTE SETUPS MENU.

Press *<PRINT>* to print the screen.

---

[21] If <A>ctivate is not selected from the Main Channel Setups screen after a sensor channel has been active, no initial event will be recorded for that channel. The first event recorded for that channel will be when the monitored input changes by more than the specified threshold.

[22] You must un-highlight the current option before you can highlight another option.

To display a different setup, highlight option number 1, "Setup." Press <+> to sequentially advance through the screens. Press <-> to move through the screens in reverse order. To "jump" to a particular screen, type in the desired setup screen number. Press <*ENTER*> to un-highlight the option.

To change the monitoring status of the displayed channel, highlight option number 2, "Status." Press <*SPACE*> to toggle the status between "ON" and "OFF." To accept the new status and un-highlight the option, press <*ENTER*>.

To change the span , highlight option number 3, "Span Value". Use the keyboard to type in the new value and press <*ENTER*> to accept the change and un-highlight the option.

"Span Value" and "Zero Value" (option number 4) are used in conjunction with "Units" (option number 5), to fit the voltage output of the input transducer to a linear equation and to generate appropriate unit values.

Span refers to the nearest integer units output of a transducer at the full scale (10 volts) of the input. If the full scale output of the transducer is greater or less than 10 V DC, set span to what a 10 V DC output would indicate. Span and zero value setups are signed integers ranging from -32,768 to +32,767.

To change the Zero Value, highlight option number 4, "Zero Value." Use the keyboard to type in the new value and press <*ENTER*> to accept the change and un-highlight the option.

"Span Value" (option number 3) and "Zero Value" are used in conjunction with "Units" (option number 5), to fit the voltage output of the input transducer to a linear equation and to generate appropriate unit values.

The zero value refers to the nearest integer units output of a transducer at 0 volts of the input. Span and zero value setups are signed integers ranging from -32,768 to +32,767.

To enter a text description of the units being monitored, highlight option number 5, "Units." Use the keyboard to type in the desired description, which can be up to 6 characters long. Press <*ENTER*> to accept the change and un-highlight the option.

To set the allowable threshold of activity before an "event" occurs, highlight option number 6, "Sensitivity." Use the keyboard to type in the new value and press <*ENTER*> to accept the change and un-highlight the option.

The acceptable range is between 0.1 and 99.9 and represents a percentage of the total span. When the current reading deviates from the previous event by more than the programmed threshold, a new event is recorded.

Adjust the sensitivity percentage to correspond directly to the variance required for an event to be recorded. The following formula can be used to derive the sensitivity from the percentage values:

Event Sensitivity = Sensitivity X (Span Value - Zero Value).

Refer to the appropriate technical manual pertaining to the available sensor channel options. These manuals each include a table listing 20 common sensitivities and what percentage to program this selection to obtain the indicated sensitivity.

The sensor related technical manuals are as follows:

1.	T & H Monitor	(656-XD-1001)	TM-113800 Volume 1
2.	Conducted RF Monitor	(656-XD-1002)	TM-113810 Volume 1
3.	Radiated RF Monitor	(656-XD-1003)	TM-113900 Volume 1

2.8.4.3 Activate

Whenever you change a Main Channel setup, you must press <*A*> to activate it. When a new setup is activated, an initial event is captured of all monitored channels.

After you activate a new setting, a status screen appears indicating the new settings. From the status screen you return to the MAIN MENU.

If you don't press <*A*>, the settings of the old Setup Screen remain active.

If you press <*EXIT*> after making changes, a screen appears warning you that the changes you made have not been activated. From this screen you can select to return to the setup screen or the MONITORING FUNCTIONS MENU. If you press <*EXIT*> without making changes, you return directly to the MONITORING FUNCTIONS MENU.

If you change the sensor channel settings you do not need to Activate the changes. An initial event is not taken, but an event is recorded as soon as a significant change takes place. (If you wish an initial event to be taken, simply select <*A*>ctivate from the Main Channel Setups screen. An initial event of all active channels, including Sensor Channels, is recorded.)[23]

2.8.5 Clearing Memory

Before beginning monitoring, it is a good idea to clear the 658 memory.

The 658 memory is cleared through the MONITORING FUNCTIONS MENU (selection 4 from the MAIN MENU).

NOTE: *If you have previously recorded event data using the 658, you may want to save this information to a disk before clearing memory.*

From the MONITORING FUNCTIONS MENU select option 3, "Delete ALL Events in Memory." You are prompted to confirm this selection.

If you select "N", you are returned to the MONITORING FUNCTIONS MENU.

If you select "Y", all events in memory are erased and you are returned to the MONITORING FUNCTIONS MENU. If event scanning is on, new reference (initial) events are immediately recorded.

CAUTION

Once event MEMORY has been erased, it CAN NEVER BE RECOVERED.

[23] Clearing memory and turning monitoring on also captures initial events for all active channels.

2.8.6 Setting Auto-Transfer Mode

Event Scanning is automatically turned off when 658 memory is full, unless a data transfer occurs. (Memory is full when there is not enough room to store a worst case event.)

If an initialized disk is in the disk drive, events are automatically transferred to the disk when the 658 memory is filled. You select whether event data is automatically transferred to disk only the first time event memory is filled, or every time that event memory fills up. This is accomplished through the DISK OPERATIONS MENU (selection 5 from the MAIN MENU).

Selection 5 from the DISK OPERATIONS MENU reads either "Auto Xfer to Disk -Multi-" or "Auto Xfer to Disk -Once-". Each time this option is selected, it toggles between -Once- and -Multi-.

If -Once- is displayed, the first time the 658 memory fills, it is dumped to disk and event scanning resumes. If the memory fills a second time, event scanning is turned off.

NOTE: *If the event disk is replaced with another (initialized) disk after the data transfer and during continued monitoring, the 658 senses that a new disk is in place and will dump once to the new disk if memory fills again. This process can be repeated.*

If -Multi- is displayed, every time the event memory is full event data is dumped to the event disk. Anything previously recorded on the event disk is lost.

2.8.7 Checking Status Screen

After changing settings, you should view the Status Screen to verify the settings. This can be accomplished in several ways.

When you activate a new setup, a revised Status Screen is automatically displayed.

Selection 6 from the MONITORING FUNCTIONS MENU also displays the status screen. You cannot return to the MAIN MENU from this screen without first viewing the Status Screen. This is so you can view the changes you have made to the monitoring functions of the 658.

You can also view the Status Screen by selecting option 3 from the MAIN MENU.

The Status Screen indicates:

- current date and time
- whether monitoring is on or off,
- what Main channels are on and the RMS values of the on channels,
- the frequency of the Synchronization channel,
- what Sensor (Transducer) channels are on,
- the number of events in memory and the percentage of memory used,
- the date and time of the last recorded event,
- the active setup number,
- the printer selected,[24] and
- if an automatic save to disk function has just occurred, a message indicating its time and date appears

[24] See subsections 2.13 through 2.13.3 for information on the use of external printers.

Select MAIN MENU or SCOPE MODE and press <*ENTER*> to make selection.

2.8.8 Checking Scope Mode

After viewing the status screen, you may want to verify the main channel setups by viewing the active channel waveshapes in real-time. The scope mode can be accessed from the Status Screen by highlighting SCOPE MODE and pressing <*ENTER*> or <*S*>, or from the VIEW EVENTS MENU by selecting option 3 ENTER SCOPE MODE.

The scope mode provides a real-time display of the active channels and permits phase and amplitude comparisons of multi-phase AC networks. It also permits voltage and current single-phase comparisons.

When the scope mode is enabled, monitoring and recording of all events is stopped. The real-time display provides you with visual monitoring and also the ability to save (record) any waveforms you are viewing. The information on the display is updated at a one second rate.

You can record the viewed waveforms as events by selecting the Save option by pressing <S> when you determine the waveforms are of interest to record as events. The events recorded can be viewed by selection through the VIEW EVENTS MENU. Each time Scope Mode is entered a Monitoring Off event is stored in memory. After exiting Scope Mode a Monitoring On event and a set of Initial events are recorded.

2.9 MONITORING DATA

Once all the correct connections have been made and the desired thresholds and parameters have been set, the 658 can be left to do its monitoring.

If the beeper is enabled, the 658 emits a beep every time an event is recorded. This feature can be turned on or off through the recorded OTHER FUNCTIONS MENU (selection 6 from the MAIN MENU).

If the beeper is off, selection 2 on the OTHER FUNCTIONS MENU reads "Turn Beeper On." Press <2> to turn the beeper on.

If the beeper is on, selection 2 on the OTHER FUNCTIONS MENU reads "Turn Beeper Off." Press <2> to turn the beeper off.

2.10 VIEWING AND ANALYZING DATA

After events have been recorded by the 658, you are ready to begin viewing and analyzing event data. There are two main ways you can approach this:

1) by viewing graphic summaries;

2) by viewing individual events.

A graphic summary is a time plot of a particular type of event recorded on a particular channel. To view a graphic summary, select option 1 from the MAIN MENU. (Refer to subsections 2.10.1 through 2.10.1.5 for more information.)

You can select to view individual events either through the MAIN MENU or from the graphic summaries.

When viewing events from the MAIN MENU (option 1, "View Events"), you can immediately view a selected event by entering the event number or the time and date the vent occurred. (Refer to the "Zoom" and "View" features discussed in subsection 2.10.1.5 for more information on estimating date and time of events.)

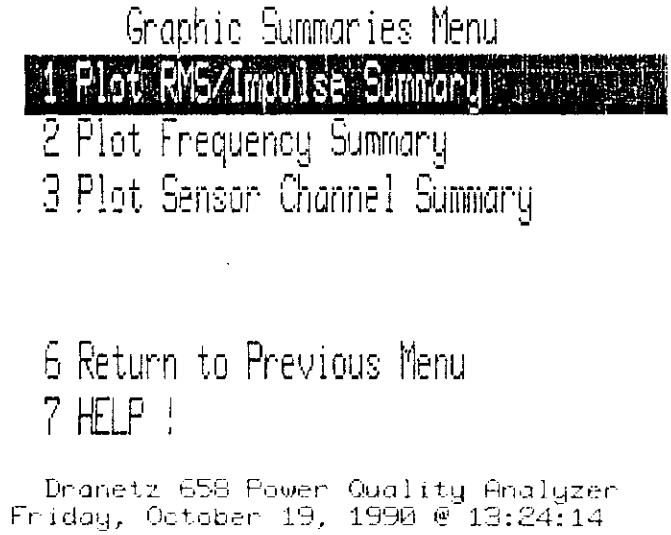
When viewing events from the graphic summaries, you can start viewing events from a selected point in the time plot. (Refer to subsections 2.10.2 through 2.10.2.5 for more information.)

Once you are viewing individual events you can page forward or backward through all events in memory. You can also jump to a specified event number. At this point, the only difference between viewing events from a graphic summary or directly from the "View Events" option is what happens when you exit from viewing individual events:

- If you chose to view events through the "View Events" option, you are returned to the MAIN MENU.
- If you chose to view events from a graphic summary, you are returned to the graphic summary that was displayed prior to viewing individual events.

2.10.1 View Graphic Summaries

To view a graphic summary of recorded events, select option 1 from the MAIN MENU. The GRAPHIC SUMMARIES MENU appears (illustrated below), allowing you to choose the type of events to be plotted.



POSSIBLE SELECTIONS AND WHAT THEY MEAN

Brief descriptions of the GRAPHIC SUMMARIES MENU selections are given below and on the following page, along with the number of the subsection to turn to for additional information.

Selection: **1 Plot RMS/Impulse Summary**

Application: Displays an RMS/Impulse summary plot of events recorded over a user specified time span. A different summary is available for each active Main Channel. This selection is discussed in subsection 2.10.1.1

Selection: **2 Plot Frequency Summary**

Application: Displays a summary plot of frequency change events recorded over a user specified time span. This selection is discussed in subsection 2.10.1.2

Selection: **3 Plot Sensor Channel Summary**

Application: Displays a summary plot of Sensor Channel events recorded over a user specified time span. A different summary is available for each active Sensor Channel. This selection is discussed in subsection 2.10.1.3

Selection: **6 Return to Main Menu**

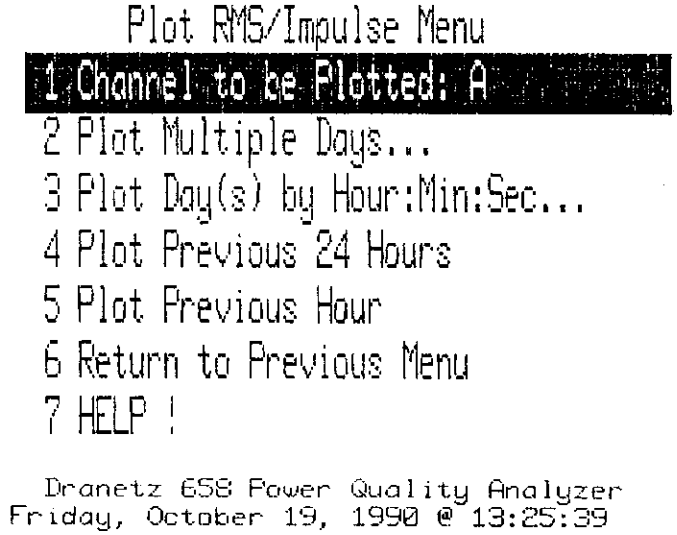
Application: Selection 6 returns you to the MAIN MENU.

Selection: **7 HELP !**

Application: Selection 7 brings up a HELP Screen which briefly describes the functions of selections 1 through 3.

2.10.1.1 Plot RMS/Impulse Summary Menu

Selection 1 in the GRAPHIC SUMMARIES MENU puts you in the PLOT RMS/IMPULSE MENU (illustrated below) which allows you to select the Main Channel to be plotted and the time span for the plot.



Possible Selections and What They Mean

Descriptions of the PLOT RMS/IMPULSE SUMMARY MENU selections are given on the following pages.

Selection: **1 Channel to be Plotted**

Application: Selection 1 cycles the channel to be plotted from A through D.[25] The desired channel should be selected before choosing a time span to plot.

Selection: **2 Plot Multiple Days**

Application: Selection 2 immediately prompts you for a start date for the plot:

Start Date mm-dd-yy =>

Type in a date in the requested format and press return. If you press <ENTER> without entering a start date, the date of the first RMS or waveform event in memory for this channel is used as the default.

You are then prompted for an end date for the plot:

End Date mm-dd-yy =>

Type in a date in the requested format and press <ENTER>. If you press <ENTER> without entering an end date, the date of the last RMS or waveform event in memory for that channel is used as the default.
You are then prompted to press <ENTER> to execute the plot. An example of an RMS/Impulse summary plot is located in subsection 2.10.1.4. Menu selections available from the RMS/Impulse summary screen are explained in subsection 2.10.1.5.

NOTE: *The maximum length for a graphic summary is 7 months. If you enter a time span greater than 7 months, a message appears telling you to enter a new time span.*

Selection: **3 Plot Day(s) by Hour:Min:Sec...**

Application: Selection 3 immediately prompts you for the start date:

Start Date mm-dd-yy =>

Type in a date in the requested format and press <ENTER>. If you press <ENTER> without entering a date, the date of the first RMS or waveform event in memory for this channel is used as the start date.

You are then prompted for a start time:

Start Time hh:mm:ss =>

[25] If the selected channel was not active during the time span you select, a message to this effect appears when you try to plot the graph.

Enter a time in military format and press <ENTER>. If you press <ENTER> without entering a time, the time of the first RMS or waveform event for this channel (since midnight) of the start date is taken as the default. If minutes or seconds are not entered, they are assumed to be "0" (for example: 2 PM = 14 <ENTER> = 14:00 <ENTER> = 14:00:00 <ENTER>).

You are then prompted for an ending date:

```
End Date  mm-dd-yy =>
```

Type in a date in the requested format and press <ENTER>. If you press <ENTER> without entering a date, the date of the last RMS or waveform event in memory for this channel is used as the ending date.

You are then prompted for an ending time:

```
End Time  hh:mm:ss =>
```

Enter a time in the requested military format and press <ENTER>. If you press <ENTER> without entering a time, the time of the last RMS or waveform event in memory for this channel and day is taken as the default. If minutes or seconds are not entered, they are assumed to be "0" (for example: 12 <ENTER> = 12:00 <ENTER> = 12:00:00 <ENTER>).

You are then prompted to press <ENTER> to execute the plot. An example of an RMS/Impulse summary plot is located in subsection 2.10.1.4. Menu selections available from the RMS/Impulse summary screen are explained in subsection 2.10.1.5.

Selection: **4 Plot Previous 24 Hours**

Application: Selection 4 immediately plots the previous 24 hours. An example of an RMS/Impulse summary plot is located in subsection 2.10.1.4. Menu selections available from the RMS/Impulse summary screen are explained in subsection 2.10.1.5.

Selection: **5 Plot Previous Hour**

Application: Selection 5 immediately plots the previous hour. An example of an RMS/Impulse summary plot is located in subsection 2.10.1.4. Menu selections available from the RMS/Impulse summary screen are explained in subsection 2.10.1.5.

Selection: **6 Return to Previous Menu**

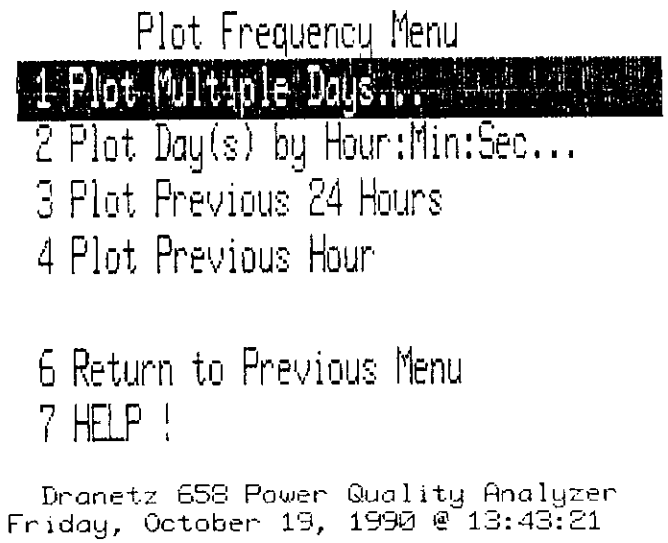
Application: Selection 6 returns you to the GRAPHIC SUMMARIES MENU.

Selection: **7 HELP !**

Application: Selection 7 brings up a HELP Screen which briefly describes the functions of selections 1 through 5.

2.10.1.2 Plot Frequency Summary Menu

Selection 2 in the GRAPHIC SUMMARIES MENU puts you in the PLOT FREQUENCY MENU (illustrated below), which allows you to select the time span for the plot.[26]



Possible Selections and What They Mean
Descriptions of the PLOT FREQUENCY MENU selections are given below and on the following pages.

Selection: **1 Plot Multiple Days**

Application: Selection 1 immediately prompts you for a start date for the multiple days plot:

```
Start Date  mm-dd-yy =>
```

Type in a date in the requested format and press <ENTER>. If you press <ENTER> without entering a start date, the date of the first frequency event in memory is used as the default.

You are then prompted for an end date for the plot:

```
End Date  mm-dd-yy =>
```

Type in a date in the requested format and press <ENTER>. If you press <ENTER> without entering an end date, the date of the last frequency event in memory is used as the default.

You are then prompted to press <ENTER> to execute the plot. An example of a Frequency summary plot is located in subsection 2.10.1.4. Menu selections available from the Frequency summary screen are explained in subsection 2.10.1.5.

NOTE: *The maximum length for a graphic summary is 7 months. If you enter a time span greater than 7 months, a message appears telling you to enter a new time span.*

[26] The frequency plot charts changes in the primary synchronization channel, not individual channels.

Selection: **2 Plot Day(s) by Hour:Min:Sec...**

Application: Selection 2 immediately prompts you for the start date:

```
Start Date  mm-dd-yy =>
```

Type in a date in the requested format and press <ENTER>. If you press <ENTER> without entering a date, the date of the first frequency event in memory is used as the start date.

You are then prompted for a start time:

```
Start Time  hh:mm:ss =>
```

Enter a time in the requested format and press <ENTER>. If you press <ENTER> without entering a time, the time of the first frequency event (since midnight) of the start date is taken as the default. If minutes or seconds are not entered, they are assumed to be "0" (for example: 12 <ENTER> = 12:00 <ENTER> = 12:00:00 <ENTER>).

You are then prompted for an ending date:

```
End Date  mm-dd-yy =>
```

Type in a date in the requested format and press <ENTER>. If you press <ENTER> without entering a date, the date of the last frequency event in memory is used as the ending date.

You are then prompted for an ending time:

```
End Time  hh:mm:ss =>
```

Enter a time in the requested format and press <ENTER>. If you press <ENTER> without entering a time, the time of the last frequency event in memory is taken as the default. If minutes or seconds are not entered, they are assumed to be "0" (for example: 12 <ENTER> = 12:00 <ENTER> = 12:00:00 <ENTER>).

You are then prompted to press <ENTER> to execute the plot. An example of a Frequency summary plot is located in subsection 2.10.1.4. Menu selections available from the Frequency summary screen are explained in subsection 2.10.1.5.

Selection: **3 Plot Previous 24 Hours**

Application: Selection 3 plots the previous 24 hours. An example of a Frequency summary plot is located in subsection 2.10.1.4. Menu selections available from the Frequency summary screen are explained in subsection 2.10.1.5.

Selection: **4 Plot Previous Hour**

Application: Selection 4 immediately plots the previous hour. An example of a Frequency summary plot is located in subsection 2.10.1.4. Menu selections available from the Frequency summary screen are explained in subsection 2.10.1.5.

Selection: **6 Return to Previous Menu**

Application: Selection 6 returns you to the GRAPHIC SUMMARIES MENU.

Selection: **7 HELP !**

Application: Selection 7 brings up a HELP Screen which briefly describes the functions of selections 1 through 4.

2.10.1.3 Plot Sensor Channel Summary Menu

Selection 3 in the GRAPHIC SUMMARIES MENU puts you in the PLOT SENSOR CHANNEL MENU (illustrated below), which allows you to select the Sensor Channel to be plotted and the time span for the plot.

Possible Selections and What They Mean
Descriptions of the PLOT SENSOR CHANNEL MENU selections are given below and on the following pages.

Selection: **1 Channel to be Plotted**

Application: Selection 1 sequences the channel to be plotted from S1 through S8.[27] The desired channel should be selected before choosing a time span to plot.

Selection: **2 Plot Multiple Days**

Application: Selection 2 immediately prompts you for a start date for the multiple days plot:

```
Start Date  mm-dd-yy =>
```

[27] If the selected channel was not active during the time span you select, a message to this effect appears when you try to plot the graph.

Type in a date in the requested format and press return. If you press <ENTER> without entering a start date, the date of the first event in memory for the specified Sensor Channel is used as the default.
You are then prompted for an end date for the plot:

```
End Date  mm-dd-yy =>
```

Type in a date in the requested format and press return. If you press <ENTER> without entering an end date, the date of the last event in memory for the specified Sensor Channel is used as the default.

