INE88.13.1

RURAL FACILITY ELECTRIC POWER QUALITY ANALYSIS

FINAL REPORT

by

J.D. Aspnes, Y.-Q. Zhao, B.D. Spell and R.P. Merritt
Institute of Northern Engineering
University of Alaska Fairbanks
Fairbanks, Alaska 99775-1760

March 1991

Prepared for

STATE OF ALASKA
DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES
STATEWIDE RESEARCH
2301 Peger Road
Fairbanks, Alaska 99709-5316

Production Cost: $19.20

Table of Contents

Abstract

This report gives results of a recently completed data collection and analysis project investigating electric power quality of two isolated utility systems in Alaska. This is the second phase of a similar effort reported in 1984 which provided the first comprehensive power quality data from four small Alaskan communities. In this report, second generation instrumentation is described and comprehensive data and data analyses are presented. These data are important because of the increased use throughout Alaska of electrical and electronic equipment that may be damaged by power system disturbances.

1.0 INTRODUCTION

This report presents results of a study which analyzed electric power quality of two isolated power systems in Alaska. The study is a follow-up of a project that was completed approximately six years ago which resulted in the first comprehensive power quality data measured in isolated rural Alaskan communities [1,3].

The follow-up or phase two project described in this report utilized second generation data collection, transmission, and analysis tools to provide much more detailed insight into the time-dependence of the power quality problems that were identified. Power demand data were recorded in 15-minute intervals. Data were collected over a period of approximately 10 months at one site (Kotzebue) and 12.5 months at the second site (Tazlina maintenance facility).

1.1 Site descriptions

The sites selected for monitoring electric power quality are the University of Alaska Fairbanks (UAF) Chukchi Branch Campus in Kotzebue (hereafter referred to as "Kotzebue") and the Alaska Department of Transportation Tazlina maintenance facility near Glennallen (hereafter referred to as "Tazlina").

The Kotzebue community has a population of approximately 2,500. Local utility peak generation is 3.7 MW and annual energy production is about 16,000 MWh. Diesel engines drive generators with an installed capacity of 7,235 kW.

Glennallen has a population of approximately 500. The local utility peak generation is 6.9 MW and annual energy production of 10,254 MWh. Diesel engine driven generators have an installed capacity of 10,442 kW. The same utility serves Valdez with a 106 mile long 138 kV transmission line connecting the Valdez and Glennallen communities. Valdez has 7,204 kW installed diesel driven generation and the nearby Solomon Gulch hydroelectric installation with 12,000 kW capacity. Combined peak demand is 16.8 MW and combined annual energy production is about 41,000 MWh [2].

The power quality and power demand instrumentation monitored all phases of a three phase, 120 V line to neutral, 60 Hz four wire grounded wye system near the building service entrance at both sites. Electrical loads included office, communications and computer equipment, motors and lighting. Both buildings are relatively modern, following National Electrical Code requirements for wiring size and distribution.

1.2 Power quality definitions and disturbance analyzer outputs

Power quality is considered good when line voltage and frequency are maintained close to their nominal values. For a single phase power system in North America, these values are 120.0/240.0 volts at 60.0 hertz. An electrical generating system and its load (televisions, computers, refrigerators, etc.) are designed to operate at these nominal values within certain tolerances. Variations outside these tolerances have been shown to impose stresses on the generating system as well as the load, possibly with failure of some element of the system or the load [3]. Poor power quality then, describes power system voltage and frequency variations from the nominal values and outside some allowed tolerances. The tolerances are determined by the specifications of the load or the generating system.

Power quality is often evaluated with commercial disturbance analyzers and poor power quality problems are subdivided into the following categories by the disturbance analyzer selected for this study [4].

1. Overvoltage: An overvoltage condition exists when the monitored voltage exceeds the user-specified upper limit for more than 2.55 seconds.

2. Undervoltage: An undervoltage condition exists when the monitored voltage drops below the user-specified lower limit for more than 2.55 seconds.

3. Voltage Surge: A surge exists when line voltage increases beyond a user-specified upper limit and returns to a within-tolerance range of values in less than 2.56 seconds.

4. Voltage Sag. A sag exists when line voltage decreases below a user-specified lower limit and returns to a within-tolerance range of values in less than 2.56 seconds.

5. Impulse: An impulse disturbance describes any line voltage change which contains frequency components in the range of 300 Hz to 500 kHz. The disturbance analyzer records magnitude, polarity and duration of the impulse. Impulse magnitude is measured with respect to the instantaneous point on the 60 Hz voltage sine wave at which it occurs. Polarity of the impulse is referenced to instrument terminal polarity markings. Duration is determined by the frequency components where 300 Hz corresponds to 3.33 msec or 3,333 microseconds per cycle and 500 kHz corresponds to 2 microseconds per cycle.

6. Frequency Change: A frequency change disturbance implies that the line frequency has changed more than a preselected amount from the last printed value. Frequency change sensitivity is user-selected over a range from 0.2 Hz to 3.0 Hz.

Poor power quality may be due to a number of factors imposed at the generator, the transmission lines or the load. Many of the undesirable effects of poor power quality can be reduced or eliminated by proper design, operation and maintenance of the generating and transmission facilities by the electric power utility. Actions which may be taken by the user or consumer to protect the load are described in a companion report titled "Rural Facility Electric Power Quality Enhancement."

2.0 SECOND GENERATION INSTRUMENTATION

2.1 Hardware

Poor power quality, resulting in outages and premature failure of equipment, has been shown to be a potentially serious problem at rural Alaskan sites [3,5]. In an earlier study of the power quality in four Alaskan villages, the type and occurrence of various poor power phenomena were quantified [3]. In that study, a Dranetz, Inc. Model 606 disturbance analyzer was used which detected, time tagged, and recorded power system sags, surges, and impulses. The recording technology was relatively old in that records were printed on paper tape. It was necessary to utilize a person in each village to change the tapes and mail them to UAF for data analysis.

In this earlier study, hundreds of feet of tape were visually inspected--inch by inch--to extract data required to evaluate sags, surges, impulses, and power outages. This information was then entered into appropriate analysis programs so as to evaluate the power quality at the site.

The volume of data, as well as difficulties associated with finding someone in a small village to change data tapes at the proper time and correctly mark the time, date, and location, made automation of the entire data gathering process an attractive alternative in future studies.

In the current project, second-generation instrumentation was proposed that would have power quality data collection sensitivity similar to the earlier system. It was further proposed to expand the scope of data collected through the installation of current transformers on site.

This would have allowed the monitoring of real power (watts), reactive volt amperes (vars) and power factor and, thus, the ability to determine the effects of system loading on observed power quality. Considering the isolation of the monitoring sites and the probable relative lack of technical sophistication of the on-site operator, the instrumentation was designed to be as automated and self-contained as practical with minimum operator interface required. Finally, because of the volume of data anticipated, it was proposed to record the data in a machine-readable format.

At the time the original proposal was written, it was determined that the most cost-effective method of implementing the instrumentation was to design a data collection system configured around a personal computer (PC). The PC would be installed at a remote site to monitor the necessary parameters and record those data on a tape cartridge which could be easily replaced on a periodic basis. Another computer at the University of Alaska Fairbanks would then be used to read the tapes from the monitoring sites and collate and analyze the data. This conceptual system had certain weaknesses in that it would have been unprotected and susceptible to poor power quality (including outages when it would, consequently, be inoperative). It would also have been very software (program) dependent.