You are then prompted to press <ENTER> to execute the plot. An example of a Sensor Channel summary plot is located in subsection 2.10.1.4. Menu selections available from the Sensor Channel summary screen are explained in subsection 2.10.1.5.

NOTE: *The maximum length for a graphic summary is 7 months. If you enter a time span greater than 7 months, a message appears telling you to enter a new time span.*

Selection: **3 Plot Day(s) by Hour:Min:Sec...**

Application: Selection 3 immediately prompts you for the start date:

```
Start  Date  mm-dd-yy =>
```

Type in a date in the requested format and press <ENTER>. If you press <ENTER> without entering a date, the date of the first event in memory for the specified Sensor Channel is used as the start date.

You are then prompted for a start time:

```
Start Time  hh:mm:ss =>
```

Enter a time in the requested format and press <ENTER>. If you press <ENTER> without entering a time, the time of the first event (since midnight) for the specified Sensor Channel of the start date is taken as the default. If minutes or seconds are not entered, they are assumed to be "0" (for example: 12 <ENTER> = 12:00 <ENTER> = 12:00:00 <ENTER>).

You are then prompted for an ending date:

```
End Date  mm-dd-yy =>
```

Type in a date in the requested format and press <ENTER>. If you press <ENTER> without entering a date, the date of the last event in memory for the specified Sensor Channel is used as the ending date.

You are then prompted for an ending time:

```
End Time  hh:mm:ss =>
```

Enter a time in the requested format and press <ENTER>. If you press <ENTER> without entering a time, the time of the last event in memory for the specified Sensor Channel is taken as the default. If minutes or seconds are not entered, they are assumed to be "0" (for example: 12 <ENTER> = 12:00 <ENTER> = 12:00:00 <ENTER>).

You are then prompted to press <ENTER> to execute the plot. An example of a Sensor Channel summary plot is located in subsection 2.10.1.4. Menu selections available from the Sensor Channel summary screen are explained in subsection 2.10.1.5.

Selection: **4 Plot Previous 24 Hours**

Application: Selection 4 immediately plots the previous 24 hours. An example of a Sensor Channel summary plot is located in subsection 2.10.1.4. Menu selections available from the Sensor Channel summary screen are explained in subsection 2.10.1.5.

Selection: **5 Plot Previous Hour**

Application: Selection 5 immediately plots the previous hour. An example of a Sensor Channel summary plot is located in subsection 2.10.1.4. Menu selections available from the Sensor Channel summary screen are explained in subsection 2.10.1.5.

Selection: **6 Return to Previous Menu**

Application: Selection 6 returns you to the GRAPHIC SUMMARIES MENU.

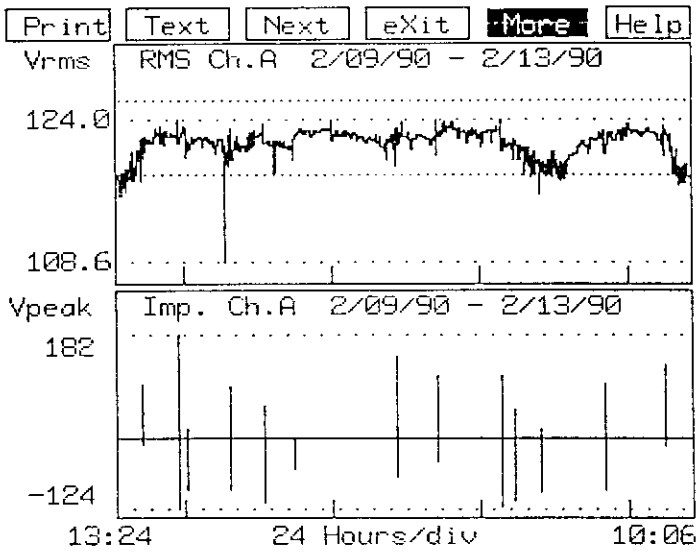
Selection: **7 HELP !**

Application: Selection 7 brings up a HELP screen which briefly describes the functions of selections 1 through 5.

2.10.1.4 Sample Summary Plots

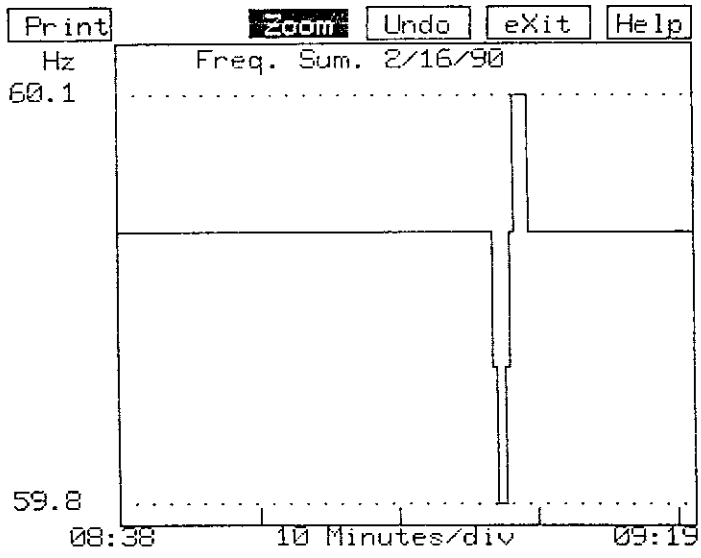
If the starting time you selected to plot is before any events of the type you specified occur, the graph will begin with the time and date of the first specified type of event in the selected time frame. Therefore, if you enter 10:00 am on the 15th as the starting time and date, but no events are recorded before 2:30 pm on the 16th, the graphic summary would begin with the event recorded at 2:30 pm on the 16th. In this way the data is displayed to its optimum resolution, and is not needlessly compressed.

Below is a sample RMS/Impulse summary plot[28]:



The type of plot, the channel the events were recorded on, and the time-span plotted appear along the top of each plot. Coarsely dotted horizontal lines on each plot indicate the maximum and minimum values recorded in this time span. These values are displayed to the left of the time plots. The RMS High and Low Limits, when shown, appear as finely dotted horizontal lines. The bottom of each graph above is marked in 24 hour divisions. The size of the divisions is indicated on the bottom of the screen and varies depending on the size of the plot. The available menu selections (displayed at the top of the screen) are discussed in subsection 2.10.1.5.

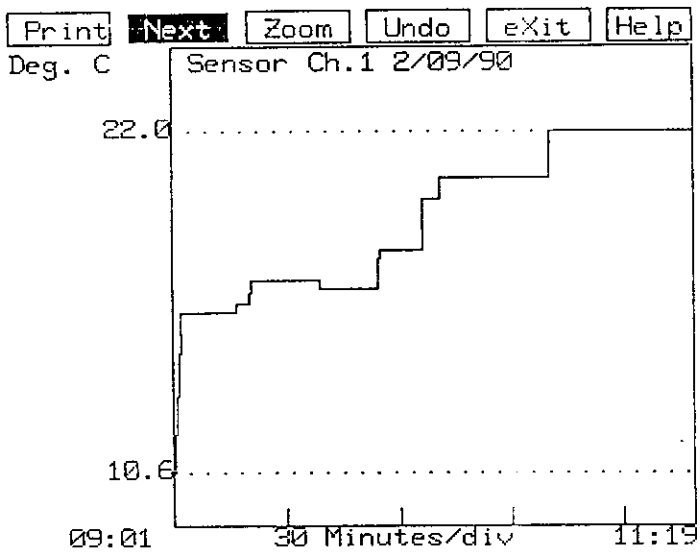
Below is an example Frequency Summary Plot:



[28] In this example, voltage was recorded; if current was recorded, "Vrms" and "Vpeak" would be replaced with "Arms" and "Apeak".

The type of plot and the time-span plotted appear along the top of the plot. Dotted horizontal lines on the plot indicate the maximum and minimum values recorded in this time span. These values are displayed (to 0.1 Hz resolution) to the left of the time plot. The bottom of the graph above is marked in 10 minute divisions. The size of the divisions is indicated on the bottom of the screen and varies depending on the size of the plot. The available menu selections (displayed at the top of the screen) are discussed in subsection 2.10.1.5.

Below is a Sensor Channel Summary Plot:



The type of plot and the time-span plotted appear along the top of the plot. Dotted horizontal lines on the plot indicate the maximum and minimum values recorded in this time span. These values are displayed to the left of the time plot. The bottom of the graph above is marked in two hour divisions. The size of the divisions is indicated on the bottom of the screen and varies depending on the size of the plot. The available menu selections (displayed at the top of the screen) are discussed in subsection 2.10.1.5.

NOTE: *Text descriptions of Sensor Channel plots are not applicable. Text descriptions of individual events (by sequential occurrence or by specific time and date) can be obtained in the* VIEW EVENTS MENU.

2.10.1.5 Summary Screen Menu Options

A menu listing several selections appears at the top of each type of graphic summary screen. Most menu selections are available for each type of summary; some are not.

The menu selections available for the RMS/Impulse Summary screen are:

Print Text Next Zoom Undo View Lims More Help eXit

The menu selections available for the Frequency Summary screen are:

Print Zoom Undo View Help eXit

The menu selections available for the Sensor Channel Summary screen are:

Print Next Zoom Undo View Help eXit

Not all menu options are displayed at the same time. Selecting certain options causes other levels of menu options to appear.

The menu options can either be selected using the cursor keys or letter keys of the keyboard. To select a menu option using the left or right cursor key, highlight the option desired and press <*ENTER*> to select. To select a menu option using the keyboard, press the key corresponding to the capital letter in the desired option.

When viewing an RMS/Impulse Summary screen, there are more options available than will fit across the top of the screen. Therefore, the options are displayed in two separate groups. Selecting the "**More**" option toggles the display between these two different groups. These menu options are treated as one level, and selections can be made (using the keyboard) from either group regardless of which group is currently displayed.

The effects of selecting any of these menu options are described below:

Print This selection causes the displayed plot to be printed.[29] The menu options are replaced on the printout with the site descriptor. The output will be sent to the unit's thermal printer unless another printer was selected.[30]

If using the 658's Thermal printer, pressing the <*EXIT*> button stops the printing.

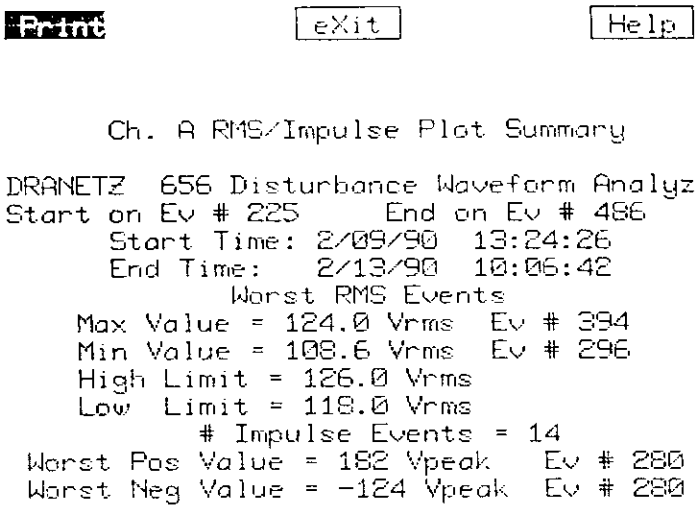
Text This selection causes a text description of the RMS/Impulse summary, including high and low limits, and worst case events, to be displayed. Three menu selections accompany this display:

Print eXit Help

[29] The graph can also be printed using <*CTRL*> + <*P*>, causing the screen to print out in its entirety, including the menu options on the top of the screen.

[30] See subsection 2.13 for information on the use of external printers.

The sample display below is the text description of the RMS/Impulse summary plot displayed in subsection 2.10.1.4:



The text indicates the input channel, the site description, the starting and ending event numbers and their time and date, the user set High and Low RMS Limits, the maximum and minimum RMS event values and their event number, the number of impulse events recorded, and the event number and value of the worst positive and negative impulse events.[31]

The "Text" menu selection is not available for Frequency or Sensor Channel summaries.

Next This selection displays the time plot of the next channel active during the selected time span. If no other channels were active during the selected time span, the same graph is displayed.

The "Next" menu selection is not available for Frequency summaries.

Zoom The zoom function is selected by pressing the <*ZOOM*> key or the keyboard <Z> key.

The zoom feature has two functions:

1) To select and expand a portion of the plot to fill the complete graph area.

2) To select a point on the graph from which to start viewing individual events.

The second function mentioned above is discussed under the "View" selection.

[31] In those cases where the plot begins or ends with a pseudo event, or if the highest or lowest RMS value was captured by a pseudo-event, the event number will not be reported. (The Zoom markers can be used to pinpoint the time and date of the minimum and maximum values.) See "Event Recording" in subsection 1.4.3 for further information on pseudo events.

When "Zoom" is chosen from the GRAPHIC SUMMARY MENU, a new level of menu selections appear. These selections are:

Print Zoom eXit View Help

Along with the new menu selections, two vertical lines (markers) are displayed to define the left and right zoom window boundaries. The time and date bounded by each marker is displayed at the bottom of the screen. Move the lines to mark the beginning and ending points for the new plot.

The markers can be moved using the left and right zoom cursor keys. Pressing and pivoting the left cursor in the direction of travel moves the left marker in the left or right direction. The right cursor key controls the movement of the right marker in the same fashion.

To move both markers at the same time, press both the *<CTRL>* button and either the left or right cursor for the respective left or right direction of markers movement.

Once the desired area is enclosed between the two markers, select "Zoom" a second time to expand the selected area to the full graph. The original GRAPHIC SUMMARY MENU is again displayed at the top of the screen.[32]

You can zoom in repeatedly, down to a 10 second time span. The "Undo" selection will return you to the previous zoom level. The *<EXIT>* key will return you to the complete time span originally requested.

Undo This selection causes the previous zoom level to be displayed. You can select "Undo" repeatedly until the complete time span originally requested is displayed.

This selection performs no function until a graph has been zoomed.

View This selection is used in conjunction with the zoom feature and allows you to view individual events starting at the point in the plot you select.
To use "View," you must first select "Zoom". "View" is one of the selections that appear in the ZOOM SELECTIONS MENU. When "Zoom" is chosen from the GRAPHIC SUMMARY MENU, two vertical lines (markers) appear on the graph. Move these lines so that the first marker immediately precedes the point in the graph where you wish to start viewing individual events. (You may wish to zoom in several times first, to get the first marker as close as possible to the first event you wish to view.)

[32] To remove the markers and re-display the original GRAPHIC SUMMARY MENU without zooming, select "eXit" from the ZOOM SELECTION MENU.

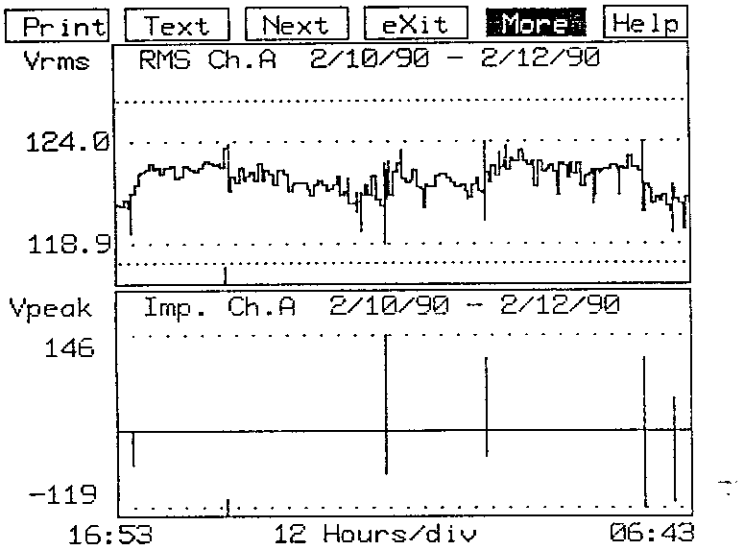
Once you have the marker as close as possible to the point you wish to view, select "View" from the ZOOM SELECTION MENU. The first event (of the type appearing in the plot) that occurs after the time indicated by the first marker is displayed on the screen. From this point you can view any of the events in memory.

Selecting "eXit" from the event screen menu returns you to the graphic summary.

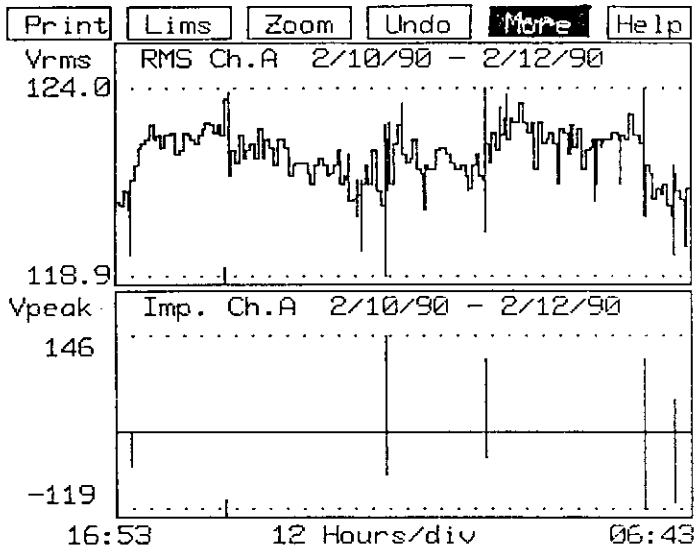
For more information on viewing individual events and on the available menu selections for these events refer to subsections 2.10.2.1 and 2.10.2.2.

Lims This selection toggles the RMS graph between displaying user set limits and not displaying these limits. Displaying the limits may cause unnecessary horizontal compression of data if the recorded values did not approach the user set High and Low Limits.

The graph below displays finely dotted horizontal limes to indicate the user set High Limit of 126 V RMS and the user set Low Limit of 116 V RMS. Two coarsely dotted horizontal lines indicate the maximum and minimum RMS values reached by events in the plot. These values are shown to the left of the plot.



The graph below covers the same time span as the graph above, but since the High and Low Limits are not displayed, the graph can display greater vertical resolution. (The magnitude of the graph is expanded, but the time span remains the same.)



More This menu option is only available for the RMS/Impulse Summary screen. Up to six menu options are displayed across the top of the screen at one time. Since more than 6 options are available for the RMS/Impulse Summary screen, they are displayed in two different groups, or sets, of menu selections. The "More" menu selection toggles the display between these two groups.[33]

Help This selection causes a help screen to appear which briefly describes all the available menu options.

eXit This selection returns you to the previous screen.

If you are viewing a text description of the graphic summary, "eXit" will return you to the graphic summary screen.

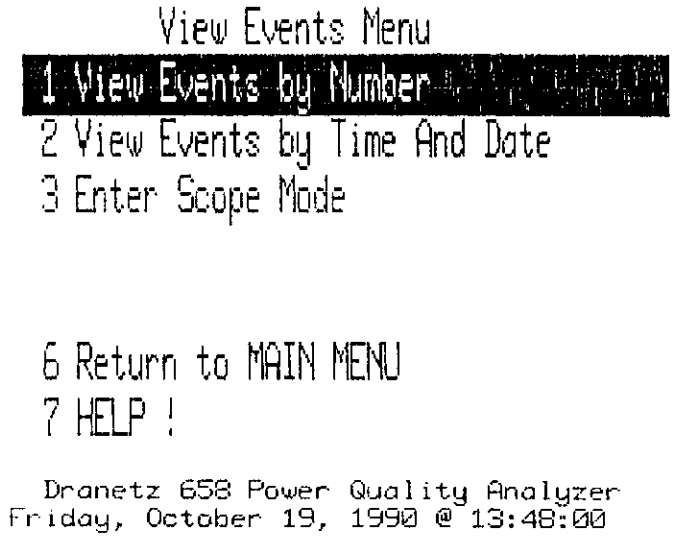
If you are viewing a graphic summary screen with the ZOOM SELECTION MENU and the zoom markers, "eXit" will remove the markers and replace the graphic summary menu.

If you are viewing the graphic summary, "eXit" will return you to the appropriate PLOT SUMMARY MENU, from which you selected the time span to be plotted.

[33] A menu option can be selected using the keyboard even if it's not in the group currently being displayed. Don't confuse this with different "levels" of menu options.

2.10.2 View Recorded Individual Events or Real-Time Waveforms

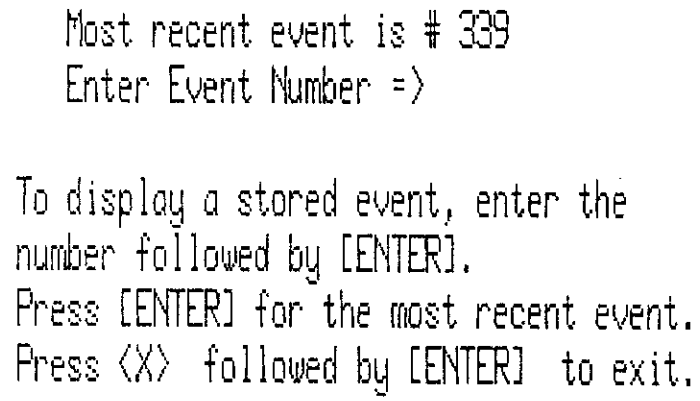
To view individual events by recorded number or recorded date, or real-time (Scope Mode) waveforms, select option 2 from the MAIN MENU. The VIEW EVENTS MENU appears (illustrated below), allowing you to select to view a particular recorded event by its assigned number, by the time and date it occurred, or real-time.



Possible Selections and What They Mean
Descriptions of the VIEW EVENTS MENU selections are given on the following pages.

Selection: **1 View Events by Number**

Application: Selection 1 immediately prompts you with a screen such as the following:



You can either enter an event number and press <*ENTER*>, or simply press <*ENTER*> to display the last or most recent event. Examples of various types of events are given in subsection 2.10.2.1. Descriptions of the menu options for these screens are given in subsection 2.10.2.2.

Selection: **2 View Events by Time and Date**

Application: Selection 2 first prompts you for a date and then a time. The first event in memory which occurred after this time and date is then displayed. If no event occurred after the selected time and date, the most recent event which occurred before that time and date is displayed. Examples of various types of events are given in subsection 2.10.2.1. Descriptions of the menu options for these screens are given in subsection 2.10.2.2.

Selection: **3 Scope Mode**

Application: Selection 3 provides a real-time scope display of the status of the main channels A, B, C, and/or D. Each channel may be selected individually or in a multiple overlay mode to show phase and subsequent line disturbance commonalities. The SCOPE MODE permits viewing of real-time waveforms. Waveforms viewed in the Scope mode can be recorded (saved in memory) where they have a number, and date and time assigned to them. These individual events can then be viewed as normal events recorded by number or time. Each Scope Mode "Save" consists of an initial waveform, RMS, and frequency event. Examples of initial events are given in subsection 2.10.2.1. Description of the menu options for the screen are given in subsection 2.10.2.4.

Selection: **6 Return to MAIN MENU**

Application: Selection 6 returns you to the MAIN MENU.

Selection: **7 HELP !**

Application: Selection 7 brings up a HELP Screen which briefly describes the functions of selections 1 and 2.