By the time that installation of the system was funded and, under an amendment to the original proposal to fund assembling and installation of a second system, some of the weaknesses were able to be mitigated. An uninterruptible power supply (UPS) was procured in order to isolate the equipment from the power line being monitored and was used at the Tazlina site only. It was determined to be more practical, whenever possible, to use off-the-shelf instrumentation components and to not have the PC installed at the monitoring site. The Dranetz Corporation had automated certain of their instrumentation such that it was possible to monitor all desired electric power qualities without having to design any transducers or on-line load monitoring software. Moreover, in addition to paper tape outputs, the automated instruments also produce a digital data stream in response to interrogation, making the data collection more automatic.

Furthermore, the cost of digital data tape recorders and computers (an additional $8,000 at each site), along with the need to identify an individual in the remote location capable of tending the system, led to the conclusion that periodic, remote interrogation of the instruments over existing telephone communication channels would be a more reliable, cost effective method of data collection. Thus, a system was designed in which a computer at UAF communicated with the remote instruments and instructed those instruments to transfer their data over a telephone link to UAF. The computer and tape deck, originally envisioned for the remote site, was then used to gather, collate and analyze data at UAF.

At each monitoring site, a Dranetz Model 626 universal disturbance analyzer mainframe with appropriate plug-in modules was used to monitor power quality by detecting and recording sags, surges, under and over voltages, impulses and frequency variations. The plug-in modules with their relevant specifications are:

626-PA-6003 3-Phase AC Monitor with
- 0.2 V line voltage resolution
- 0.2 Hz line frequency resolution
- 1 V @ 1 μS impulse resolution

626-PA-6013 Mass Storage Module with capacity to store 960 disturbance events.

The above specifications for the 626-PA-6003 are identical with the previous Dranetz Model 606. The 626 mainframe provides a paper tape readout in the same style as the 606 but it also has an RS-232c communications port through which data may be accessed in a digital format. As noted, the device has the capability to store up to 960 disturbance events, allowing interrogation once per day.

As proposed, in order to evaluate the relationship between the disturbance events and the load conditions at a specific time, it was decided to include an electric power analyzer at the remote site. The Dranetz Model 808 electric power/demand analyzer was chosen because, like the Dranetz 626 described above, it can be interrogated remotely, providing a digital data output. With three phase service, the three line-to-neutral voltages are connected directly to the analyzer and line current is sensed by placing a clip-on current transformer around each phase conductor.

The Dranetz 808 directly measures voltage, current and real power (watts) at some specified interval. It can then compute reactive volt-amperes (vars), power factor, energy and an average demand. Its rated accuracy is 0.2% of full-scale on all parameters which, with the scale factors used, is an accuracy of 12 watts, volts, or vars.

At each of the two remote sites, the two instruments (Model 626 and Model 808) were installed. Each device served as its own data recorder. Each recorder was provided with an RS-232c port but it was not possible to connect them together and, as mentioned, it was not considered feasible to have a computer on site to interrogate each separately or to run two dedicated RS-232c cables. To permit the two recorded data sources to be read independently, an RS-232c compatible, code activated terminal switch was installed between a telephone circuit and the instruments.

The Western Telematic, Model CAS-41 terminal switch was selected to accomplish the remote switching between the two data sources. This switch interfaces the two instruments to a single telephone line. It can be dialed directly and will respond to a control character code, transmitted over the telephone line through a computer modem, causing it to select one of the instruments. After selection, the switch routes the communications from the instrument to the phone line. The data are read from the memory modules in the Dranetz 808 and Dranetz 626 instruments in sequence and transmitted over the telephone line at a 300

Baud rate where they are received and stored in the data logging and analysis computer at UAF.

2.2 Software development and utilization

The Dranetz 808 and 626 data formats are virtually identical to the older style (Dranetz 606) paper tape format and, as such, cannot be readily collated by computer. As part of this project, special data conversion programs were written to rearrange the data into a Lotus 123 spreadsheet format. These programs utilize as inputs the ASCII character data files from the Dranetz 626 or the 808. Each program converts either 808 or 626 data files into files that Lotus 123 can import with the /File Import Numbers function. This software allowed use of the extensive analysis and graphical display capabilities of the Lotus 123 software.

The conversion program for the 808 data creates two output files; filename.808 contains all recognizable data, filename.ERR contains all data not placed into filename.808. The corresponding conversion program for the 626 data creates six output files; filename.FRQ contains frequency data, filename.VLT contains voltage data, filename.SAG contains sag data, filename.SRG contains surge data, filename.IMP contains impulse data and filename.ERR contains all data not placed in one of the other five files. The source code for the data conversion programs is listed in Appendix A.

In addition to the data conversion programs and Lotus 123 software, two additional programs were heavily utilized by this project. Microsoft Word, a word processing program, deletes errors and extraneous ASCII symbols produced during data transmission and separates data into files corresponding to 24-hour time intervals. MultiCom PC, by Multi-Tech Systems, Inc., is the software used to control the microcomputer (PC) located at UAF when it is operating in communication mode. This software provides menu-driven selection of many features such as: interactive terminal mode communication, manual or direct dialing of up to 20 phone numbers, and data capture to a designated file (downloading).

3.0 POWER SYSTEM DISTURBANCE DATA

Power system disturbance data were gathered at two sites, Kotzebue and Tazlina, in 1988 and 1989. Data were separated into summer and winter periods to help determine seasonal dependence, if any, of the measured disturbances. At both sites, the summer interval includes May through August for a total of 123 days. The winter interval for the Kotzebue site covers 52 days from January 9, 1988 to the end of February 1988. The winter interval for Tazlina spans the months of November 1988 through February 1989, or 120 days. Data were collected, however, between January 9, 1988 and November 1, 1988 at the Kotzebue site and between February 17, 1988 and February 28, 1989 at Tazlina.

In the following two sections, data for the Kotzebue site are presented first, followed by Tazlina site data. Results are provided for the maximum power swing day and the minimum power swing day for both winter and summer at both sites. The maximum power swing day is defined as the day during a typical week in which the maximum power swing (greatest difference between minimum and maximum load power) occurred. For Kotzebue, this was Wednesday in the summer and Friday in the winter. For Tazlina, the maximum power swing day was Thursday in the summer and Tuesday in the winter. The minimum power swing day is defined as the day during a typical week in which the minimum power swing occurred. For both Kotzebue and Tazlina, this was Saturday in the summer and Sunday in the winter.

The vast quantity of data resulting from this project has been reduced to the figures appearing in the next two sections of this report.

3.1 Kotzebue Site

Electric power disturbance data for the Kotzebue site are presented in Figure K1 through Figure K85. Figure descriptions appear first as a group followed by the figures themselves.

Figures K1 through K18 show data from the Dranetz Model 808 electric power/demand analyzer. Figures K1 through K9 give results for the winter season while Figures K10 through K18 provide similar information for the summer. All remaining figures present data provided by the Dranetz Model 626 universal disturbance analyzer. Figures K19 through K40 show winter and summer voltage impulse data, Figures K41 through K53 give winter and summer voltage sag data, Figures K54 through K69 provide winter and summer voltage surge data, Figures K70 through K81 give winter and summer frequency disturbances, and Figures K82 through K85 show overvoltage and undervoltage information. As will be seen, several figures representing data from the Tazlina site have no corresponding figures for the Kotzebue location. This is because there were no recorded surges on either the maximum or the minimum power swing days nor were there any recorded frequency disturbances on the minimum power swing day at Kotzebue.

FIGURE DESCRIPTIONS

3.1.1 808:

Winter

Figure K1. The plot of Average Power Demand versus Day of Week (winter) shows the distribution of average power demand (in KW) according to different days of a week. Amplitude of the line represents the average power demands (hourly basis) during the winter.

Figure K2. The plot of Average Voltage versus Day of Week (winter) shows the distribution of average voltage (in Volts) according to different days of a week. Amplitude represents average voltages occurring in the same time period (hourly basis) during the winter.