2.10.2.1 Sample Event Screens

The different types of events that the 658 can record are described on the following pages.

Initial Events

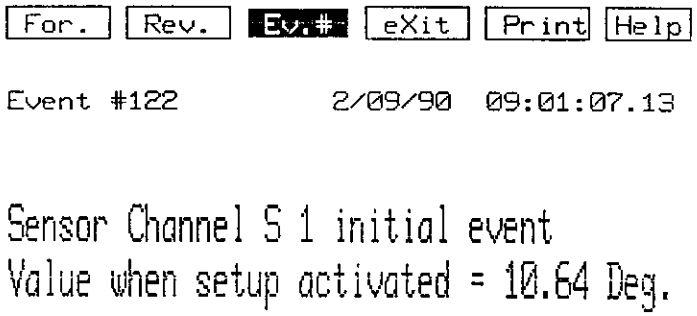
When the 658 is powered on, a reference reading is taken of:

- the active Sensor Channel values,
- the active Main Channel waveforms,
- the active Main Channel RMS values,
- and the frequency value.

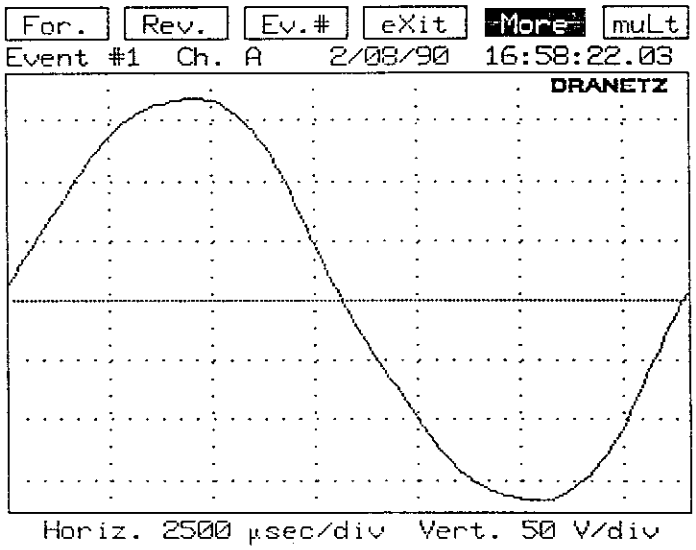
These readings, or initial events, are also recorded when monitoring is turned on or whenever a new setup is activated from the MONITORING FUNCTIONS MENU. When the Save option is initiated in the SCOPE MODE, these events are also recorded.

Below are some examples of these events:

Initial Sensor Channel Event[34]



Initial Main Channel Waveform Event



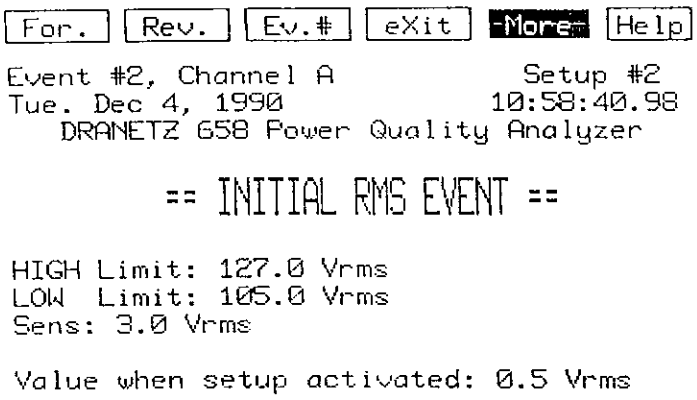
The text line below the screen displays the values for the divisions used in the grid on the graph. In the example above, each division as you go from left to right across the screen represents 2500 microseconds. Each division as you go from the top to the bottom of the screen represents 50 volts.

The text line above the screen indicates the event's position in memory[35], the channel recorded, and the date and time the disturbance occurred.

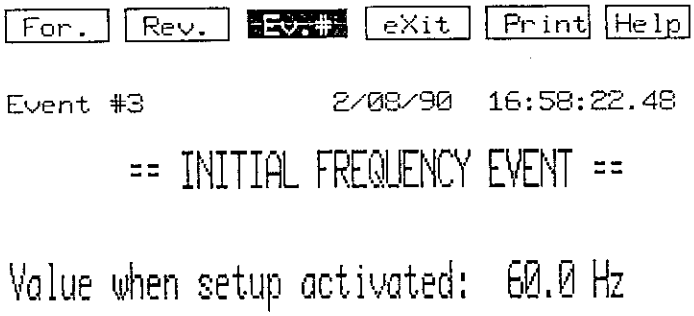
[34] An initial event is recorded for each active Sensor Channel.

[35] One event can consist of up to four screens, one for each active Main Channel.

Initial Main Channel RMS Event[36]

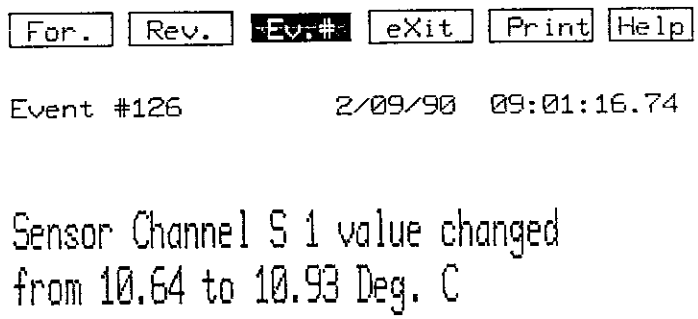


Initial Frequency Event



Sensor Channel Events

When a monitored Sensor Channel changes by more than the user specified sensitivity from the previously recorded event for that channel, a new event is recorded. This new event then becomes the reference for the next event. Below is a sample Sensor Channel Event.[37]



[36] An initial event is recorded for each active Main Channel.

[37] Sensor Channel events are only recorded if your 658 contains a transducer board and is set up to monitor Sensor Channels.

Waveform Events

Several different types of disturbances each result in a waveform event. These disturbances can generally be lumped into two broader categories: waveform deviation and voltage or current impulses.

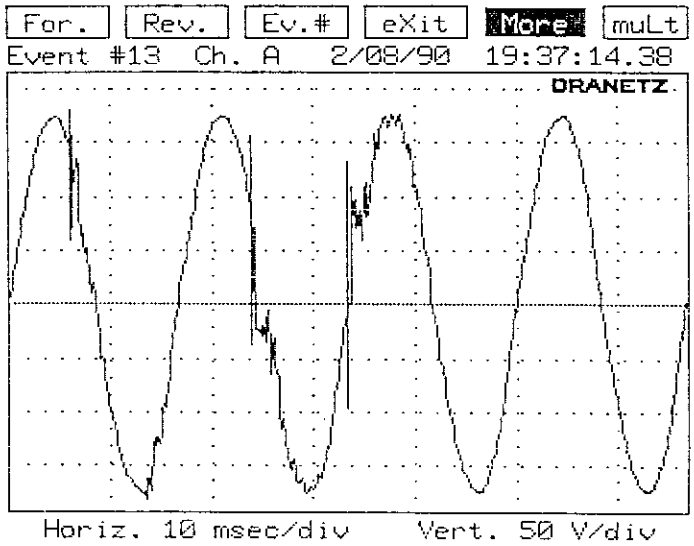
Waveform Deviation: The 658 uses the previous waveform event as a reference when monitoring each active Main Channel. Changes in waveform can be the result of harmonic disturbances or changes in absolute value RMS. Whenever the waveshape varies by more than the programmed sensitivity from the last cycle of the last event for that channel, an event occurs.[38] This means that a "snapshot" of the waveform is recorded for each monitored Main Channel. Each "snapshot" is simultaneous and part of the same event and therefore given the same event number.

Impulse disturbances: The 658 also records Impulse disturbances which are high frequency transients that trigger high frequency sampling mode for greater resolution. Again, a "snapshot" is taken of each monitored Main Channel.

Both types of disturbances are illustrated in the Main Channel Settings subsection (2.8.4.1).

Waveform events can consist of a single cycle or multiple cycles. The event is considered to have ended when the waveform has stabilized for four cycles or if the event reaches 64 Kbytes in length.

The sample waveform event illustrated below is a multi-cycle impulse event[39]. Appendix B contains more example waveform disturbances and descriptions of what is being illustrated.



The text line below the screen displays the values for the divisions used in the grid on the graph. In the example above, each division as you go from left to right across the screen represents 10 milliseconds. Each division as you go from the top to the bottom of the screen represents 50 volts.

[38] See Main Channel Setups subsection (2.8.4.1) for information on threshold sensitivity.

[39] If monitoring current instead of voltage, "Arms" and "Apeak" would appear instead of "Vrms" and "Vpeak".

The text line above the screen indicates the event's position in memory[40], the channel recorded, and the date and time the disturbance occurred.

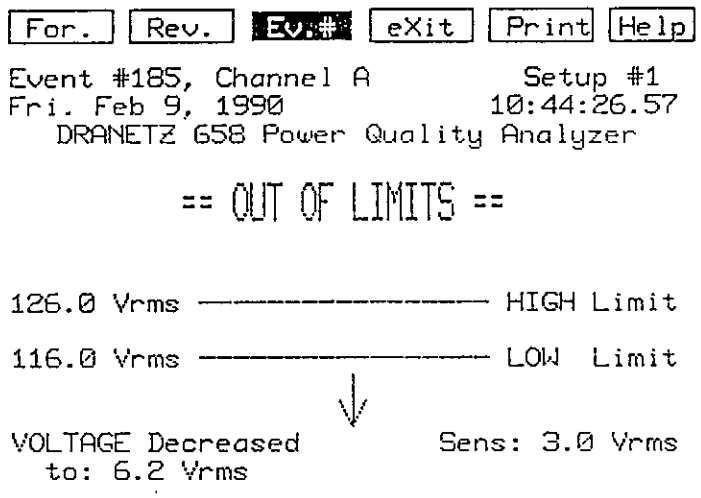
Out-of-Limits RMS Events

An Out-of-Limits Event occurs when the RMS of any monitored channel goes above or below the user set limits for one cycle or longer.[41] Once out of these limits, a new event is recorded each time the RMS increases or decreases from previously recorded RMS by more than the specified sensitivity. An Out-of-Limits event is also recorded when the RMS returns to be within the specified limits.

RMS events are recorded only for the channel which goes out of limits: an RMS event on one main channel does not trigger an event on any other main channel.

Data reported by an RMS event may overlap with data reported by a waveform event: a sag in voltage, for example, may be recorded as both a waveform event and a simultaneous RMS event. This depends on the threshold settings for these two parameters. Since RMS events occupy far less space in memory than waveform events, it is usually good practice to set the wave threshold so that it does not trigger on relatively minor changes in voltage or current which can be recorded more efficiently by the High and Low limits thresholds.

The Out-of-Limits event illustrated below was recorded when the Voltage RMS went below the user set Low Limit of 116.0 volts.



The first line of text on the screen indicates the event number, the channel the event occurred on, and the setup screen that was active at the time the event occurred. The date and time the RMS exceeded its limits is indicated in the second line of text. The third line displays the "Site Information" identifier (set through the MONITORING FUNCTIONS MENU).

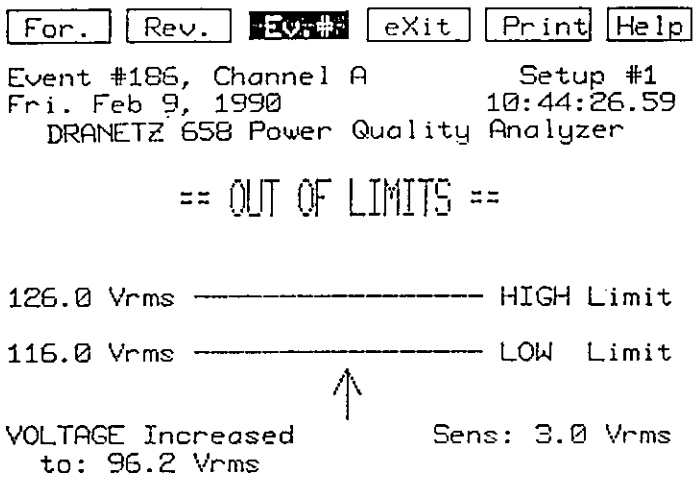
The middle of the screen displays the values of the high and low limits at the time the event occurred. The direction of the arrow on the screen illustrated above indicates that the RMS value decreased. The arrow, shown as originating below the line, indicates the previous value was below the low limit. If the arrow appeared crossing the lower line, it would indicate that this value had previously been within the acceptable limits.

---

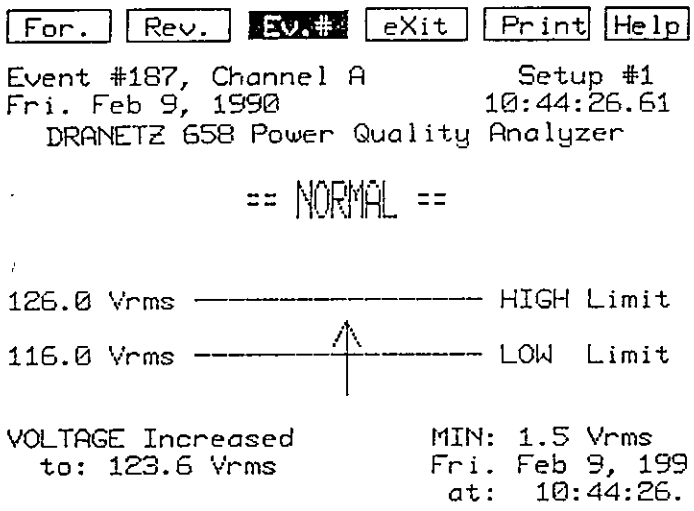
[40] One event can consist of up to four screens, one for each active Main Channel.

[41] See Main Channel Setups subsection (2.8.4.1) for information on threshold sensitivity.

In the illustration below, the arrow indicates that the RMS value increased by more than the user-set sensitivity while out-of-limits. This sensitivity value is displayed in the lower right portion of the screen.



The arrow in the illustration below, shown crossing the lower limit line, indicates that the RMS value returned to within the user set limits. The minimum value recorded while out of limits[42] is displayed in the lower right portion of the screen along with the time and date that it occurred.

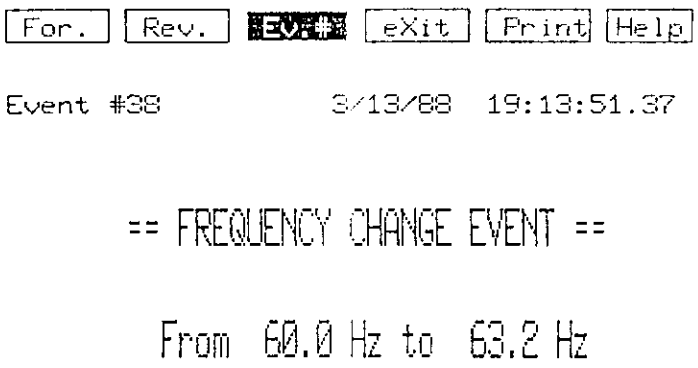


In each of the three previous illustrations, the actual RMS values that caused the event are displayed in the lower left hand corner of the screen.

[42] The is the lowest one-cycle value reached regardless of the sensitivity setting.

Frequency Events

A Frequency Event is recorded when the frequency changes by more than the user set sensitivity from the previously recorded frequency event. This event then becomes the reference for the next frequency event. An example of a Frequency event appears below:



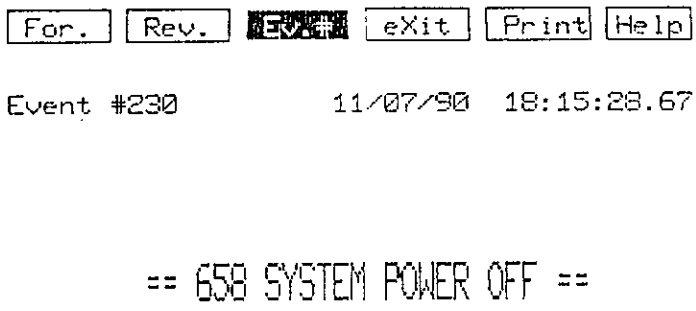
The first line of text indicates the event number, and the date and time the event occurred. The previous frequency value is indicated along with the new value.

Power ON/OFF Event

A Power OFF event occurs when unit is turned off or when power being supplied to the unit is lost and the battery in the UPS has been exhausted.

A Power ON event occurs when the unit is turned on or when power being supplied to the unit is restored.

A sample Power Off event is illustrated below, indicating the date and time the event occurred.



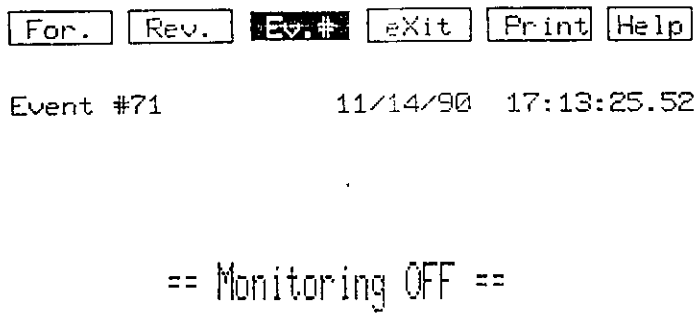
Monitoring ON/OFF Event

A Monitoring ON or OFF event can occur under two conditions:

- When the monitoring function (scanning event) is turned on or off manually by selecting menu 4 TURN MONITORING ON/OFF of menu 4 MONITORING FUNCTIONS from the MAIN MENU

- When the SCOPE MODE is selected, the monitoring function is automatically turned off and the OFF event is recorded. When the SCOPE MODE selection is terminated, the monitoring function is resumed and the ON event is recorded.

Sample Monitoring OFF and ON events are shown below indicating the time and date the event occurred.



2.10.2.2 Event Screen Menu Options

A menu listing several selections appears at the top of each type of event screen. Not all menu options are available for all event screens, although some options are common to all screens.

The menu selections available for Sensor Channel events (including initial Sensor Channel events) are:

For. Rev. Ev.# eXit Print Help

The menu selections available for Frequency events (including initial Frequency events) are:

For. Rev. Ev.# eXit Print Help

The menu selections available for Power ON/OFF events are:

For. Rev. Ev.# eXit Print Help

The menu selections available for Out-Of-Limits events are:

For. Rev. Ev.# eXit Print Help

The menu selections available for the Initial RMS events are:

For. Rev. Ev.# eXit Print Help mAins Sensors More

The menu selections available for the Waveform events are:

For. Rev. Ev.# eXit Print mUlt Text Zoom Undo thD More

When viewing a Waveform event or an Initial RMS event, there are more options available than will fit across the top of the screen. Therefore, the options are displayed in two separate groups. Selecting the "More" option toggles the display between these two different groups. These menu options are treated as one level, and selections can be made (using the keyboard) from either group regardless of which group is currently displayed.

The menu options can either be selected using the left or right cursor keys or the keyboard. To select a menu option using the cursor key, press and pivot the key in the direction of travel required. When the desired option is highlighted, press ENTER To select a menu option using the keyboard, press the key corresponding to the capital letter in the desired option.

The effects of selecting these menu options are described below:

Ev.# This selection allows you to jump to any particular event in memory. When you select "Ev.#," a screen appears prompting you enter an event number. The number of the last event in memory is displayed as a reference. Type in the number of the event you wish to view and press <*ENTER*> to view the desired event.

eXit The precise function of this selection depends upon which screen you are viewing, and on how you got there.

If you started viewing events from the "View Events" option in the MAIN MENU, then this selection will return you to the VIEW EVENTS MENU. If you started viewing events from a graphic summary screen, this selection will return you to that screen.

If you had previously selected a menu option (besides "More") that caused a new set of menu options to be displayed, this selection will return you to the previous set of menu options and its corresponding screen display.

For. This (Forward) selection advances the display to the next screen. This may be the next channel recorded for the same event, or it may be the next event in memory. The upper and lower cursor keys may be used for Forward and Reverse selections.

Help This selection causes a help screen to appear which briefly describes all the displayed or available menu options.

mAins This menu selection is only available for Initial RMS events. This selection displays the Main Channel setups at the time the event occurred.

When "mAins" is selected, a new level of menu options appear. These options are:

Print eXit Help

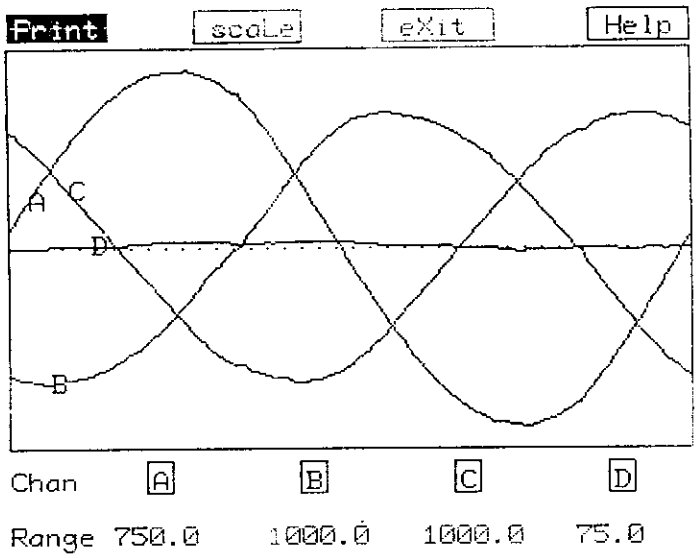
More This menu selection is only available for Waveform events and Initial RMS Events.

Up to six menu options can be displayed across the top of the event screen at one time. When more than 6 options are available, they are displayed in two different groups, or sets, of menu selections. The "More" menu selection toggles the display between these two groups.[43]

[43] A menu option can be selected using the keyboard even if it's not in the group currently being displayed. Don't confuse this with different "levels" of menu options.

muLt This (multiple waveform) selection permits two or more channel waveforms of that event to be superimposed in an overlay display to provide phase and interference event comparison. This is similar in function to the scope mode. Channel waveforms displayed must be recorded as part of the event number. For example; if channels A and B only were captured for that event, then only Channels A and B will be displayed. The channels can be turned on or off and can be scaled individually.

The sample waveform event illustrated below is a multiple waveform selection display.



Channel selection is shown by channel identifiers displayed next to the leading edge of the waveform. Pressing <*A*> or <*B*> toggles the respective channel on or off, with the OFF label shown in the range value block. To change the range scale, select the "sca*L*e" <L> first, then select the channel. The range box is highlighted and range changes may be made using the cursor up or down key to cycle through the ranges and AUTO positions.

Selecting the multiple mode provides a new menu option.

Print scaLe eXit Help

Print This selection causes the displayed event to be printed.[44] The menu options are replaced on the printout with the site descriptor. The output will be sent to the unit's thermal printer unless another printer was selected.[45]

If using the 658's thermal printer, pressing <EXIT> stops the printing.

Rev This selection displays the previous screen. This may be another channel recorded for the same event, or it may be the previous event in memory. The upper and lower cursor keys may be used for Forward and Reverse selections, or press the keyboard <R>.

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[44] The event can also be printed using <*CTRL*> + <*P*>, causing the screen to print out in its entirety, including the menu options on the top of the screen.

[45] See subsections 2.13 through 2.13.3 for information on the use of external printers.

scaLe This option selects the voltage or current RMS range scale for the respective channels selected used in the multiple (muLt) mode. The ranges for the six selections follow:

VH	AUTO, 25.0 thru 1500.0 Volts in 17 increments
VL	AUTO, 2.5 thru 150.0 Volts in 17 increments
I5	AUTO, 0.41 thru 25.00 Amps in 17 increments
I30	AUTO, 2.5 thru 150.0 Amps in 17 increments
I300	AUTO, 25.0 thru 1500.0 Amps in 17 increments
I3K	AUTO, 250 thru 15000 Amps in 17 increments

Sensors This menu selection is only available for Initial RMS events. This selection displays the Sensor Channel setups at the time the event occurred. Each active channel's setups are displayed on a separate screen.

When "Sensors" is selected, a new level of menu options appear. These options are:

Print Next preV eXit Help

The two menu options not discussed elsewhere in this subsection are "preV" (previous) and "Next." These options page you through the setup screens for the Sensor Channels that were active at the time the Initial RMS Event was recorded.

Text This selection is only available for Waveform events and causes a text description of the Waveform to be displayed. A new level of menu selections accompany this display. These options are:

Print eXit Help

The sample display below is the text description of the Waveform event displayed in subsection 2.10.2.1:

```
[Print]          eXit          [Help]

Event #13, Channel A          Setup #1
Thu. Feb 8, 1990             19:37:14.38
   DRANETZ 658 Power Quality Analyzer

Avg. Freq. Over 20 Cycles =  60.0 Hz

RMS Voltages Measured:
Previous = 123.3
 Vmin = 123.7 Vmax = 124.1

High Frequency Hits: 3
   Worst HF Event:
   Amplitude +139 Vpk
   Position  357°
```

The first line of the text screen indicates the event number, the channel the waveform was recorded on, and the number of the Setup that was active at the time the event occurred. The second line of the text screen gives the date and time the event occurred. The third line displays the site identifier.

The text screen also displays the average frequency, the RMS value of the last cycle, the minimum and maximum RMS values for this event, the number of high frequency hits for this event, and the amplitude and position of the worst of these high frequency hits.

thD
Thd This selection is only available for Waveform events and allows you to perform an analysis of the harmonic distortion on the waveform from the fundamental frequency up to the 50th harmonic for 45-65 Hz only. (400 Hz mode not available)

This option is discussed in detail in subsection 2.10.3.
Refer to Appendix D for a further description and the application of harmonic analysis.

Undo This selection is only available for Waveform events. This selection causes the previous (higher) zoom level to be displayed. You can select "Undo" repeatedly until the complete event is displayed.

This selection performs no function until a waveform has been zoomed.

Zoom This selection is only available for Waveform events. The zoom feature allows you to expand and redraw any portion of the waveform. Because of the complexity of this feature, it is discussed in detail in the following subsection (2.10.2.3). An overview is given here.

When "Zoom" is selected, a new level of menu options appear. These options are:

Print Zoom eXit Help

Along with the new menu selections, a square box ("zoom box") appears in the center of the screen over the waveform. This zoom box defines the area to be expanded. The cursors are used to change the size and location of the zoom window to surround the portion of the waveform you wish to expand.

Once the zoom box is in position, select "Zoom" a second time to expand the selected area.[46] The original WAVEFORM EVENT MENU is again displayed at the top of the screen.

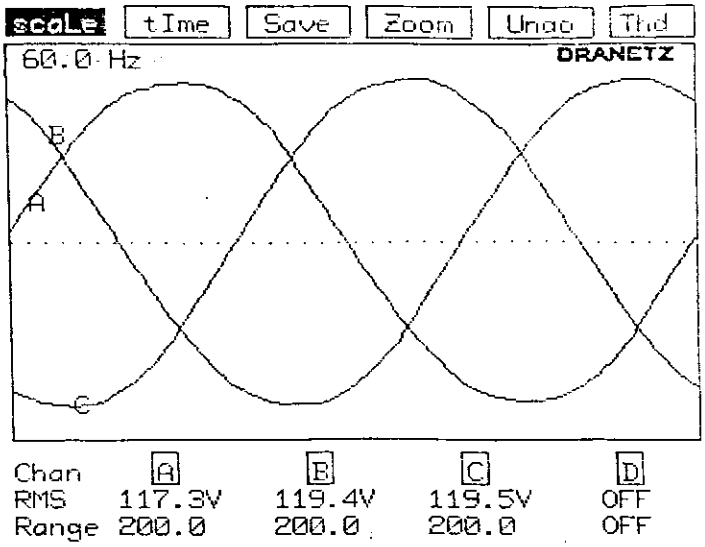
You can zoom in repeatedly, up to 50 or 25 μSec per division (depending on the event). The "Undo" selection will return you to the previous zoom level.

[46] To return to the original graphic summary without zooming, select "eXit" from the ZOOM SELECTION MENU.

2.10.2.3 Scope Mode Display

Real-time display of waveforms are those waveforms occurring at the time they are being displayed, rather than past waveforms stored as events in memory, and are similar to oscilloscope displays. These waveforms are shown for one cycle only (for each channel) and are updated at a one second rate. Text is displayed on the screen to show the frequency, RMS value, waveform related channel identifier, range per division value, and monitoring on/off condition of each channel. Menu options at the top of the display provide for selection of range scaling of each channel waveform, timeout control, save (record) events, zoom, and total harmonic distortion (THD) analysis.

A sample display of real-time is shown below indicating selection of three channels for display and monitoring.



The desired channel to be displayed is selected by pressing the corresponding key to toggle the channel on or off. When on, the RMS and Range values are displayed; when off, OFF is displayed. Not Applicable (N/A) is shown to indicate that a channel is not activated in the Main Channel Setups; you can activate it, however, through the Monitoring Functions Menu.

When first displayed, each channel is automatically scaled to fit the graph and the RMS value and units/division are shown. The graph vertical center is the zero crossover line with a peak vertical division (Range) above and below the line. High frequency spikes are not used in the autoscaling.

To change Range values use scaLe. First Press <L>, then select a channel to highlight the range value. Use the cursor upper or lower keys to scroll through a list of ranges (AUTO, 25.0 thru 1500). Select AUTO for autoranging. When you have set the range scales for all channels, <EXIT> out of the scaLe menu.

To store the event and its related data in memory, use Save. Pressing <S> will create in memory: a waveform and RMS event (for each of channels being viewed), and an initial frequency event. At this point, the Edit Site descriptor screen will be displayed. If a new site descriptor is desired, edit the string. Select "NO" to keep the same string.

Because monitoring is automatically turned off in this mode, a timeout (tIme) function is used to return the unit back to normal operation. The default timeout is 10 minutes, with selection times of 1 to 30 minutes selectable. To set timeout, press <I>, type in the value and press <ENTER> to resume.

2.10.2.4 Scope Mode Display Menu Options

A menu listing several option appears at the top of the Scope Mode display screen. The menu options available for the Scope Mode events are:

scaLe tIme Save Zoom Undo Thd

The menu options can either be selected using the left or right cursor keys or the keyboard. To select a menu option using the cursor key, press and pivot the key in the direction of travel required until the option is highlighted, then press ENTER To select a menu option using the keyboard, press the key corresponding to the capital letter in the desired option.

The effects of selecting these menu options are described below:

Save This selection saves the viewed event to memory as the active Main Channel waveforms (one waveform for each channel displayed), Main Channel RMS values, and the frequency value.

scaLe This option selects the voltage or current RMS range scale for the respective channels selected used in the Scope Mode. The ranges for the six selections follow:

VH	AUTO, 25.0 thru 1500.0 Volts in 17 increments
VL	AUTO, 2.5 thru 150.0 Volts in 17 increments
I5	AUTO, 0.41 thru 25.00 Amps in 17 increments
I30	AUTO, 2.5 thru 150.0 Amps in 17 increments
I300	AUTO, 25.0 thru 1500.0 Amps in 17 increments
I3K	AUTO, 250 thru 15000 Amps in 17 increments

tIme This selection provides a range of 1, 2, 5, 10, 20 and 30 minutes for the unattended timeout function of the Scope Mode. The default timeout is 10 minutes. If there is no keyboard activity during this period, the Scope Mode is disabled and the 658 reverts to the Status Screen, and monitoring of events is enabled.

thD Thd This selection allows you to perform an analysis of the harmonic distortion on the waveform from the fundamental frequency (45-65 Hz) up to the 50th harmonic.

This option is discussed in detail in subsection 2.10.3.

Refer to Appendix D for a further description and application of harmonic analysis.

Undo This selection is available for Waveform events or Harmonic Graph display. This selection causes the previous zoom level to be displayed. You can select "Undo" repeatedly until the complete event is displayed.

This selection performs no function until a waveform has been zoomed, or the harmonic graph values have been decreased.

Zoom This selection is available for Waveform events and Harmonic graphs. The zoom feature allows you to expand and redraw any portion of the waveform, or enlarge or reduce relative harmonic graph quantities. Because of the complexity of this feature, it is discussed in detail in the following subsection (2.10.2.4). An overview is given here.

When "Zoom" is selected, a new level of menu options appear. These options are:

Print Zoom eXit Help

For Waveforms: along with the new menu selections, a square box ("zoom box") appears in the center of the screen over the waveform. This zoom box defines the area to be expanded. The cursors can be used to change the size and location of the zoom window to surround the portion of the waveform you wish to expand.

Once the zoom box is in position, select "Zoom" a second time to expand the selected area.[47] The original WAVEFORM EVENT MENU is again displayed at the top of the screen.

You can zoom in repeatedly, up to 50 or 25 μSec per division (depending on the event). The "Undo" selection will return you to the previous zoom level.

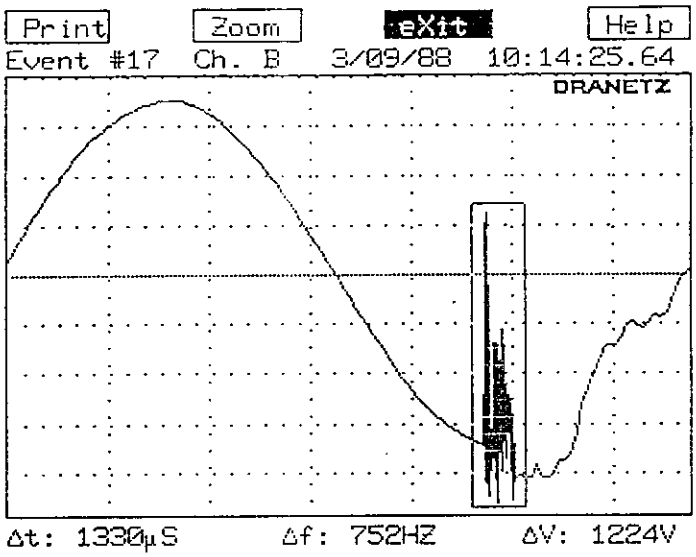
For Graphs: along with the new menu selections, The graph scaling is changed (decreased), along with its relative amplitudes of the harmonics displayed. For each additional zoom selection the graph parameters decrease proportionately. The "Undo" selection returns you to the original and will revert to increasing the graph scaling until the maximum is reached.

2.10.2.5 Zooming

When a time-plot, waveform event, or harmonic graph is displayed on the screen, the zoom feature allows you to expand a selected portion of the screen. This sub-section pertains to the zoom feature available when viewing waveform events only.

[47] To return to the original graphic summary without zooming, select "eXit" from the ZOOM SELECTION MENU.

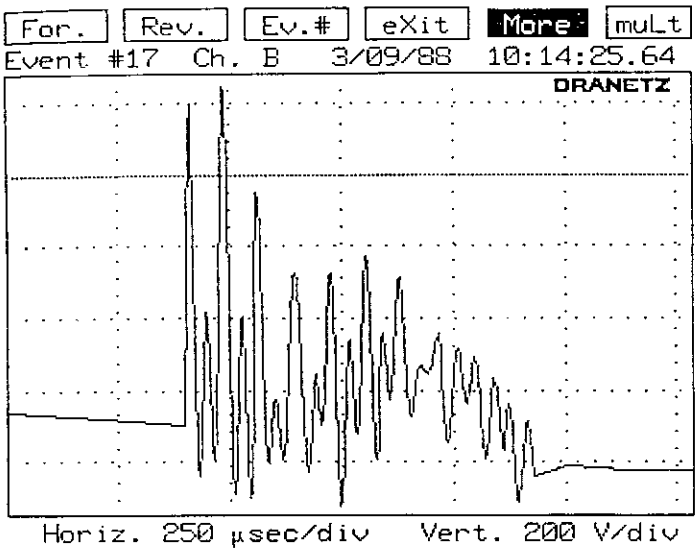
When you select "Zoom" from the menu on the top of the screen, a square box ("zoom box") appears in the center of the screen over the waveform. Use the cursors to re-position the zoom box so that it surrounds the area to be expanded, as in the example below.



The dotted grid on the event screen represents amplitude and time. The horizontal lines are measured in microseconds or milliseconds. The vertical lines are measured in Volts or Amps. The text line below the screen indicates the width (Δt - change in time) and the height (ΔV - change in voltage, ΔA - change in current) of the zoom box. Re-positioning the zoom box affects these values. Frequency (f), the reciprocal of time (1/Δt), is useful if a full cycle is framed by the zoom box.

In the example above, the high frequency burst lasted approximately 1000 μSec and achieved a peak to peak excursion of approximately 1200 volts.

Once the zoom box is in position, select "Zoom" a second time to expand the selected area,[48] as in the example below.



The original WAVEFORM EVENT MENU is again displayed at the top of the screen.

Menu Options

Along with the zoom box, a new level of menu options appear. These options are:

Print Zoom eXit Help

These options are explained below:

Print This selection causes the screen display to be printed.[49] The menu options are replaced on the printout with the site descriptor. The output will be sent to the unit's Thermal printer unless another printer was selected.[50]

If using the 658's Thermal printer, pressing <EXIT> stops the printing.

Zoom Selecting this option causes the area enclosed by the zoom box to be expanded to the full area occupied by the waveform. The regular WAVEFORM EVENT MENU screen re-appears at the top of the screen.

eXit This selection causes the zoom box to disappear and returns you to the previous level menu without zooming the waveform.

Help This selection causes a help screen to appear which briefly describes the other menu options. The help screen also explains how to re-position the zoom box.

---

[48] To return to the original waveform without zooming, select "eXit" from the ZOOM SELECTION MENU.

[49] The event can also be printed using <*CTRL*> + <*P*>, causing the screen to print out in its entirety, including the menu options on the top of the screen.

[50] See subsections 2.13 through 2.13.3 for information on the use of external printers.

Positioning The Zoom Box
The boundaries of the zoom box can be moved using the cursor keys or the keyboard.

The cursor keys are arranged in the geometric pattern representative of the zoom box boundaries. The upper and lower cursor keys provide control of the upper and lower boundaries, respectively, of the zoom box to raise or lower or lower the respective boundary as required. The left and right cursors provide left and right boundary control, respectively.

To move the entire zoom box left or right, press and hold down the left or right cursor key and the <CTRL> key simultaneously. Release the keys when the location desired is reached.

The keys and how they affect the movement of the zoom box are illustrated in Figure 2-13.

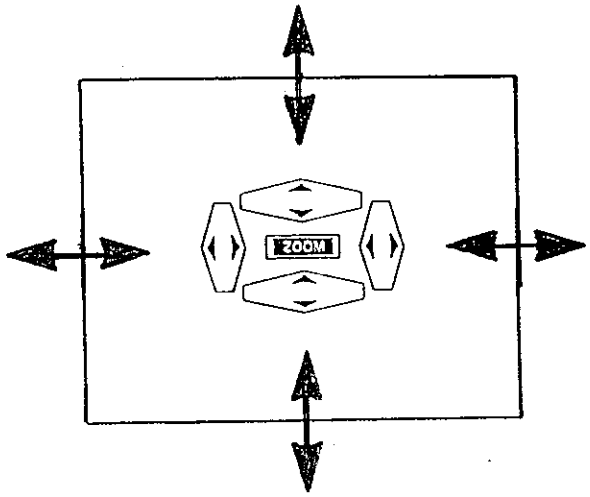


FIGURE 2-13. CURSOR KEYS FOR POSITIONING THE ZOOM BOX

Zoom Increments
You can continue to zoom in on each waveform until you reach either the minimum time (Δt) or voltage/current (ΔV) increment: 25 μsec/division or 2 V/division. Once this point is reached, the 658 doesn't allow further zooms. The various time and voltage increments available are listed in TABLE 2-3.

Zooming Out
To return to the previous (higher) zoom-level, select "Undo" by pressing <U> key. You can select <U> repeatedly until you are viewing the original waveform or you can press <EXIT> or <X> to return immediately to the original waveform..

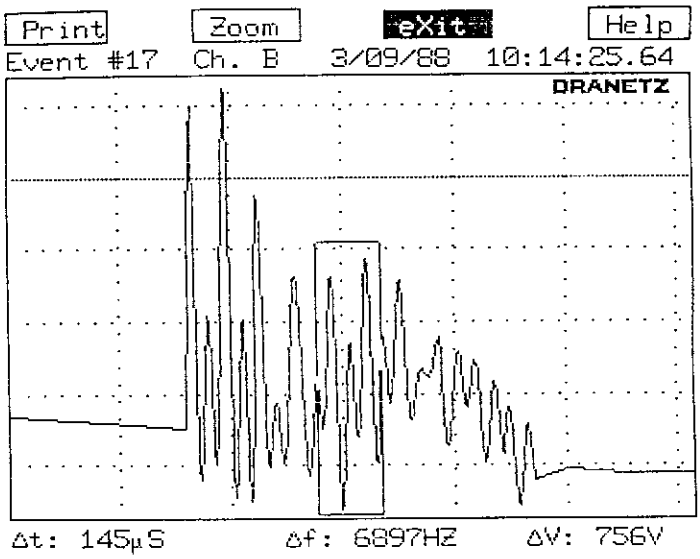
TABLE 2-4. TIME AND VOLTAGE INCREMENTS FOR ZOOMING

Time Increments Per Division	Voltage/Current Increments Per Division*
25 μsec	2 V or A
50 μsec	5 V or A
100 μsec	10 V or A
250 μsec	20 V or A
500 μsec	50 V or A
1000 μsec	100 V or A
2500 μsec	200 V or A
5000 μsec	500 V or A
5 msec	1000 V or A
10 msec	2000 V or A
25 msec	
50 msec	* Values apply for VH, VL, I30, and I300
100 msec	For I5 divide values by 100
250 msec	For I3K multiply values by 10

Uses For Zoom

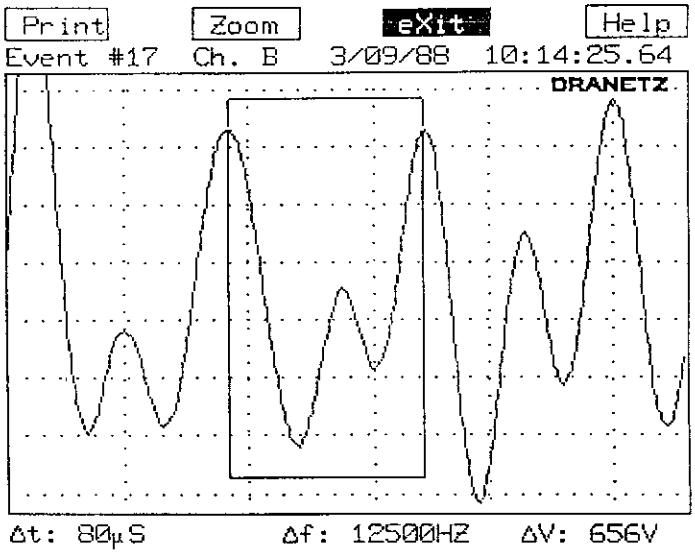
Obviously, zoom can be used to take a closer look at any part of the waveform. It can be used to isolate one specific cycle of a multi-cycle event for individual viewing or for performing a harmonic Analysis.[51]

As shown earlier in this subsection, zoom can be used for estimating disturbance duration and amplitude. Zoom can also be used to measure the frequency of a full cycle in a disturbance. Below is a zoomed representation of the high frequency burst illustrated earlier in this subsection. The section of the burst selected for expansion is framed by the zoom box.



[51] To perform a harmonic Analysis, refer to subsection 2.10.3. Refer to the special harmonics section in the Appendix D for further information on how to use this option.

When zoomed, the selected section is seen in greater detail, and a cyclic pattern is readily apparent.[52] By positioning the zoom box around a full cycle as in the illustration below, it can be seen that the predominate frequency is approximately 12.0 kHz.



2.10.3 Total Harmonic Distortion (THD)

The THD function performs harmonic analysis on an individual cycle of voltage or current in the view individual event mode or scope mode of the VIEW EVENTS MENU. The analysis is performed on one cycle of a continuous series of cycles indicating that harmonic distortion is present. Harmonic distortion analysis should not be performed on a singular disturbance event or a cycle of a short duration disturbance. The analysis provides a Harmonic Graph output, showing the harmonic spectrum and relative amplitude of the fundamental frequency through the 50th harmonic, and a Relative Harmonics Content Table showing the relative percentages of harmonic content and phase angles. The resultant graph and table are identical in content in both modes. Because the event mode waveform may have more than one cycle displayed, the event mode provides a means of selecting one cycle for analysis. In the scope mode, only one cycle of real-time data is displayed so that the pre-selection cycle is not required.

The following subsection discusses how the event mode of harmonic analysis is performed. Using harmonic analysis in Scope Mode is similar, and differences between modes will be described where they occur. Menu options for both modes are described in subsection 2.10.3.2.

[52] The edges of the plot are referenced to low frequency sample points, which occur every 1/7.2 kHz (see TABLE 1.1), or approximately every 139 μSec. High frequency samples occur approximately every 0.5 μSec. Because of this, the start and end points of the zoomed graph may encompass a slightly larger interval than that selected by the zoom box.

2.10.3.1 Performing The Analysis

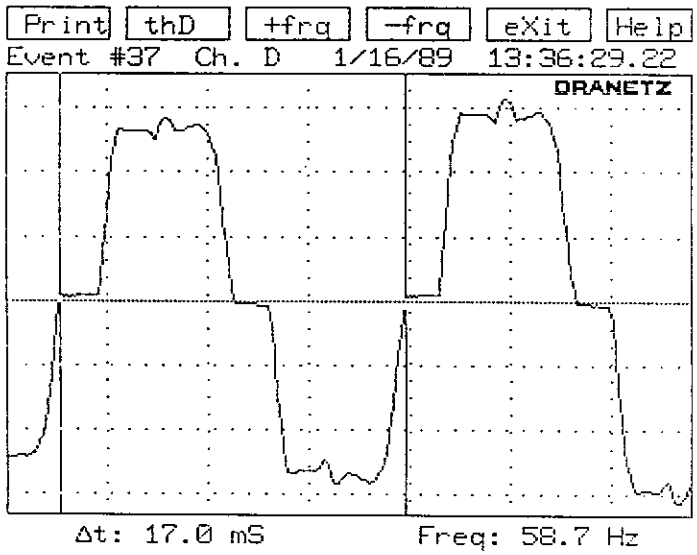
Harmonic Analysis can be performed only on a single waveform event representing a continuous series of similar events. To perform a harmonic analysis, select "thD" from the EVENT SCREEN MENU or "Thd" from the SCOPE MODE Screen Menu. A new level of menu selections appear. These selections are:

Print thD +frq -frq eXit Help

The effects of selecting "thD", "+frq", and "-frq" are described in the contents of this subsection. Each of the menu options available throughout this process are discussed together in subsection 2.9.3.2.