Figure K3. The plot of Average Power Factor versus Day of Week (winter) shows the distribution of average power factor according to different days of a week. Amplitude represents the average power factor (hourly basis) during the winter.

Figure K4. The plot of Average Power Demand versus Time of Day (winter, minimum power swing day) shows the distribution of average power demand (in KW) according to different times in a day. Only the data of minimum power swing days (Sundays on this site) are included, and amplitude represents the average power demand (hourly basis) during the winter.

Figure K5. The plot of Average Voltage versus Time of Day (winter, minimum power swing day) shows the distribution of average voltage (in Volts) according to different times in a day. Only the data of minimum power swing days (Sundays on this site) are included, and amplitude represents the average voltage (hourly basis) during the winter.

Figure K6. The plot of Average Power Factor versus Time of Day (winter, minimum power swing day) shows the distribution of average power factor according to different times in a day. Only the data of minimum power swing days (Sundays on this site) are included, and amplitude represents the average power factor (hourly basis) during the winter.

Figure K7. The plot of Average Power Demand versus Time of Day (winter, maximum power swing day) shows the distribution of average power demand (in KW) according to different times in a day. Only the data of maximum power swing days (Fridays on this site) are included, and amplitude represents the average power demand (hourly basis) during the winter.

Figure K8. The plot of Average Voltage versus Time of Day (winter, maximum power swing day) shows the distribution of average voltage (in Volts) according to different times in a day. Only the data of maximum power swing days (Fridays on this site) are included, and amplitude represents the average voltage (hourly basis) during the winter.

Figure K9. The plot of Average Power Factor versus Time of Day (winter, maximum power swing day) shows the distribution of average power factor according to different times in a day. Only the data of maximum power swing days (Fridays on this site) are included, and amplitude represents the average power factor (hourly basis) during the winter.

Summer

Figure K10. The plot of Average Power Demands versus Day of Week (summer) shows the distribution of average power demands (in KW) according to different days of a week. Amplitude of the line represents the average power demands (hourly basis) during the summer.

Figure K11. The plot of Average Voltage versus Day of Week (summer) shows the distribution of average voltages (in Volts) according to different days of a week. Amplitude represents the average voltages (hourly basis) during the summer.

Figure K12. The plot of Average Power Factor versus Day of Week (summer) shows the distribution of average power factor according to different days of a week. Amplitude represents the average power factor (hourly basis) during the summer.

Figure K13. The plot of Average Power Demand versus Time of Day (summer, minimum power swing day) shows the distribution of average power demand (in KW) according to different times in a day. Only the data of minimum power swing days (Saturdays on this site) are included, and amplitude represents the average power demand (hourly basis) during the summer.

Figure K14. The plot of Average Voltage versus Time of Day (summer, minimum power swing day) shows the distribution of average voltage (in Volts) according to different times in a day. Only the data of minimum power swing days (Saturdays on this site) are included, and amplitude represents the average voltage (hourly basis) during the summer.

Figure K15. The plot of Average Power Factor versus Time of Day (summer, minimum power swing day) shows the distribution of average power factor according to different times in a day. Only the data of minimum power swing days (Saturdays on this site) are included, and amplitude represents the average power factor (hourly basis) during the summer.

Figure K16. The plot of Average Power Demand versus Time of Day (summer, maximum power swing day) shows the distribution of average power demand (in KW) according to different times in a day. Only the data of maximum power swing days (Wednesdays on this site) are included, and amplitude represents the average power demand (hourly basis) during the summer.

Figure K17. The plot of Average Voltage versus Time of Day (summer maximum power swing day) shows the distribution of average voltage (in Volts) according to different times in a day. Only the data of maximum power swing days (Wednesdays on this site) are included, and amplitude represents the average voltage (hourly basis) during the summer.

Figure K18. The plot of Average Power Factor versus Time of Day (summer maximum power swing day) shows the distribution of average power factor according to different times in a day. Only the data of maximum power swing days (Wednesdays on this site) are included, and amplitude represents the average power factor (hourly basis) during the summer.