In both modes the assumed fundamental frequency is shown at the bottom of the screen, along with the duration (Δt) of one cycle.

In the multi-cycle event waveform shown below, the event number is displayed along with the date and time. In addition, two vertical cycle markers are displayed at the zero crossover points of the first cycle. The portion of the waveform bounded by the markers is the area on which the harmonic analysis will be performed. Initially, the first marker is set at the beginning of the screen, and the second marker is set at an interval corresponding to 60 Hz after the first marker. These markers can be moved in unison to select the cycle of interest for harmonic analysis, and they are adjusted in width to indicate frequency compensation for that cycle. The "+frq" and "-frq" menu options at the top of the display prompt you that the +/- frequency compensation option is available.



To Select a Cycle for Analysis. To select the cycle of interest for analysis, two methods are available. Pressing and holding the left (<) or right cursor (>) key in the direction of travel desired will move both markers. Position the markers to enclose the cycle at the zero crossover points. The other method (for 3 or more cycles displayed) jumps to a complete cycle for a cycle by cycle selection. Press and hold the desired direction cursor key (< or >) and press <CTRL> to move the markers in unison to the next cycle at the zero crossovers.

To Adjust for Frequency Compensation. On multi-cycle events, the frequency default to 60 Hz. If you know the frequency of the event (accurate frequency meter or counter measured value) you can compensate the frequency used in the harmonic analysis of the event cycle being viewed. Frequency compensation of the displayed cycle can be adjusted to within 0.1 Hz. Press (+) to increase the frequency (decrease delta time) and (-) to decrease the frequency.(increase delta time). The frequency displayed in Hz will change in 0.1 Hz increments and the right marker only will move left or right to increase or decrease the markers width inversely to the frequency change. The frequency compensation may be adjusted between 45.0 Hz and 65.0 Hz. To return the frequency to exactly 60.0 Hz press <U>; for 50.0 Hz press <F>.

Single Cycle Events and Scope Mode Display If the event is a single cycle, or you are in Scope Mode, the markers are not displayed and similar conditions exist for the displayed waveform in both modes.. In the scope mode display shown below the frequency is displayed and the frequency compensation can still be performed. Although the frequency displayed will change in 0.1 Hz increments when frequency compensation is performed, no other effect is noted.

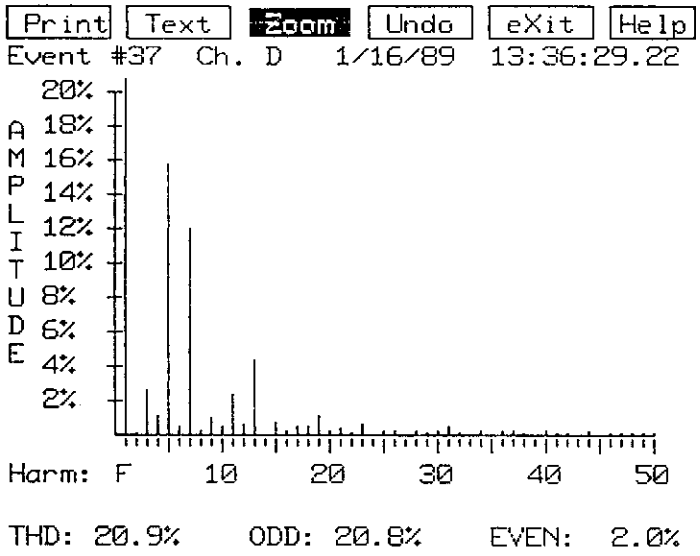
To Select the Harmonic Analysis Graphic Display. Once the cycle of interest has been selected and frequency compensation has been performed, the harmonic analysis can be selected. From either mode display press <D> to select total harmonic distortion "thD".

A graphic display of the fundamental frequency to the 50th harmonic appears, along with a new level of menu selections. These selections are:

```
Print Text Zoom Undo eXit Help
```

The effects of selecting "Zoom", "Undo", and "Text" are described in the contents of this subsection. Each of the menu options available throughout this process are discussed together in Subsection 2.10.3.2.

A spectral graph similar to the one below is displayed on the screen, showing the amplitude of the harmonics in relation to the fundamental frequency..

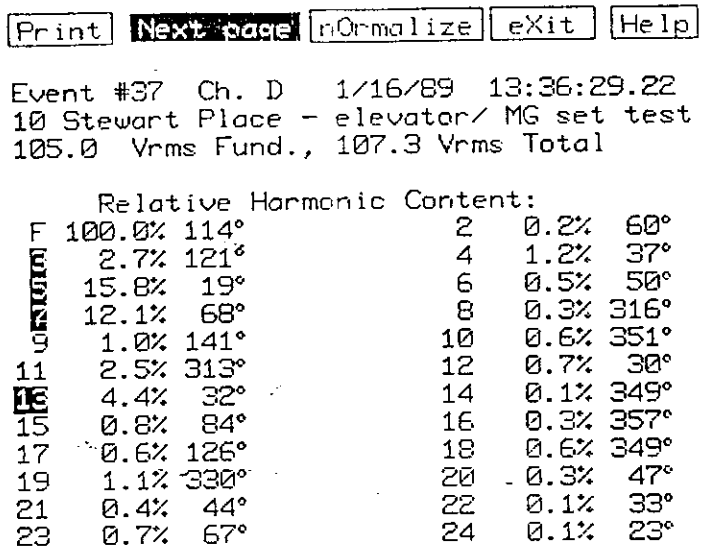


The first line in the spectrum is the reference fundamental frequency with its amplitude zoomed to 20% to show greater clarity of values. The percent magnitude of the first 50 harmonics are graphed relative to the fundamental. The total harmonic distortion (THD), and the ODD and EVEN harmonic contributions are shown as percentages at the bottom of the graph.

The ODD contribution is the square root of the sum of the squares of the relative amplitudes of harmonics 3, 5, and 7 through 49; the EVEN is similar for harmonics 2, 4, and 6 through 50. Note that the THD is the square root of the sum of the squares of the ODD and EVEN distortions.

"Zoom" may be used to increase the resolution of the graph down to 10% full scale; "Undo" reverses the effect of a previous "Zoom" up to 1000% full scale. (Useful when viewing current harmonics, especially triplen harmonics.)

To Select the Relative Harmonic Content Table From the Harmonic Graphics Display Screen select "Text" by pressing <*TEXT*> to display the Relative Harmonic Content Table. The table consists of two pages. Press <N> to select the next (second) page. The screens appear, such as those below, along with a new level of menu selections.



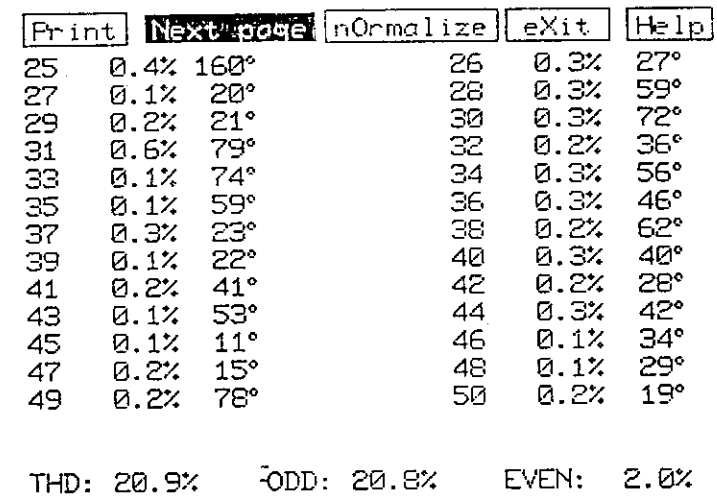
Print | Next page | nOrmalize | eXit | Help

Event #37 Ch. D 1/16/89 13:36:29.22
10 Stewart Place - elevator/ MG set test
105.0 Vrms Fund., 107.3 Vrms Total

Relative Harmonic Content:

F	100.0%	114°	2	0.2%	60°
3	2.7%	121°	4	1.2%	37°
5	15.8%	19°	6	0.5%	50°
7	12.1%	68°	8	0.3%	316°
9	1.0%	141°	10	0.6%	351°
11	2.5%	313°	12	0.7%	30°
13	4.4%	32°	14	0.1%	349°
15	0.8%	84°	16	0.3%	357°
17	0.6%	126°	18	0.6%	349°
19	1.1%	330°	20	0.3%	47°
21	0.4%	44°	22	0.1%	33°
23	0.7%	67°	24	0.1%	23°

First Page



Print | Next page | nOrmalize | eXit | Help

25	0.4%	160°	26	0.3%	27°
27	0.1%	20°	28	0.3%	59°
29	0.2%	21°	30	0.3%	72°
31	0.6%	79°	32	0.2%	36°
33	0.1%	74°	34	0.3%	56°
35	0.1%	59°	36	0.3%	46°
37	0.3%	23°	38	0.2%	62°
39	0.1%	22°	40	0.3%	40°
41	0.2%	41°	42	0.2%	28°
43	0.1%	53°	44	0.3%	42°
45	0.1%	11°	46	0.1%	34°
47	0.2%	15°	48	0.1%	29°
49	0.2%	78°	50	0.2%	19°

THD: 20.9% ODD: 20.8% EVEN: 2.0%

Second Page

The percent magnitude of the first 50 harmonics relative to the fundamental are displayed in two pages with the four highest values highlighted. The phase angle of each harmonic is also displayed. The Total Harmonic Distortion (THD), as well as the ODD and EVEN contributions, are displayed at the bottom of the screen.

Two Vrms values are given at the top of the screen: The Vrms of the fundamental frequency only and the Vrms value corresponding to the total composite frequency.

The total Vrms is the square root of the sum of the squares of the fundamental and all harmonics. Because of this summation, a waveform could have a THD of 50% but the difference in RMS values between the fundamental frequency and the composite frequency might be only 10%.

The menu selections available for the text screen are:

`Print` **`Next page`** **`nOrmalize`** **`eXit`** **`Help`**

Selecting "`Print`" from the Text screen menu causes a 2-column formatted table corresponding to the above display to be printed.

The other menu options are discussed in subsection 2.10.3.2.

2.10.3.2 Harmonic Analysis Menu Options

The Menu Options available through the Harmonic Analysis process are discussed below. Not all menu options are available at all phases of the process.

`eXit` This selection returns you to the previous screen.

`Help` This selection causes a help screen to appear which briefly describes all the available menu options.

`+frq` This option allows you to increase the frequency (in 0.1 Hz increments) of the area of the waveform that the analysis is to be performed on. The maximum allowable frequency is 65 Hz. When a multiple cycle event is displayed, this selection causes the right marker to move closer to the left marker.

`-frq` This option allows you to decrease the frequency (in 0.1 Hz increments) of the area of the waveform that the analysis is to be performed on by 0.1 Hz increments. The minimum allowable frequency is 45 Hz. When a multiple cycle event is displayed, this selection causes the right marker to move away from the left marker.

nOrmalize This option lets you normalize the phase of the displayed harmonics. This option toggles between normalized or not. See Appendix D.6 for more information.

Next page This selection is highlighted to inform you that another page is available containing additional information.

Prev page This highlighted selection informs you that the page displayed is a continuation of information, and that a previous page of information exist.

Print This selection causes the displayed plot to be printed.[53] The menu options are replaced on the printout with the site descriptor. When selected from the Text screen, a 2-column formatted table corresponding to the display is printed.

The output will be sent to the unit's thermal printer unless another printer was selected.[54] If using the 658 Thermal printer, pressing the <EXIT> button stops the printing.

Text This selection causes a text display of each harmonic along with its magnitude and phase shift (relative to the fundamental) to be displayed. A new level of menu selections accompany this display:

Print eXit Help

Undo This selection causes the next higher zoom level to be displayed. You can select Undo repeatedly until 1000% full scale is displayed.

Zoom When the analysis is first performed, the graph displayed may range between 100% and 1000% of the fundamental (depending on the magnitude of the harmonics in the graph). "Zoom" may be used to increase the resolution of the graph down to 10% of full scale.

The available Zoom levels for the graph are 1000%, 500%, 200%, 100%, 50%, 20%, and 10%. "Undo" reverses the effect of a previous "Zoom".

[53] Use <*CNTRL*> + <*P*> to print the screen in its entirety, including the menu options on the top of the screen.
[54] See Subsection 2.13 for information on the use of external printers.

2.11 DISK OPERATIONS

The 658 contains a 3-1/2 inch disk drive. The drive is used to transfer events and setup information from and to the 658 memory and for initializing (formatting) disks. A disk may be duplicated by reading into memory, then reading out to a formatted blank disk.

In addition, the drive can be preset to automatically transfer a full memory of 658 recorded events to an installed disk at a one-time load or multiple load mode. This Auto Xfer to Disk mode is described in subsection 2.8.6.

Disks can be formatted in two methods: IBM format of 9 sectors/track, or Drantez format of 18 sectors/track. The 9 sectors/track 658 data diskettes require the Dranetz 658-OS-2001 software for analysis on a PC: the binary data files are not accessible through DOS. The Dranetz format is used in earlier equipment, such as the Model 656. The default format in the 658 (operating system version 4.0, or higher) is 9 sectors/track; however, the 18 sectors/track format can be selected in the Systems Tools Menu (refer to subsection 2.14). Selection of the 18 sectors/track format is required when writing to formatted disks for use with 656's, 658's (version 3.x), or for PC's (using GHA software) running version 3.x.

The disk functions are selected through the DISK OPERATIONS MENU (Selection 5 from the MAIN MENU):

NOTE: *During any disk operations (saving information to disk, getting information from disk, or initializing a new disk), the 658 suspends all monitoring. Monitoring immediately resumes when the disk operation is completed.*

Brief descriptions of selections 1 through 3 on the DISK OPERATIONS MENU are given in the following subsections. Duplicating a disk is accomplished by selections 1 and 2. Selection 5 is described in subsection 2.8.6.

NOTE: *For best results, always use high quality, double sided, double density disks. **DO NOT** use high-density (HD) diskettes. If you need additional disks, see subsection 1.10.*

To write protect a disk, slide the tab at the bottom corner of the disk so that the slot is open. With the slot open, you cannot initialize (format) or write to the disk. To initialize or write to a disk, slide the tab to close the slot before inserting the disk into the 658.

2.11.1 Transfer Data From Disk

Selection 1 from the DISK OPERATIONS MENU lets you transfer events and setups stored on a disk into 658 memory. Place the source disk into the disk drive before selecting this option.

CAUTION

All of the data presently in the 658 memory will be replaced with the data from the disk. If you wish to view the current data again at a later time, be sure the data is saved to a disk before proceeding with this operation.

NOTE: *The 658 will read all previous versions of 658, 656A, or 656 data disks back to version 1.4.*

Press <1> to initiate "Get Information From Disk" operation. The following prompt is displayed:

```
Read Events and Setups

This disk contains both events and
setups; loading it will overwrite
the events and setups in memory.

Load events and setups from disk?
   Yes                    No
```

Select Yes to load events. Select No to return to the Disk Operations Menu. The Reading Disk message is displayed to inform you of tracks remaining to be transferred. On the disk drive, the indicator is lit to indicate disk operation.

```
Reading Disk sec/track = 9 (IBM)

Press <EXIT> to abort

Tracks Remaining => 1
```

Tracks remaining will be indicated by countdown while data is being transferred. At the end of data transfer the events are formatted and are indicated by countup. When formatting is completed, the disk transfer successful message is displayed.

```
FORMATTING EVENTS..

Disk Transfer Successful
Press any key to continue...
```

If no disk is inserted before selecting the option, the 658 displays the following message.

```
No disk was inserted in the drive.
Insert and press any key to continue.
```

If the disk is invalid because of no event data, the invalid message is displayed.

```
Invalid Event Disk!
Press any key to continue...
```

If disk transfer fails the following message is displayed:

```
Disk Transfer Failed
Press any key to continue...
```

2.11.2 Transfer Data to Disk

Selection 2 from the DISK OPERATIONS MENU lets you save events data and setups to a formatted disk. Place the destination disk into the disk drive before selecting this option.

CAUTION

All of the data previously on the destination disk is destroyed when you use this selection. Be sure the destination disk is empty or that data contained on it is no longer needed.

Press <2> to initiate "Save Information To Disk" operation. The following prompt is displayed:

```
        Save Events and Setups
Insert the 658-formatted DS,DD disk;
sec/track = 9 (IBM).
CAUTION: This will wipe out all prev-
iously stored data on this disk!

        Save Events & Setups?
```

Select Yes to save events and setups. Select No to return to the Disk Operations Menu. The Writing To Disk message is displayed and the tracks remaining to be transferred will count down. On the disk drive, the indicator is lit to indicate disk operation.

```
Writing to Disk

 Press <EXIT> to abort

 Tracks Remaining => 0

Disk Transfer Successful
Press any key to continue...
```

While data transfer is in progress, the 658 lets you know how many tracks are remaining. When transfer is successful the Disk Transfer Successful message is displayed. Press any key to return to the Disk Operations Menu.

If no disk is inserted before selecting the option or disk transfer fails, the 658 displays an error message identical to those of "Data Transfer From Disk" operation.

NOTE: *If an unformatted disk (or a disk with an improper format) is inserted, the disk will be automatically formatted.*

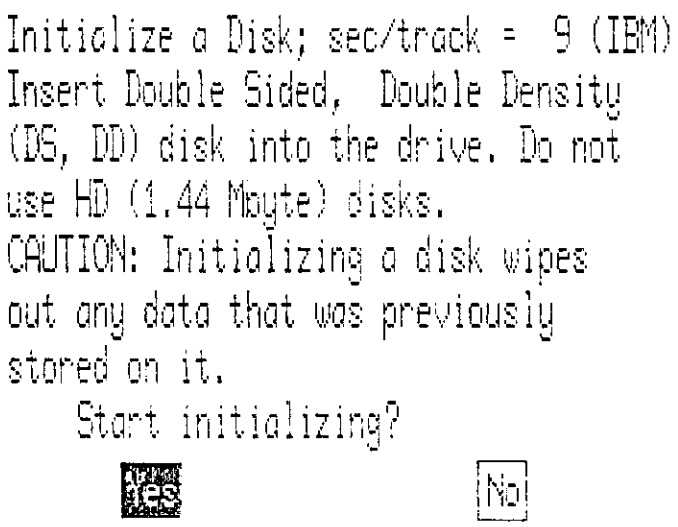
2.11.3 Initialize (Format) a New Disk

Selection 3 from the DISK OPERATIONS MENU lets you initialize (format) a new disk. A disk must be initialized before any information can be stored on it.

CAUTION

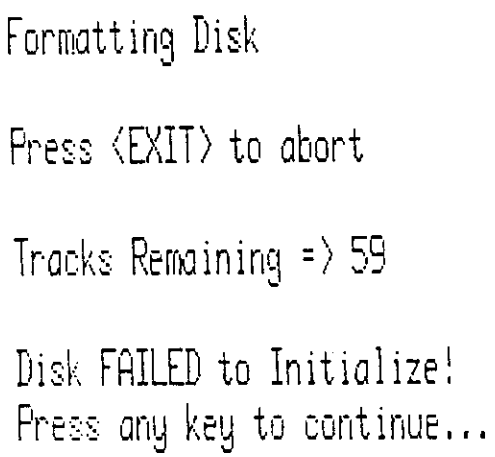
All of the data previously on the initialized disk is destroyed when you use this selection. Be sure the disk is empty or that data contained on it is no longer needed.

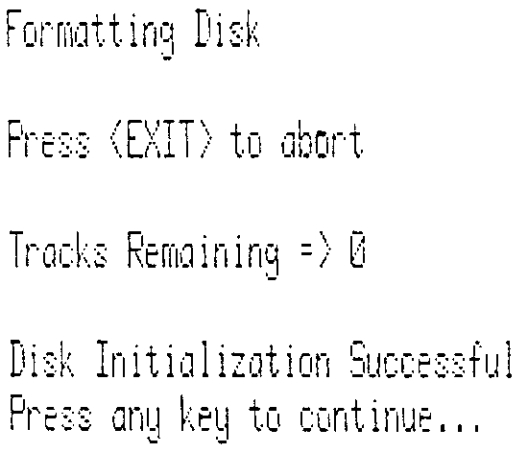
Press <3> to initiate "Initialize A New Disk" operation. The following prompt is displayed:



Select Yes to start initializing or select No to return to the Disk Operations Menu. Initialization takes about 2 minutes. If you press <*EXIT*>, initialization is aborted.

During formatting, if an initialization error is detected a failure message is displayed; if initialization is successful, the success message is displayed.





Press any key to return to the Disk Operations Menu.

2.11.4 Duplicating a Disk

To make a duplicate disk, the disk contents must be read into memory, then the contents of memory will be transferred to the new disk as a duplicate. If the disk is unformatted (or improperly formatted) it will be automatically formatted. To accomplish this operation, perform the procedures of subsections 2.11.1 and 2.11.2, Transfer Data From Disk and Transfer Data To Disk, respectively.

CAUTION

All of the data previously in memory is destroyed when you use this method of duplicating a disk. Also, be sure destination disk is empty or that data on it is no longer needed.

2.12 REMOTE COMMUNICATION

Event data and system setups can be transferred between two 658 Mainframes[1], or between a 658 and a personal computer. The transfer can take place in one of two ways:

1) over the telephone lines using a modem at each site; or

2) through an RS-232C direct connection if the two sites are within 50 feet of each other.

Selection 3-REMOTE COMMUNICATIONS MENU from the OTHER FUNCTIONS MENU lets you perform various remote communication functions.

2.12.1 Communication Connections

Direct serial connection is made through the 658's Main port, located on the rear panel of the unit.

Modem connections can be made using the optional 2400 Baud Internal Modem, an external 1200 or 2400 baud Hayes Smartmodem, or a user supplied Modem connected to the unit's Main port.

NOTE *Refer to subsection 2-15 for important information related to modem connection to telephone lines.*

2.12.1.1 Main Port Description

The Main port is a female, 25-pin, RS-232C serial data port providing an output from 1200 to 9600 baud. The Main port lets the 658 communicate with another 658 or a personal computer (up to 50 feet away) through direct RS232 connection. The main port can be connected to an external modem for communication over greater distances. TABLE 2-5 provides the descriptions of the Main Port Pinouts.