3.1.2 626:

3.1.2.1 Impulse

Winter

Figure K19. The plot of Number of Impulses versus Days of Week (winter) shows the distribution of number of impulses according to different days of a week. Amplitude of each bar represents the total number of impulses occurring in the same period (hourly basis) during the winter.

Figure K20. The plot of Average Magnitude of Impulses versus Day of Week (winter) shows the distribution of average magnitude of impulses (in Volts) according to different days of a week. Amplitude of each bar represents the average magnitude of impulses occurring in the same time period (hourly basis) during the winter.

Figure K21 The plot of Average Duration of Impulses versus Day of Week (winter) shows the distribution of average duration of impulses (in microseconds) according to different days of a week. Amplitude of each bar represents the average duration of impulses occurring in the same time period (hourly basis) during the winter.

Figure K22 The plot of Number of Impulses verses Magnitude (winter) shows the distribution of number of impulses according to different magnitude. Amplitude of each bar represents the total number of impulses whose magnitudes are in a specific range (the magnitude interval is 10 V).

Figure K23 The plot of Number of Impulses versus Duration (winter) shows the distribution of number of impulses according to different duration. Amplitude of each bar represents the total number of impulses whose durations are in a specific range (the duration interval is 50 microseconds).

Figure K24 The plot of Number of Impulses versus Time of Day (winter, minimum power swing day) shows the distribution of number of impulses according to different times in a day. Only the data of minimum power swing days (Sundays on this site) are included, and amplitude of each bar represents the total number of impulses occurring in the same time period (hourly basis) during the winter.

Figure K25 The plot of Average Magnitude of Impulses versus Time of Day (winter, minimum power swing day) shows the distribution of average magnitude of impulses (in Volts) according to different times in a day. Only the data of minimum power swing days (Sundays on this site) are included, and amplitude represents the average magnitude of impulses occurring in the same time period (hourly basis) during the winter.

Figure K26 The plot of Average Duration of Impulses versus Time of Day (winter, minimum power swing day) shows the distribution of average duration of impulses (in microseconds) according to different times in a day. Only the data of minimum power swing days (Sundays on this site) are included, and amplitude of the line represents the average duration of impulses occurring in the same time period (hourly basis) during the winter.

Figure K27 The plot of Number of Impulses versus Time of Day (winter, minimum power swing day) shows the distribution of number of impulses according to different times in a day. Only the data of minimum power swing days (Fridays on this site) are included, and amplitude of each bar represents the total number of impulses occurring in the same time period (hourly basis) during the winter.

Figure K28 The plot of Average Magnitude of Impulses versus Time of Day (winter, minimum power swing day) shows the distribution of average magnitude of impulses (in Volts) according to different times in a day. Only the data of minimum power swing days (Fridays on this site) are included, and amplitude represents the average magnitude of impulses occurring in the same time period (hourly basis) during the winter.

Figure K29 The plot of Average Duration of Impulses versus Time of Day (winter, minimum power swing day) shows the distribution of average duration of impulses (in microseconds) according to different times in a day. Only the data of minimum power swing days (Fridays on this site) are included, and amplitude of the line represents the average duration of impulses occurring in the same time period (hourly basis) during the winter.

Summer

Figure K30 The plot of Number of Impulses versus Days of Week (summer) shows the distribution of number of impulses according to different days of a week. Amplitude of each bar represents the total number of impulses occurring in the same time period (hourly basis) during the summer.

Figure K31 The plot of Average Magnitude of Impulses versus Day of Week (summer) shows the distribution of average magnitude of impulses (in Volts) according to different days of a week. Amplitude of each bar represents the average magnitude of impulses occurring in the same time period (hourly basis) during the summer.

Figure K32 The plot of Average Duration of Impulses versus Day of Week (summer) shows the distribution of average duration of impulses (in microseconds) according to different days in a week. Amplitude of each bar represents the average duration of impulses occurring in the same time period (hourly basis) during the summer.