Data is transmitted through the Main Port to another 658, modem, or personal computer at 1200 to 9600 baud with 8 data bits, 1 start-bit, 1 stop-bit, and no parity or handshaking.

[1] A 658 running on version 3.0 (or later) of the Operating System can retrieve data from a 656 or from a 658 running on an earlier version of the Operating System, although the reverse is not true (due to the more complex data structure of the later versions of the Operating System). In addition, not all remote functions are available for the older models.

TABLE 2-5. MAIN PORT PINOUT DESCRIPTION

Pin Name	Function	Direction	Description of Operation
1 GND	Protective Ground	Not Applicable	Shield of interface cable should be connected to this pin which is tied to the internal frame ground.
2 RCV	Receive Data	Input	658 receives serial data input from the connected device.
3 XMT	Transmit Data	Output	658 sends output to the connected device.
7 GND	Signal Ground	Not Applicable	Internally connected to pin 1.

2.12.1.2 Cables for Main Port Connections

Direct Connection To Another 658

To connect one 658 to another 658, use a null-modem cable (P/N 113446-G1). Figure 2-14 illustrates the lines running between the cable connectors for a null-modem cable.

Direct Connection To A PC

The serial cable used for direct connection to a PC is 25-pin, male-to-female, with straight through pin-to-pin connections. This cable (P/N 113449-G1) is supplied as an optional accessory and can be ordered separately from Dranetz Technologies. (See section 1.10 for ordering information.)

Direct Connection To An External Modem

To connect the 658 to an external modem use a null-modem cable (113446-G1). Figure 2-14, illustrates the lines running between the cable connectors for a null-modem cable.

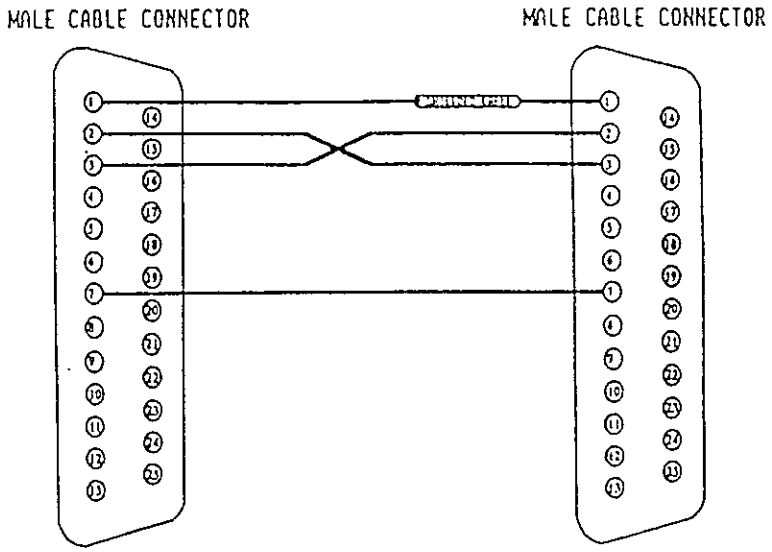


FIGURE 2-14. NULL-MODEM CABLE PINOUTS

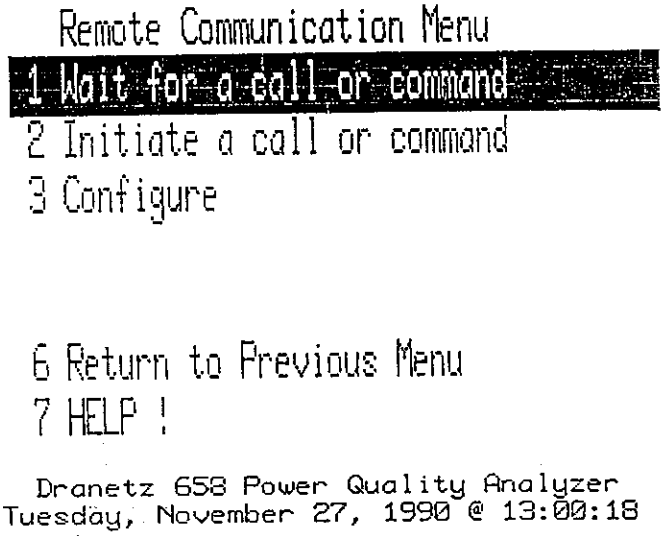
2.12.2 Initialize Communication

After the proper connections are made, the communications parameters are established along with call/command mode of operation of the local and remote units. This is done through selection of the REMOTE COMMUNICATION MENU (selection 3 from the OTHER FUNCTIONS MENU).

When preparing two 658 units for communication, set the remote unit (the one to be called) first. Then initiate communication using the local unit.

When communication is to be between a 658 and a PC, the 658 must be set as a remote unit. Communication is initiated from the local designated PC.

Selection 3 in the OTHER FUNCTIONS MENU brings up the REMOTE COMMUNICATION MENU:



Possible Selections and What They Mean
Brief descriptions of the REMOTE COMMUNICATION MENU selections 1 through 3 are given below and on the following page.

Selection: **1 Wait for a Call or Command**

Application: Selection 1 initializes the remote modem (Wait Call) or direct link (Wait Command) and puts the 658 in a mode in which it waits for a call or commands from another 658 or PC. A 658 in this mode is referred to as the "remote unit." If phone lines are to be used, the remote unit *must* be equipped with the internal modem option, an external Hayes 1200 or 2400 Smartmodem, or a user specified modem. Use selection 3-Configure to select modem or direct link mode of operation.

NOTE *The main port must be configured properly (selection 3, Configure), before "Wait for a Call or Command" is selected.*

Selection: **2 Initiate a Call or Command**

Application: Selection 2 initializes the local modem (Initiate Call) or direct link (Initiate Command) and puts the 658 in the "Initiate" mode. A 658 initiating a call or command is referred to as the "local unit". When selected, the local unit tries to establish communications with the remote unit. If successful, the Remote Interface Menu is displayed. Status, events, and setup data from the remote unit can now be accessed locally. If phone lines are to be used, the local unit *must* be equipped with the internal modem option, an external Hayes 1200 or 2400 Smartmodem, or a user specified modem. As with the remote unit, use selection 3-Configure to select modem or direct link mode of operation.

Selection: **3 Configure**

Application: Accesses menu to change the Main Port's Baud rate and to select the configurations for the 658's internal modem, external Hayes modem, user-specified modem, or direct link. US or European communications standards and pulse make/break ratios can be selected for the Hayes or internal modems. Initialization strings can be edited for the user-specified modems.

2.12.2.1 Selecting Parameters

Selecting parameters is performed when initial communications is to be established or when changes to the configuration or protocol is performed. In general, once established, the parameters remain the same and only initiate or wait commands are used.

Selection 3-Configure from the REMOTE COMMUNICATION MENU lets you select main port connection configuration and to select Baud rate and protocol. There are four connection configurations and two or four Baud rates depending on the modem or direct link used. The available settings, including baud rates and the U.S. (Bell 212A) or European (CCITT) standards, are listed in Table 2-6.

Selecting 3-Configure and then selecting the port connection, Baud rate, and protocol (if required) brings up a display similar to the following:

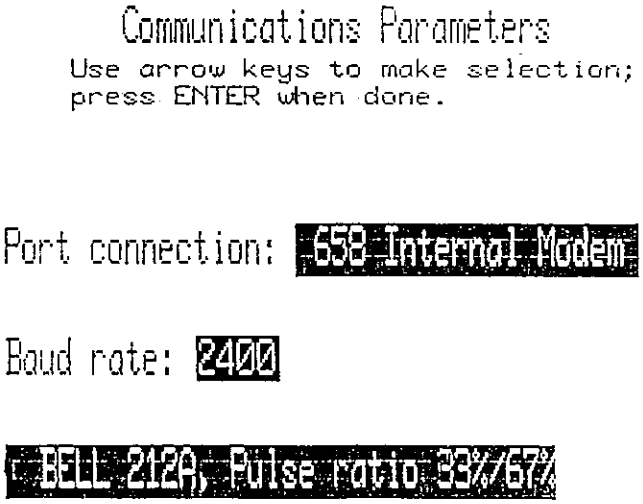


TABLE 2-6. AVAILABLE SETTINGS FOR RS-232 INTERNAL & EXTERNAL COMMUNICATION PORT CONNECTIONS

Hayes 2400 Modem	1200 Baud	Bell 212A*	CCITT*
	2400 Baud		CCITT*
658 Internal Modem	1200 Baud	Bell 212A*	CCITT*
	2400 Baud		CCITT*
Direct Link	1200 Baud		
	2400 Baud		
	4800 Baud		
	9600 Baud		
User-Specified Modem	1200 Baud	(User programmable answer and	
	2400 Baud	originate initialization string, and	
	4800 Baud	dial prefix)	
	9600 Baud		

* Two different pulse ratios (39%/61% and 33%/67%) are available with this setting for use with pulse (rotary) dialing phone lines.

Use the cursor keys to scroll through the four Port connection selections: Direct Link, Hayes 2400 Modem, 658 Internal Modem, and User-Specified Modem. With selection highlighted, Press <ENTER>.

The Baud rate selections are displayed and highlighted next for all connections. Use the cursor keys to select the Baud rate desired. Baud rates available are dependent on the port connection selected; see table 2-6. Make selection and Press <ENTER>.

Protocol selections are displayed and highlighted next for internal and Hayes modems only. Use cursor keys to toggle through the protocol selections. Make selection and press <ENTER>.

For User-Specified Modem connection pressing <ENTER> brings up the following display:

```
 1   Edit initialization string for
     receiving a call.   Currently:
ATZE0V0X4S0=1
 2   Edit initialization string for
     originating a call. Currently:
ATZE0V0X4S0=0
 3   Edit dial prefix.   Currently:
ATDT

Select 1,2,3, or EXIT.
```

Select 1, 2, 3 to edit the respective line of text regarding the initialization string or dial prefix. A Help screen is displayed to assist you in editing. Refer to your respective modem manual for codes. Press <EXIT> or <ENTER> when done.

2.12.2.2 Setting Remote 658

The first step is to set the remote 658 for the type of connection and desired baud rate. (Refer to subsection 2.12.2.1 for information on available settings.)

The second step is to place the 658 in the proper mode (depending on type of connection).

Modem Connection

The remote 658 that's being called must be put in the "Waiting For A Call" mode. This is accomplished through the REMOTE COMMUNICATION MENU (selection 3 from the OTHER FUNCTIONS MENU).

From the REMOTE COMMUNICATION MENU select option 1, "Wait for a Call." You are prompted to connect the modem to the 658 Main Port (or connect the phone line directly to the internal modem option if installed) and to press any key for initialization. After several seconds, the modem is initialized and the 658 remains in the "Wait for a Call" Mode where it awaits a call while continuing to monitor for events.

To abort this mode press <CTRL> <X> twice.

NOTE: *The DIP switch on an external Hayes 1200 Smartmodem must be set as: 1,2,3,4,6,8 DOWN; all others UP.*

Direct Connection

If transferring data to another 658 using a direct serial connection, the 658 is initiated automatically and no prompts are required. This is accomplished through the REMOTE COMMUNICATION MENU select option 1. The screen displays the message that "This 658 is now under remote control." The remote 658 remains in the "Wait for a Call" Mode while continuing to monitor for events.

To quit this mode press <CTRL> <X>. To return to this mode select option 1 from the Remote Communications Menu.

2.12.3 Initiating Call From Local Unit

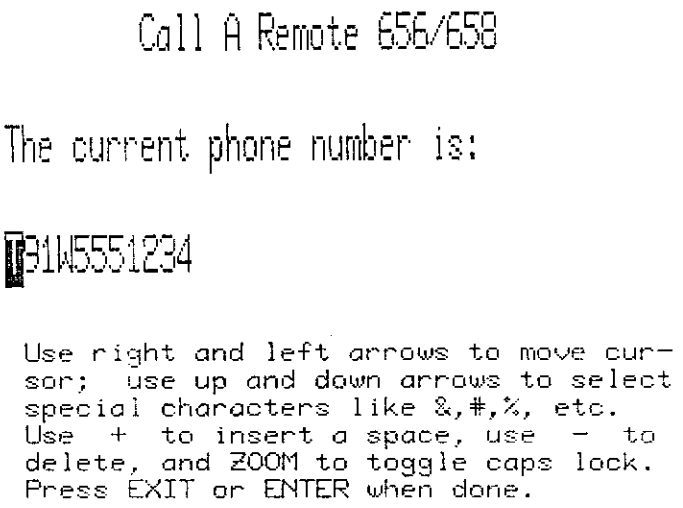
The first step is to set the local 658 for the type of connection and desired baud. (Refer to subsection 2.12.1 for information on available settings.)

The second step depends on the type of connection being used.

Direct Connection
To initiate a call using a direct connection, select option 2, "Initiate a call or command" from the REMOTE COMMUNICATION MENU. As long as the remote 658 you are calling is connected properly, the REMOTE INTERFACE MENU appears on the screen.

NOTE: *The DIP switch on an external Hayes 1200 Smartmodem must be set as: 1,2,3,4,6,8 DOWN; all others UP.*

Modem Connection
To initiate a call using a modem connection, select option 2, "Initiate a call or command" from the REMOTE COMMUNICATION MENU. The screen prompts you to connect the modem (or connect the phone line directly to the internal modem option if installed) to the 658 Main Port and to press any key for initialization. Once the modem is initialized, you are prompted to enter the telephone number of the remote 658 you are calling.



Follow the dialing instructions prompts on the screen. When communications is established the REMOTE INTERFACE MENU appears.

2.12.4 Remote Interface Menu

The REMOTE INTERFACE MENU appears when communication is established:[56]

Possible Selections and What They Mean
Brief descriptions of the REMOTE INTERFACE MENU selections 1 through 6 are given below.

Selection: **1 Get Status Screen**

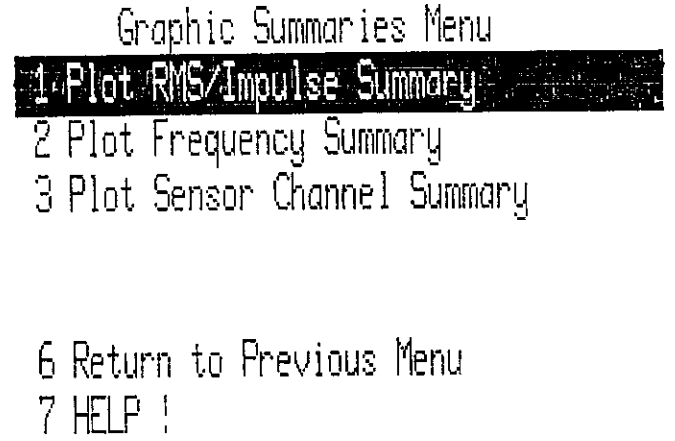
Application: Selection 1 instructs the remote 658 to send its status information. A Status Screen such as the following appears:

From the Status Screen, selection 5, "Activate a New Setup," lets you select a setup number and then activate the selected setup in the remote 658. Selection 6 returns you to the REMOTE INTERFACE MENU, and selection 7 brings up a HELP Screen which describes the functions of selections 5 and 6.

[56] Hold down <*CTRL*> and press the <*X*> key twice to terminate communication with the remote 658 at any time.

Selection: **2 Get Graphic Summaries**

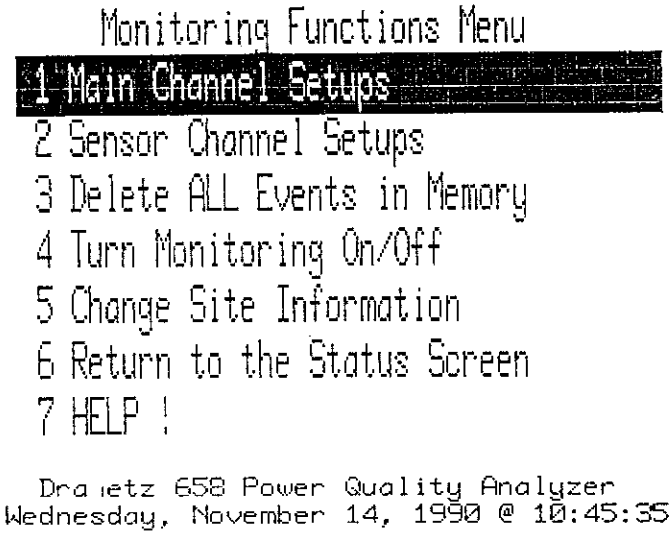
Application: Selection 2 instructs the remote 658 to send a graphic summary plot and text description to the local 658, as defined by the GRAPHIC SUMMARIES MENU. The GRAPHIC SUMMARIES MENU appears:



Selections 1, 2, 3, in the GRAPHIC SUMMARIES MENU are described in subsections 2.10.1.1, 2.10.1.2, and 2.10.1.3. Selection 6 returns you to the REMOTE INTERFACE MENU. Selection 7 brings up a HELP Screen which briefly describes the functions of selections 1 through 3.

Selection: **3 Change Setups**

Application: Selection 3 instructs the remote 658 to send its Main and Sensor Channel setups. After transmission, the local 658 displays the MONITORING FUNCTIONS MENU:



Main Channel setups[57] are edited through selection 1; Sensor Channel setups[58] are edited through selection 2. When exiting the editing mode (selection 6, "Return to the Status Screen"), you are given the option of sending the revised setups back to the remote 658 or leaving the setups as they are. Selection 7 brings up a HELP Screen which briefly describes the functions of selections 1 through 6.

Selection: **4 Transfer All Events**

Application: Selection 4 instructs the remote 658 to send all of its events and setup information to the local 658.

Selection: **5 Delete All Events**

Application: Selection 5 instructs the remote 658 to delete all events in memory.

Selection: **6 End Communication**

Application: Selection 6 terminates communication with the remote 658. The remote 658 regains control and use of its keyboard.

2.13 EXTERNAL PRINTER

The 658 can be connected to an external printer through its Auxiliary port, located on the unit's rear panel.

2.13.1 Auxiliary Port Description

The Auxiliary port is a female, 9-pin, RS-232C compatible serial port fixed at 9600 baud. The Auxiliary port lets the 658 send its output to an external printer.

Data is transmitted through the Auxiliary Port to an external printer at 9600 baud with 8 data bits, 1 start-bit, 1 stop-bit, and no parity.

TABLE 2-7 provides the descriptions of the Auxiliary Port pinouts.

[57] Refer to subsection 2.8.4.1 for information on Main Channel setups.
[58] Refer to subsection 2.8.4.2 for information on Sensor Channel setups.

TABLE 2-7. AUXILIARY PORT PINOUT DESCRIPTION

Pin Name	Function	Direction	Description of Operation
1 GND	Protective Signal Ground	Not Applicable	Shield of interface cable should be connected to this pin which is tied to the internal frame ground.
2 RCV	Receive Data	Input	658 receives serial data input from the connected device. DTR must be TRUE for data to be recognized.
3 XMT	Transmit Data	Output	658 sends output to the connected device provided DTR is TRUE.
4 DTR	Data Terminal Ready	Input	This signal must be TRUE for the 658 to acknowledge the presence of a connected device. A FALSE state immediately disables the data transfer.

2.13.2 Cables for Auxiliary Port Connections

Connection to an external printer is made through the Auxiliary Port. You directly connect the Auxiliary Port to an external printer's 25-pin female connector using Dranetz Auxiliary Port Cable 113447-G1.[59]

FIGURE 2-15 illustrates the wiring between the cable connectors.

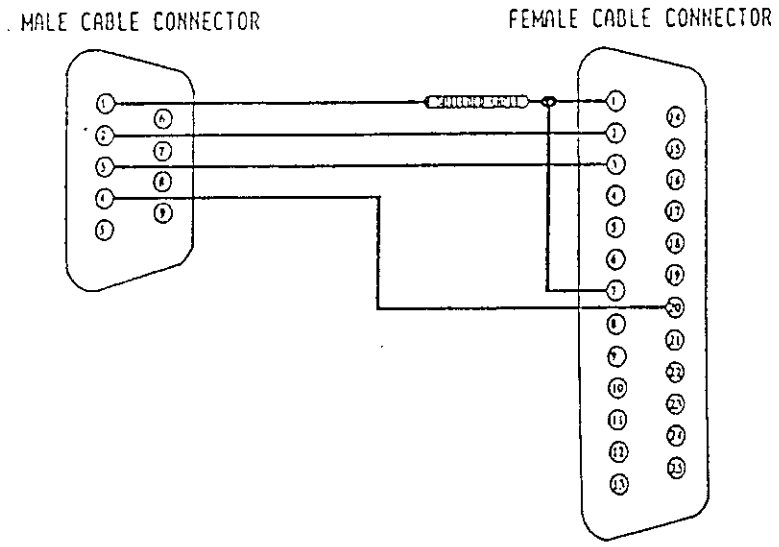


FIGURE 2-15. AUXILIARY PORT CABLE PINOUTS

[59] This cable is an optional accessory. See section 1.10 for ordering information.

2.13.3 Selecting External Printer

Selection 4 from the OTHER FUNCTIONS MENU lets you change the printer setup from the built-in printer to one of the following supported external serial printers connected to the Auxiliary Port:

- Hewlett-Packard ThinkJet
- Epson LX-800
- Okidata ML-192
- Apple Imagewriter

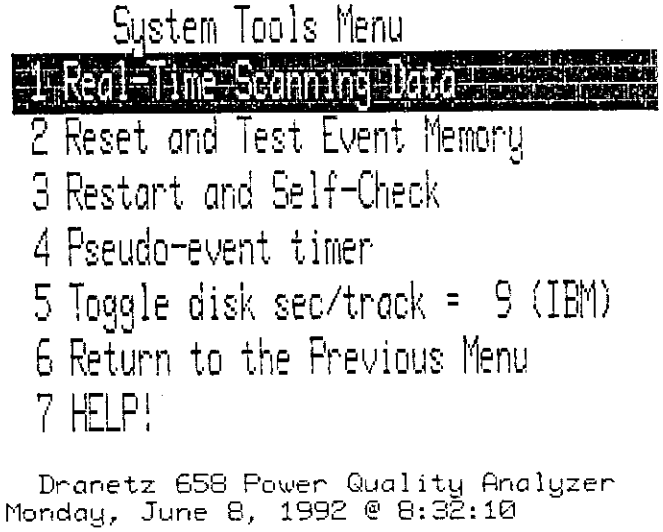
NOTE: *If you are using an external printer, refer to its operating manual for any necessary switch or jumper selections that may be required.*

Pressing *<SPACE>* steps you through the available printer selections, including the 658 internal thermal printer. Press *<EXIT>* to exit when the desired printer selection is displayed.

2.14 658 SYSTEM TOOLS MENU

Selection 5 from the OTHER FUNCTIONS MENU brings up a prompt for the access code to get into the 658 SYSTEM TOOLS MENU. The access code is **DRAN**.

Type *DRAN* and then press ENTER The 658 SYSTEM TOOLS MENU appears:



Possible Selections and What They Mean
Brief descriptions of the SYSTEM TOOLS MENU selections are given below.

Selection: **1 Real-Time Scanning Data**

Application: Refer to Volume 2 of this manual. This selection is applicable to the maintenance of the 658, not its operation.

Selection: **2 Reset and Test Event Memory**

Application: Selection 2 prompts you to verify the selection by selecting Yes. If you do so, all of the stored events are erased and the setups return to their original factory settings.

Selection: **3 Restart and Self-Check**

Application: Selection 3 resets the 658 (similar to turning the instrument off and then on) and runs the initial diagnostics self-test.

Selection: **4 Pseudo-event timer**

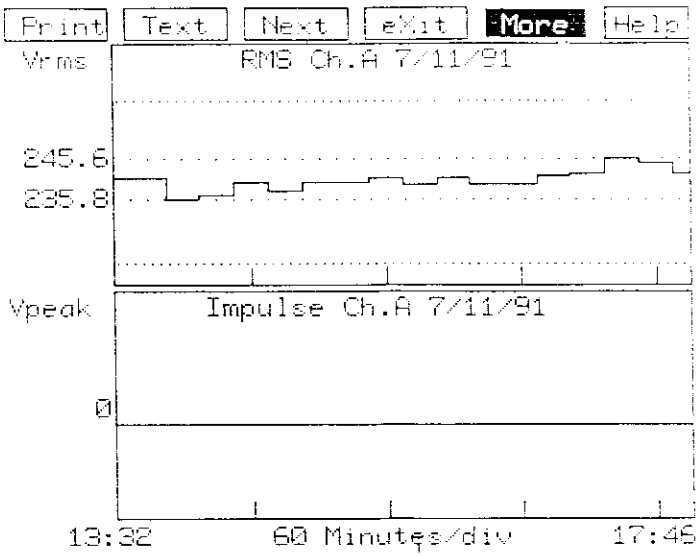
Application: Selection 4 brings up the screen shown below that prompts you to select the pseudo event time period. The selectable period is 1 sec minimum to 23 hr, 59 min, and 59 sec, maximum. Default time is 15 minutes.

Enter new time in hh:mm:ss format. When time is entered, the approximate memory fill time in days will be automatically computed and displayed on the screen.

```
The pseudo event timer is set to:
00:15:00
Note that these pseudo events consume
system memory; at the present rate,
and with no activity on the line,
the memory will fill in approximately
200 days.
Enter new time, or <EXIT>
hh:mm:ss ->
```

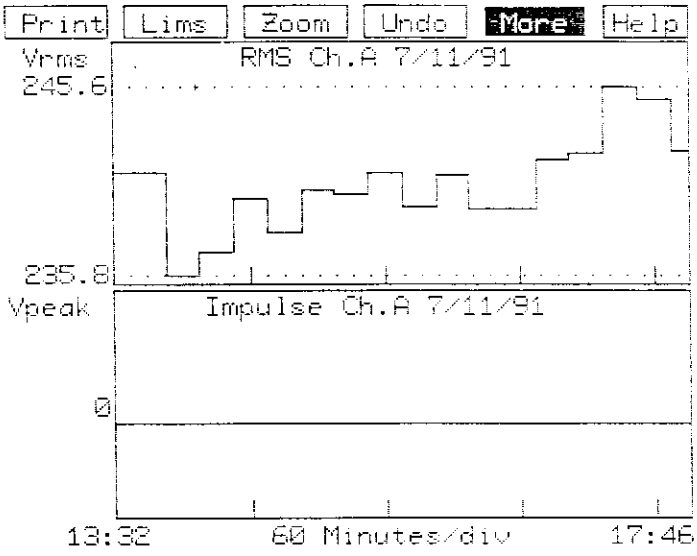
NOTE: *Pseudo events are captured RMS values used to give added information on the graphic summary plots when no disturbance events have occurred. This provides the user with a record of ambient RMS level variations within threshold limits. Pseudo events are not viewable as individual events, since they do not represent a threshold limit crossing. They are captured as a snapshot at the beginning of each pseudo event period. See next page for a time plot of pseudo events.*

Refer to the following screen for explanation of the pseudo events displayed.



During the 4 hours 15 minutes of event time shown on the time plot above, only pseudo events are shown. The RMS voltage readings are 15 minutes apart and do not cross the upper or lower operator set limits (fine pitch dotted lines) of 262 Vrms and 218 Vrms, respectively. The maximum RMS pseudo event reading (shown by coarse pitch dotted lines) is 245.6 Vrms, whereas the minimum level is 235.8 Vrms.

By selecting MORE and then selecting the LIMS function the following expanded limits time plot may be observed.



Selection: **5 Toggle disk sec/track = 9 (IBM) or Toggle disk sec/track = 18 (Dranetz)**

Application: Selection 5 toggles for selection of either disk sec/track of 9 (for IBM format) or 18 (for older Dranetz 65x formats, such as that used on the Dranetz Model 656). See subsection 2.11 for more detailed information.

Selection: **6 Return to the Previous Menu**

Application: Selection 6 returns you to the OTHER FUNCTIONS MENU.

Selection: **7 HELP !**

Application: Selection 7 brings up a HELP Screen which briefly describes the functions of selections 1 through 4.

2.15 INTERNAL MODEM OPTION

2.15.1 Compliance With FCC Rules and Regulations

The optional internal 1200/2400 baud Hayes compatible modem complies with Part 68 of the FCC rules. On the rear panel of this equipment is a label that contains, among other information, the FCC registration number and ringer equivalence number (REN) for this equipment. If requested, this information must be provided to the telephone company.

2.15.2 Notification of the Telephone Company

All direct connection to the telephone network must be made through standard plugs and jacks as described in Part 68, Subpart F of the FCC Rules. The terminal equipment (Dranetz 658 Power Quality Analyzer equipped with the internal modem option) cannot be used on public coin service provided by the telephone company. Connection to Party Line Service is allowable and subject to state tariffs. (Contact the state public utility commission, public service, or corporation commission for information).

2.15.3 Connection to the Telephone Network

Before connecting the equipment to the telephone network, notify the telephone company of the line that you are using, the FCC Registration Number, the Ringer Equivalence of the Modem, and the type of Jack used for connection.

FCC Registration Number: AK396F-19592-MD-E
Ringer Equivalence: 0.4B
Phone Jack (USOC): RJ-11C

2.15.4 Ringer Equivalence Number (REN)

The REN is used to determine the quantity of devices which may be connected to the telephone line. Excessive REN's on the telephone line may result in the devices not ringing in response to an incoming call. In most, but not all areas, the sum of the REN's should not exceed five (5.0). To be certain of the number of devices that may be connected to the line, as determined by the total REN's, contact the telephone company to determine the maximum REN for the calling area.

2.15.5 Incidence of Harm

If the terminal equipment (Dranetz 658 Power Quality Analyzer equipped with the internal modem option) causes harm to the telephone network, the telephone company will notify you in advance that temporary discontinuance of service may be required. But if advance notice isn't practical, the telephone company will notify the customer as soon as possible. Also, you will be advised of your right to file a complaint with the FCC if you believe it is necessary.

2.15.6 Responsibilities of the Telephone Company

The telephone company may make changes in it's facilities, equipment, operations, or procedures that could affect the operation of the equipment. If this happens, the telephone company will provide advance notice in order for you to make the necessary modifications in order to maintain uninterrupted service.

2.15.7 In Case of Trouble

If trouble is experienced with this equipment (Dranetz 658 Power Quality Analyzer equipped with the internal modem option), please contact Dranetz Customer Service Department, (908) 287-3680 for repair and (or) warranty information. If the trouble is causing harm to the telephone network, the telephone company may request you to remove the equipment from the network until the problem is resolved.

2.15.8 Service

All service and repairs must be performed by Dranetz Technologies, Inc. If unauthorized modification or repair is performed, both the FCC Registration and the manufacturer's warranty in effect become null and void. If a malfunction is suspected, it is your responsibility to contact Dranetz Customer Service Department for further instructions. Telephone Number: (908) 287-3680

SECTION III
OPERATIONAL TESTS

3.1 GENERAL

The 658 automatically performs a diagnostics self-test each time it is turned on. The results of the test are indicated on the Start-Up Screen. The self-test checks the integrity of the following sections:

- Display RAM
- Event Memory
- Front End Processor (FEP)Data RAM

3.1.1 If All Tests PASS

If no malfunctions are detected, the initial Start-Up Screen displays "PASSED" for the four tests and you are ready to proceed.

3.1.2 If Any Tests Don't PASS

Any malfunctions detected are listed descriptively along with what action you should take.

NOTE: *Refer to Appendix A for a listing of the possible hardware/software error messages and the actions you should take.*

If necessary, refer to subsection 1.11 (FACTORY REPAIR) for the proper procedure on contacting Dranetz Customer Service Department before returning the unit for repair.

3.2 CALIBRATION

The recommended calibration interval for the 658 is every 12 MONTHS.

We recommend that you return the unit to Dranetz Customer Service Department for calibration. If you decide to do so, first contact Dranetz to obtain an authorization number:

Telephone Number: (908) 287-3680 FAX Number: (908) 287-8627
Telex Number: 499-7808 Cable: DRANETZ
TWX Number: (908) 997-9553

Then fill out the REPAIR/SERVICE ORDER form enclosed in this manual and ship it along with the unit to Dranetz Customer Service Department. (If this form is missing, ask Dranetz for a replacement.)

3.2.1 Battery Pack Replacement

The 658 contains an internal battery pack. For optimal use and reliability, we recommend that you have the battery pack replaced every 2 YEARS.

Replacement can be performed in the field or by Dranetz. Consult the Dranetz Customer Response Center for more information at (908) 287-3680.

APPENDIX A

SERIES 658 HARDWARE AND SOFTWARE ERROR MESSAGES

A.1 GENERAL

This appendix contains a listing of the possible hardware/software error messages that can appear on screen during operation. Following each error message is the appropriate action you should take.

A.2 ERROR MESSAGES

1. This version of disk software will not work with the current version of ROMs installed. To upgrade the ROMs, please call Dranetz Customer Service Dept. at (USA) 908-287-3680

2. A System exception has occurred on the CRT board.

   The unit cannot function until it is repaired. Please call Dranetz Customer Service Dept. at (USA) 908-287-3680

3. A System exception has occurred on the Floppy Disk board.

   The unit cannot function until it is repaired. Please call Dranetz Customer Service Dept. at (USA) 908-287-3680

4. A System exception has occurred on the FPIB board.

   The unit cannot function until it is repaired. Please call Dranetz Customer Service Dept. at (USA) 908-287-3680

5. A System exception has occurred on the Printer board.

   The unit cannot function until it is repaired. Please call Dranetz Customer Service Dept. at (USA) 908-287-3680

6. A System exception has occurred on the FEP board.

   The unit cannot function until it is repaired. Please call Dranetz Customer Service Dept. at (USA) 908-287-3680

7. A System exception has occurred in Event Memory.

   The unit cannot function until it is repaired. Please call Dranetz Customer Service Dept. at (USA) 908-287-3680

8. A System exception has occurred on the FEP board.

   (An applicable message is listed here)

9. A System exception has occurred on the CPU board.

   Turning the unit off and on may correct the problem. If this message appears again, the unit must be repaired. If so, please call Dranetz Customer Service Dept. at (USA) 908-287-3680

10. There is a software mismatch in the CPU software.

    Turning the unit off and on may correct the problem. If this message appears again, the unit must be repaired. If so, please call Dranetz Customer Service Dept. at (USA) 908-287-3680

11. There is a software mismatch in the FEP software.

    Turning the unit off and on may correct the problem. If this message appears again, the unit must be repaired. If so, please call Dranetz Customer Service Dept. at (USA) 908-287-3680

12. There is a software mismatch in the FEP software.

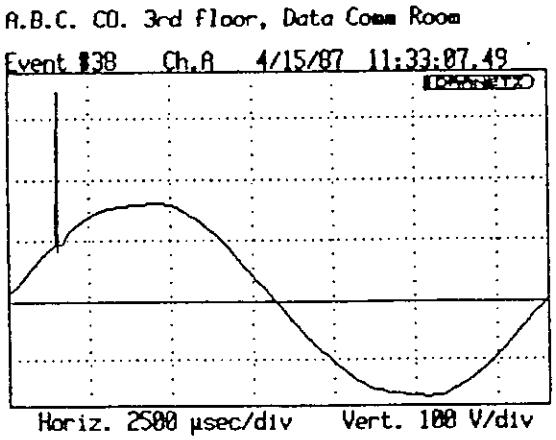
    The unit cannot function until it is repaired. Please call Dranetz Customer Service Dept.
    (USA) 908-287-3680

APPENDIX B
EXAMPLE WAVEFORM DISTURBANCES

B.1 EXAMPLES

This appendix contains various example waveform disturbances and their associated text displays.

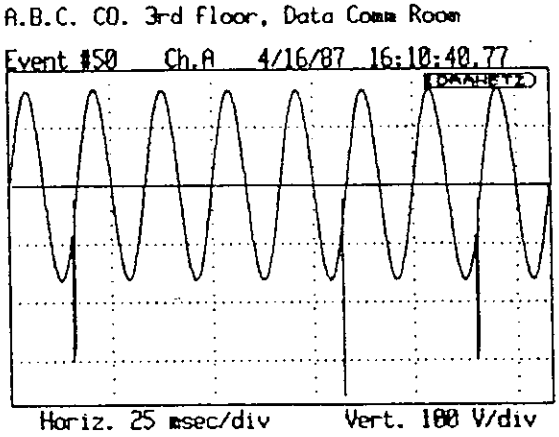
Below is an example single cycle Line A-to-Neutral impulse disturbance with an amplitude of +256 Vpk:




```
Event #38, Channel A Setup #02
Wed. Apr 15, 1987  11:33:07.49
A.B.C. CO. 3rd floor, Data Comm Room

Avg. Freq. Over 20 Cycles = 60.0 Hz
RMS Voltages Measured:
Prev. Event=117.0 Vmin=116.3 Vmax=116.3
High Frequency Hits: 1
   Worst HF Event:
   Amplitude +256 Vpk
   Position  33 degrees
```

Below is an example multicycle Line A-to-Neutral sequence of impulse disturbances with worst case amplitude of -290 Vpk:

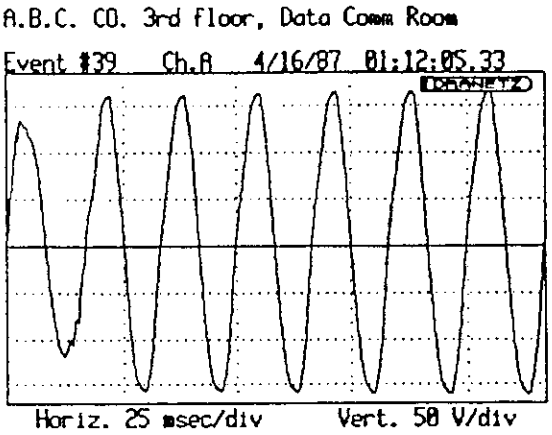



```
Event #50, Channel A Setup #02
Thu. Apr 16, 1987  16:10:40.77
A.B.C. CO. 3rd floor, Data Comm Room

Avg. Freq. Over 20 Cycles = 60.1 Hz
RMS Voltages Measured:
Prev. Event=114.5 Vmin=115.1 Vmax=123.1
High Frequency Hits: 3
   Worst HF Event:
   Amplitude -290 Vpk
   Position  335 degrees
```

In the above displays, "High Frequency Hits" are the number of separate high frequency occurrences in the event. "Position" indicates the sine wave phase position of the worst case high frequency event.

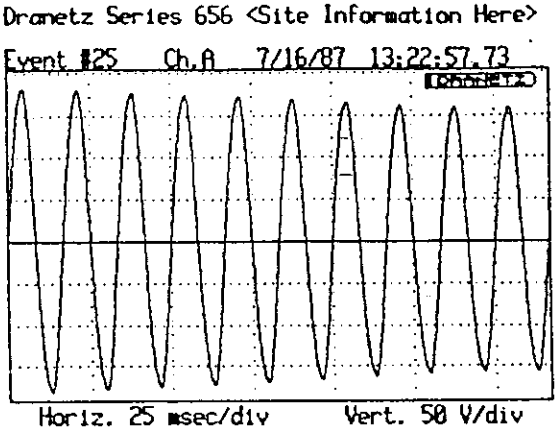
Below is an example single cycle Line A-to-Neutral sag disturbance that reached a minimum of 92.7 V. The beginning of the waveform is the sag and the rest is the waveform after it has returned to within limits:



Event #39, Channel A Setup #02
Thu. Apr 16, 1987 01:12:05.33
A.B.C. CO. 3rd floor, Data Comm Room

Avg. Freq. Over 20 Cycles = 60.0 Hz
RMS Voltages Measured:
Prev. Event=116.3 Vmin=92.7 Vmax=117.5
High Frequency Hits: 0

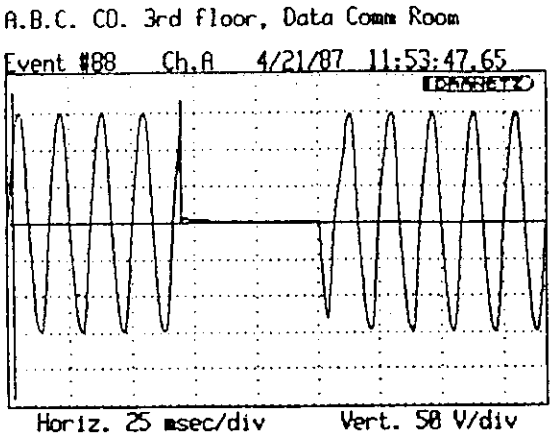
Below is an example multicycle Line A-to-Neutral sine disturbance that reached a maximum of 130.0 V. The beginning of the waveform is the surge and the rest is the waveform returning to normal state:



Event #25, Channel A Setup #01
Thu. Jul 16, 1987 13:22:57.73
Dranetz Series 656 <Site Information Here>

Avg. Freq. Over 20 Cycles = 60.0 Hz
RMS Voltages Measured:
Prev. Event=134.7 Vmin=112.5 Vmax=130.0
High Frequency Hits: 0

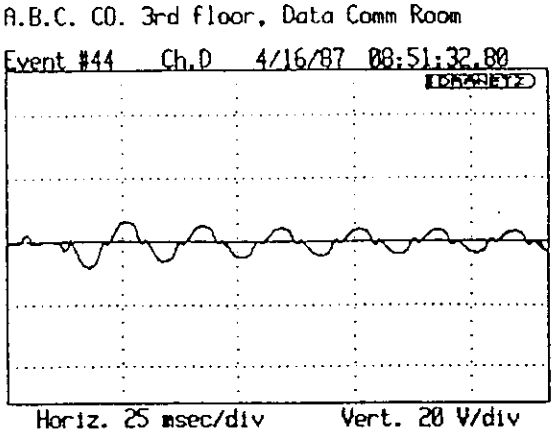
Below is an example multicycle Line A-to-Neutral voltage dropout:



Event #88, Channel A Setup #02
Tue. Apr 21, 1987 11:53:47.65
A.B.C. CO. 3rd floor, Data Comm Room

Avg. Freq. Over 20 Cycles = 60.0 Hz
RMS Voltages Measured:
Prev. Event=106.7 Vmin=2.5 Vmax=107.4
High Frequency Hits: 2
Worst HF Event:
Amplitude -329 Vpk
Position 42 degrees

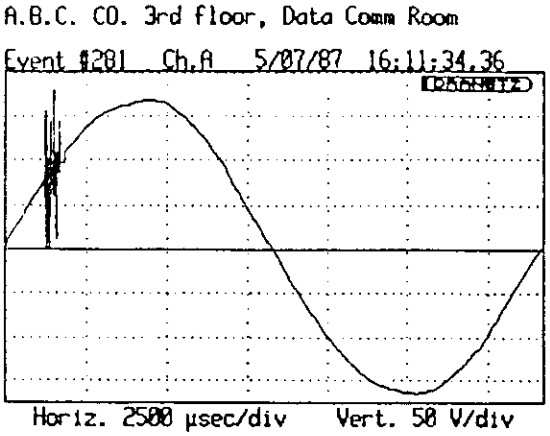
Below is an example multicycle Neutral-to-Ground RMS disturbance:



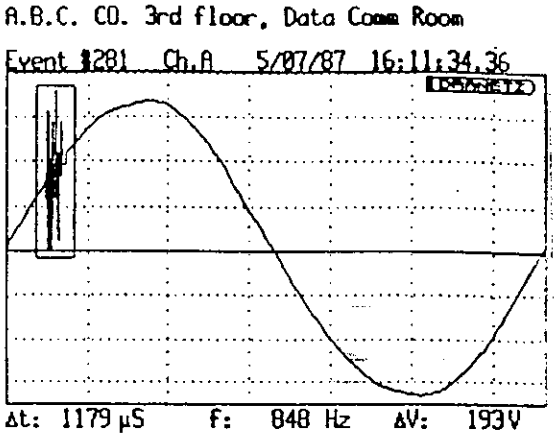
Event #44, Channel D Setup #02
Thu. Apr 16, 1987 08:51:32.80
A.B.C. CO. 3rd floor, Data Comm Room

Avg. Freq. Over 20 Cycles = 60.0 Hz
RMS Voltages Measured:
Prev. Event=1.3 Vmin=2.2 Vmax=3.3
High Frequency Hits: 0

Below is an example Line A-to-Neutral high frequency "burst" disturbance:



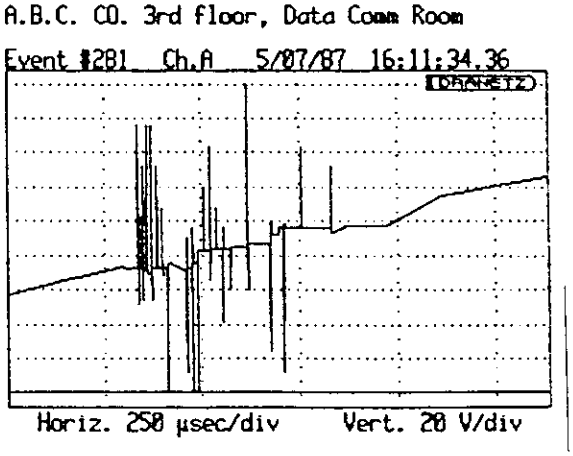
Below is the disturbance on the left after the zoom box has been brought up and positioned:



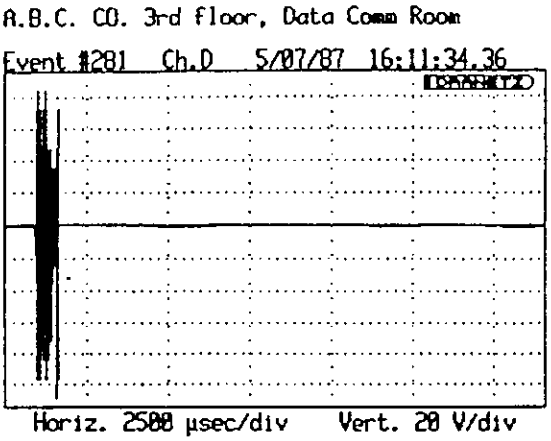
Event #281, Channel A Setup #02
Thu. May 7, 1987 16:11:34.36
A.B.C. CO. 3rd floor, Data Comm Room

Avg. Freq. Over 20 Cycles = 60.0 Hz
RMS Voltages Measured:
Prev. Event=118.5 Vmin=117.8 Vmax=117.8
High Frequency Hits: 1
Worst HF Event:
Amplitude +94 Vpk
Position 26 degrees

Below is the same disturbance after it has been zoomed:



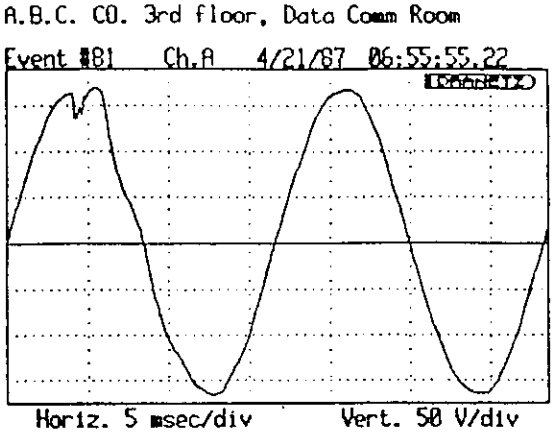
Below is an example Neutral-to-Ground high frequency "burst" disturbance:



Event #281, Channel D Setup #02
Thu. May 7, 1987 16:11:34.36
A.B.C. CO. 3rd floor, Data Comm Room

Avg. Freq. Over 20 Cycles = 60.0 Hz
RMS Voltages Measured:
Prev. Event=0.7 Vmin=0.3 Vmax=0.3
High Frequency Hits: 1
Worst HF Event:
Amplitude -100 Vpk
Position 21 degrees

Below is an example Line A-to-Neutral waveform disturbance caused by a load being turned on in the building:



Event #81, Channel A Setup #02
Tue. Apr 21, 1987 06:55:55.22
A.B.C. CO. 3rd floor, Data Comm Room

Avg. Freq. Over 20 Cycles = 60.0 Hz
RMS Voltages Measured:
Prev. Event=119.6 Vmin=118.1 Vmax=118.7
High Frequency Hits: 0

APPENDIX C

MAIN & SENSOR (TRANSDUCER) CHANNEL SETUP SCREENS

C.1 GENERAL

This appendix contains the 16 factory pre-set Main Channel Setup screens, figure C-1, and four Sensor (Transducer) Channel Setup screens, figure C-2. The setup number corresponding to each screen is displayed in the upper left corner.

Each of the 16 default setups stored in the 658 memory corresponds to a particular circuit monitoring application. A sampling of some of the setups are described in paragraph 2.4.5.3. The following list identifies which fault setup to use for each circuit type. These threshold setting are intended to serve as a guideline and you may want to adjust the values of some parameters to adapt to the actual electrical environment in your application. Modified setups can be returned to the original default settings by selecting the Reset and Test Event Memory, option 2, of the System Tools Menu.

Setup No.	Line Voltage	Neutral Voltage[2]	Phase	Current	Note
01	120 VAC[1]	N to G	Single	-	
02	120 VAC[1]	N to G	Single	-	RMS mode, wave capture de-sensitized
03	120 VAC[1]	N to G	Single	Line	20 Amp nominal
04	208 VAC[3]	-	Single	Line	30-Amp, TR-2019A probe
05	208 VAC[3]	-	3 ϕ Wye	-	
06	208 VAC[3]	-	3 ϕ Wye	-	RMS mode, wave capture de-sensitized
07	220 VAC[1]	N to G	Single	-	
08	277 VAC[1]	-	3 ϕ Wye	-	
09	277 VAC[1]	N to G	3 ϕ Wye	-	
10	277 VAC[1]	-	3 ϕ Wye	Line	TR-2019A Probe
11	277 VAC[1]	-	3 ϕ Wye	2-phase	Line A & B, voltage and current
12	277 VAC[1]	-	3 ϕ Wye	-	RMS mode, wave capture de-sensitized
13	240 VAC[3]	-	3 ϕ Delta		5% Tolerance
14	480 VAC[3]	-	3 ϕ Delta	-	5% Tolerance
15	120 VAC[1]/ 5 VDC	N to G	Single	-	5 VDC
16	120 VAC[1]	-	3 ϕ Wye	3-phase	0-5 Amp Isolated Termination Box

1 Line to Neutral
2 N to G - Neutral to Ground
3 Line to Line

1 Setup #01	A	B	C	D
2 Range	VH	VL	Off	Off
3 Hi Lim	127	02.0	72.4	72.4
4 Lo Lim	105	00.0	00.0	00.0
5 Sens.	003	01.0	72.4	72.4
6 Imp.	0100	025.0	612.0	612.0
7 Wave	010	05.0	72.4	72.4
8 Freq.	Sens: 0.5	Range:	45-65	Hz
Activate	Print	eXit	Help	

1 Setup #02	A	B	C	D
2 Range	VH	VL	Off	Off
3 Hi Lim	127	02.0	72.4	72.4
4 Lo Lim	105	00.0	00.0	00.0
5 Sens.	003	01.0	72.4	72.4
6 Imp.	0100	025.0	612.0	612.0
7 Wave	100	25.0	72.4	72.4
8 Freq.	Sens: 0.5	Range:	45-65	Hz
Activate	Print	eXit	Help	

1 Setup #03	A	B	C	D
2 Range	VH	VL	I300	Off
3 Hi Lim	127	03.0	005	72.4
4 Lo Lim	105	00.0	000	00.0
5 Sens.	005	01.0	005	72.4
6 Imp.	0100	024.0	0050	612.0
7 Wave	010	05.0	015	72.4
8 Freq.	Sens: 0.5	Range:	45-65	Hz
Activate	Print	eXit	Help	

1 Setup #04	A	B	C	D
2 Range	VH	I300	Off	Off
3 Hi Lim	221	005	72.4	72.4
4 Lo Lim	181	000	00.0	00.0
5 Sens.	005	005	72.4	72.4
6 Imp.	0150	0050	612.0	612.0
7 Wave	020	020	72.4	72.4
8 Freq.	Sens: 0.5	Range:	45-65	Hz
Activate	Print	eXit	Help	

1 Setup #05	A	B	C	D
2 Range	VH	VH	VH	Off
3 Hi Lim	221	221	221	72.4
4 Lo Lim	181	181	181	00.0
5 Sens.	005	005	005	72.4
6 Imp.	0150	0150	0150	612.0
7 Wave	020	020	020	72.4
8 Freq.	Sens: 0.5	Range:	45-65	Hz
Activate	Print	eXit	Help	

1 Setup #06	A	B	C	D
2 Range	VH	VH	VH	Off
3 Hi Lim	221	221	221	72.4
4 Lo Lim	181	181	181	00.0
5 Sens.	005	005	005	72.4
6 Imp.	0150	0150	0150	612.0
7 Wave	150	150	150	72.4
8 Freq.	Sens: 0.5	Range:	45-65	Hz
Activate	Print	eXit	Help	

1 Setup #07	A	B	C	D
2 Range	VH	VL	Off	Off
3 Hi Lim	233	03.0	72.4	72.4
4 Lo Lim	192	00.0	00.0	00.0
5 Sens.	005	02.0	72.4	72.4
6 Imp.	0200	025.0	612.0	612.0
7 Wave	020	05.0	72.4	72.4
8 Freq.	Sens: 0.5	Range:	45-65	Hz
Activate	Print	eXit	Help	

1 Setup #08	A	B	C	D
2 Range	VH	VH	VH	Off
3 Hi Lim	293	293	293	72.4
4 Lo Lim	241	241	241	00.0
5 Sens.	005	005	005	72.4
6 Imp.	0200	0200	0200	612.0
7 Wave	030	030	030	72.4
8 Freq.	Sens: 0.5	Range:	45-65	Hz
Activate	Print	eXit	Help	

Figure C-1. Main Channel Default Setup Screens (Sheet 1)

1 Setup #09	A	B	C	D
2 Range	VH	VH	VH	VL
3 Hi Lim	293	293	293	03.0
4 Lo Lim	241	241	241	00.0
5 Sens.	005	005	005	01.0
6 Imp.	0200	0200	0200	024.0
7 Wave	030	030	030	05.0
8 Freq.	Sens: 0.5	Range:	45-65	Hz
Activate	Print	eXit	Help	

1 Setup #10	A	B	C	D
2 Range	VH	VH	VH	I300
3 Hi Lim	293	293	293	005
4 Lo Lim	241	241	241	000
5 Sens.	005	005	005	005
6 Imp.	0200	0200	0200	0050
7 Wave	030	030	030	020
8 Freq.	Sens: 0.5	Range:	45-65	Hz
Activate	Print	eXit	Help	

1 Setup #11	A	B	C	D
2 Range	VH	I300	VH	I300
3 Hi Lim	293	005	293	005
4 Lo Lim	241	000	241	000
5 Sens.	005	005	005	005
6 Imp.	0200	0050	0200	0050
7 Wave	030	030	030	030
8 Freq.	Sens: 0.5	Range:	45-65	Hz
Activate	Print	eXit	Help	

1 Setup #12	A	B	C	D
2 Range	VH	VH	VH	Off
3 Hi Lim	293	293	293	72.4
4 Lo Lim	241	241	241	00.0
5 Sens.	005	005	005	72.4
6 Imp.	0200	0200	0200	612.0
7 Wave	724	724	724	72.4
8 Freq.	Sens: 0.5	Range:	45-65	Hz
Activate	Print	eXit	Help	

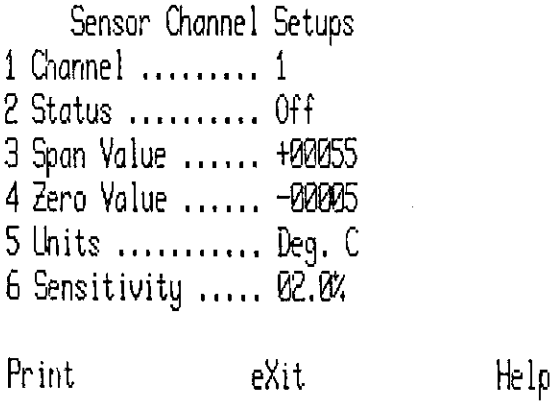
1 Setup #13	A	B	C	D
2 Range	VH	VH	VH	Off
3 Hi Lim	252	252	252	72.4
4 Lo Lim	228	228	228	00.0
5 Sens.	005	005	005	72.4
6 Imp.	0200	0200	0200	612.0
7 Wave	050	050	050	72.4
8 Freq.	Sens: 0.5	Range:	45-65	Hz
Activate	Print	eXit	Help	

1 Setup #14	A	B	C	D
2 Range	VH	VH	VH	Off
3 Hi Lim	504	504	504	72.4
4 Lo Lim	456	456	456	00.0
5 Sens.	010	010	010	72.4
6 Imp.	0400	0400	0400	612.0
7 Wave	080	080	080	72.4
8 Freq.	Sens: 0.5	Range:	45-65	Hz
Activate	Print	eXit	Help	

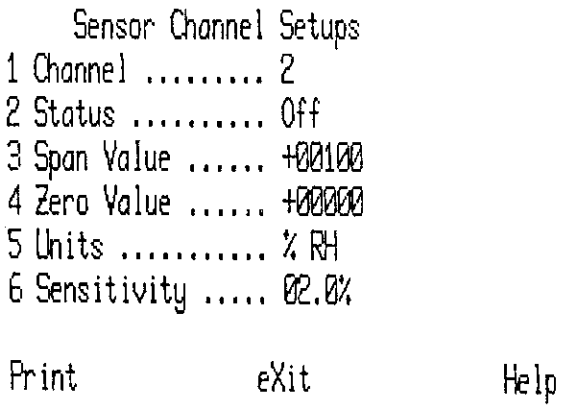
1 Setup #15	A	B	C	D
2 Range	VH	VL	VL	Off
3 Hi Lim	127	02.0	05.5	72.4
4 Lo Lim	105	00.0	04.5	00.0
5 Sens.	003	01.0	00.5	72.4
6 Imp.	0100	025.0	005.0	612.0
7 Wave	010	05.0	01.0	72.4
8 Freq.	Sens: 0.5	Range:	45-65	Hz
Activate	Print	eXit	Help	

1 Setup #16	A	B	C	D
2 Range	VH	I5	I5	I5
3 Hi Lim	127	1.00	1.00	1.00
4 Lo Lim	105	0.00	0.00	0.00
5 Sens.	003	0.10	0.10	0.10
6 Imp.	0100	25.00	25.00	25.00
7 Wave	010	2.00	2.00	2.00
8 Freq.	Sens: 0.5	Range:	45-65	Hz
Activate	Print	eXit	Help	

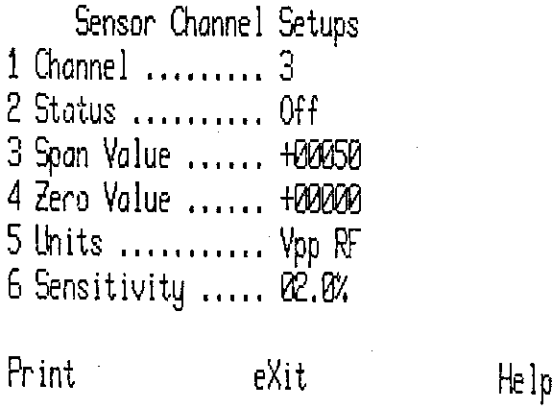
Figure C-1. Main Channel Default Setup Screens (Sheet 2)



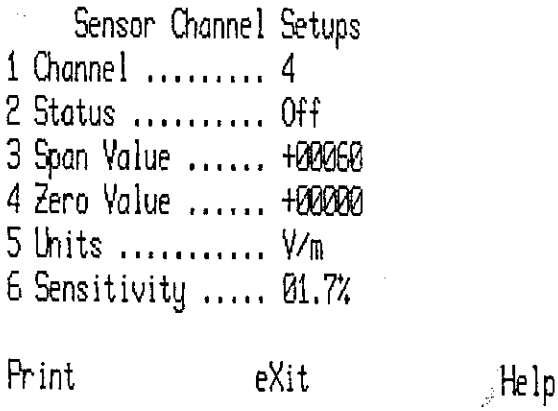
T & H Monitor Screen
(Degrees)



T & H Monitor Screen
(Relative Humidity)



Conducted RF Monitor Screen
(Volts RF)



Radiated RF Monitor Screen
(RF Volts/Meter)

Figure C-2. Sensor (Transducer) Channel Setup Screens

APPENDIX D

HARMONIC DISTORTION ANALYSIS

D.1 GENERAL

The Total Harmonic Distortion (THD) function of the 658 operating system provides the means for performing harmonic distortion analysis on an individual cycle of voltage or current. This harmonic analysis produces an output spectrum graph showing the fundamental frequency to the 50th harmonic. In addition, a table of relative harmonic content is produced.

The Total Harmonic Distortion analysis function is selected from the waveform event screen or the real-time (Scope Mode) screen. These events are described in subsection 2.9.

D.2 WHAT IS HARMONIC ANALYSIS ?

Conventional power system analysis deals with the problem of voltage and frequency deviations. Harmonic Analysis deals with the problem of waveform distortions.

The waveform events captured by the 658 depict the waveform in its time domain. When viewed in this manner, the amplitude versus time of the waveform is displayed. The waveform can also be depicted in the frequency domain where a spectrum depicts the fundamental frequency and its harmonic content in an amplitude versus frequency format. The relation between how the waveform exists in these two domains forms the basis for harmonic analysis.

Harmonic frequencies are integer multiples of the fundamental frequency. The second harmonic has a frequency twice that of the fundamental, the third harmonic has a frequency three times that of the fundamental, and so on. For a 60 Hz power system, the fundamental frequency is 60 Hz, the second harmonic is 120 Hz, the third is 180 Hz, etc. When the content of all the harmonic frequencies are summed with the fundamental frequency, the result is the displayed waveform. Any deviation from a sinusoidal shape is due to the existence of harmonic components.

When performing a harmonic analysis, the 658 calculates the magnitudes of the fundamental frequency and higher order harmonics of the waveform by use of the discrete Fourier transform. The calculation is carried out up to the 50th harmonic. The phase shift of the individual harmonics in relation to the fundamental frequency is also calculated. These calculations are displayed in two separate forms: a graph displaying all the harmonics and their relative magnitudes, and a table listing each harmonic with its percent of distortion and phase shift.

Although harmonic analysis can be performed on any complete cycle, harmonics only cause damage when they exist for a significant length of time. Since the 658 records an event when the waveform deviates (by more than the user set sensitivity) from the last cycle in the previously recorded waveform event, the cycle to cycle repetition of the harmonic distortion does not cause additional events to be recorded. When analyzing event data for harmonic distortion, it is important to understand the following:

- If the initial waveform event captured by the 658 is distorted, and no other waveform events are recorded for a period of time, it means that there was no significant change in the overall waveshape from cycle to cycle. Therefore all the cycles were as distorted as the first waveform event and the harmonic distortion was steady state. This assumption is affected by the sensitivity of the 658's waveform ("wave") threshold. The possible variation in the waveform before a new event, is related to the value of this threshold setting.

- If a distorted waveform event is captured occasionally and is followed shortly thereafter by a sinusoidal waveform event, the harmonic distortion is not steady state. However, if these distortions occur often, a correlation should be made as to what is causing them.

- If the distortion is steady state or lasts for any significant length of time, a harmonic analysis could help find ways to correct the situation before costly damage to sensitive equipment has occurred.

NOTE: *One way to capture a steady state condition with the 658 is to select <S>ave from the Scope Mode. When this is selected, an event is recorded of all active channels.*

D.3 DAMAGE FROM HARMONIC DISTURBANCES

One reason harmonics cause so much damage is that they generate excessive heat, which can result in general equipment failure, overloading of power apparatus and systems, or shorter life-span of instruments and components.

Another reason harmonics are so harmful is that they degrade power quality, which can result in unreliable operation of electrical equipment. If the equipment in question is a computer system, harmonics may cause loss of important data stored on the system.

Among other problems, harmonic distortions can be responsible for:

- overheating of neutral conductors and connections,
- overheating and premature failure of supply transformers,
- failure (or rupturing) of power factor-correcting capacitors
- excessive electrical noise,
- power interruption (overcurrents tripping circuit breakers and blowing fuses),
- power loss (due to heat loss in cables),
- building wire failure,
- failure or misoperation of sensitive electronic equipment, and
- interference with communication networks and equipment.

Current harmonics tend to be less severe further from their point of origin. Voltage harmonics, on the other hand, have a tendency to propagate and disperse throughout the system, and can therefore cause damage and other problems at great distances from their point of origin.

D.4 POSSIBLE CAUSES OF HARMONIC DISTORTION

Often equipment causing harmonic distortion is bought in small quantities. With each additional load on the line, the increase in the amount of distortion is small, but after several harmonic generating components are placed on the line, the total distortion can be damaging to the very equipment causing the distortion.

Additionally, certain equipment which would not normally cause significant distortion can considerably increase its harmonic contribution during transient disturbances and when operating outside its normal state range.

It is important to determine the source of the harmonic disturbance in order to determine how to prevent or control it. The most prevalent sources are non-linear loads, which are rapidly increasing in numbers and new applications. Typical non-linear loads include:

- personal computers and other microprocessor-based devices,
- Uninterruptible Power Supplies (UPS),
- fluorescent lighting (especially newer electronic ballast types),
- battery chargers,
- static power converters,
- AC heating controls,
- AC and DC motor controllers,
- rectifiers,
- switch-mode power supplies used in electronic and office equipment,
- power electronics such as variable-speed drives, SCR-controlled heaters, etc.

Other causes of harmonic distortion include AC/DC static converters, arc furnaces, welders, and saturation of power distribution transformers.

D.5 TRIPLEN HARMONICS

Triplen harmonics, one of the most troublesome types of harmonic disturbances, involve the 3rd harmonic and odd multiples of the 3rd harmonic.

The 3rd harmonic is almost always the most prevalent, attains the highest magnitude, and causes the most problems. The magnitude of these harmonics can be several times that of the fundamental frequency.

On a balanced three-phase wye system with no harmonics present, the line currents cancel vectorially in the neutral, and the neutral current is zero. Since triplen harmonics do not cancel each other in the neutral, but are instead arithmetically additive, they result in increased current in the neutral conductors. The neutral current containing these harmonics can be almost twice that of the phase current.

D.6 NORMALIZING THE PHASE

The harmonic analysis is performed on a selected portion of the waveform. The phase values are computed in respect to the waveshape of this selected area. They are of the form:

$$\text{Cos [(Harmonic Number X Angle) - Phase]}$$

Often it is desirable to normalize the phase of the fundamental to 0°. This can be done with the formula:

$$\text{Normalized Phase} = \text{(Harmonic Number X Fundamental Phase) - Harmonic Phase}$$

For example, suppose we have analyzed a piece of a waveform where the fundamental is at 70° and the second harmonic is 110°. Normalizing the phase of the second harmonic gives

$$\text{Normalized Phase} - (2 \times 70°) - 110° = 30°$$

Thus, when the fundamental is 0°, the second harmonic is 30°.

D.7 AFTER THE ANALYSIS

Once the existence of harmonics has been confirmed, the source of the disturbance must be determined. With the 658 Analyzer connected to the power line, take a steady state reading with the suspected source on and again with the suspected source off. (If the equipment is capable of performing several types of functions, perform these functions with the 658 connected to the power line, and correlate the time the different function were performed to determine if they affect the harmonic content of the power line.)

Since current harmonics are stronger close to the source, measurements can be taken at several points on the power line to pin point the source. Voltage harmonics, on the other hand, retain their magnitude at great distances from their point of origin, and are therefore harder to pin point.

After you determine the source of the harmonics and the magnitudes of the offensive frequencies, the next step is to develop a way to control or eliminate the problem. This includes assessing the allowable levels of harmonics in your system, taking into consideration the sensitivity of your existing (and future) equipment to harmonic distortion.

Protecting your system from harmonics is expensive but necessary. Controlling harmonics may be easier and less costly than removing them completely. When determining the level of protection you need, the following costs should be weighed against each other:

- cost of equipment used for controlling (additional conductors, transformers, etc.) or eliminating (filters, etc.) the condition
- cost of replacing or repairing equipment damaged by harmonics
- the cost of time lost when the equipment is not working
- the cost of damage done to your company's image if you are not able to meet deadlines or the quality of your output suffers due to deterioration of your equipment caused by harmonics

Although individual needs and requirements vary, some steps to lessen the severity of existing harmonics would be:

- supplement existing conductors with additional conductors,
- increase conductor size,
- derate existing transformers and motors,
- replace exiting transformers with larger units,
- load new transformers in accordance with derating guidelines

Harmonic prevention or elimination depends on the use of properly designed and tuned harmonic filters placed at each non-linear load to block the unwanted frequencies from affecting the rest of the system. If the load changes, the filter may have to be redesigned.

The 658 clearly indicates the most offensive harmonic frequencies along with their contribution to the total harmonic distortion. This information is important when designing the filter.