Figure K33 The plot of Number of Impulses versus Days of Week (summer) shows the distribution of number of impulses according to different magnitude. Amplitude of each bar represents the total number of impulses whose magnitudes are in a specific range (the magnitude interval is 10V).

Figure K34 The plot of Number of Impulses versus Duration (summer) shows the distribution of number of impulses according to different duration. Amplitude of each bar represents the total number of impulses whose durations are in a specific range (the duration interval is 50 microseconds).

Figure K35 The plot of Number of Impulses versus Time of Day (summer, minimum power swing day) shows the distribution of number of impulses according to different times in a day. Only the data of minimum power swing days (Saturdays on this site) are included, and amplitude of each bar represents the total number of impulses occurring in the same time period (hourly basis) during the summer.

Figure K36 The plot of Average Magnitude of Impulses versus Time of Day (summer, minimum power swing day) shows the distribution of average magnitude of impulses (in Volts) according to different times in a day. Only the data of minimum power swing days (Saturdays on this site) are included, and amplitude represents the average magnitude of impulses occurring in the same time period (hourly basis) during the summer.

Figure K37 The plot of Average Duration of Impulses versus Time of Day (summer, minimum power swing day) shows the distribution of average duration of impulses (in microseconds) according to different times in a day. Only the data of minimum power swing days (Saturdays on this site) are included, and amplitude of the line represents the average duration of impulses occurring in the same time period (hourly basis) during the summer.

Figure K38 The plot of Number of Impulses versus Time of Day (summer, maximum power swing day) shows the distribution of number of impulses according to different times in a day. Only the data of maximum power swing days (Wednesdays on this site) are included, and amplitude of each bar represents the total number of impulses occurring in the same time period (hourly basis) during the summer.

Figure K39 The plot of Average Magnitude of Impulses versus Time of Day (summer, maximum power swing day) shows the distribution of average magnitude of impulses (in Volts) according to different time in a day. Only the data of maximum power swing days (Wednesdays on this site) are included, and amplitude of the line represents the average magnitude of impulses occurring in the same time period (hourly basis) during the summer.

Figure K40 The plot of Average Duration of Impulses versus Time of Day (summer, maximum power swing day) shows the distribution of average duration of impulses (in microseconds) according to different times in a day. Only the data of maximum power swing days (Wednesdays on this site) are included, and amplitude of the line represents the average duration of impulses occurring in the same time period (hourly basis) during the summer.

3.1.2.2 Sag

Winter

Figure K41 The plot of Number of Sags versus Days of Week (winter) shows the distribution of number of sags according to different days of a week. Amplitude of each bar represents the total number of sags occurring in the same time period (hourly basis) during the winter.

Figure K42 The plot of Average Magnitude of Sags versus Days of Week (winter) shows the distribution of average magnitude of sags (in Volts) according to different days of a week. Amplitude represents the average magnitude of sags occurring in the same time period (hourly basis) during the winter.

Figure K43 The plot of Average Duration of Sags versus Days of Week (winter) shows the distribution of average duration of sags (in seconds) according to different days of a week. Amplitude of the line represents the average duration of sags occurring in the same time period (hourly basis) during the winter.

Figure K44 The plot of Number of Sags versus Magnitude (winter) shows the distribution of number of sags according to different magnitude. Amplitude of each bar represents the total number of sags whose magnitudes are in a specific range (the magnitude interval is 10V).

Figure K45 The plot of Number of Sags versus Duration (winter) shows the distribution of number of sags according to different duration. Amplitude of each bar represents the total number of sags whose durations are in a specific range (the duration interval is 0.05 seconds).

Summer

Figure K46 The plot of Number of Sags versus Days of Week (summer) shows the distribution of number of sags according to different days in a week. Amplitude of each bar represents the total number of sags occurring in the same time period (hourly basis) during the summer.

Figure K47 The plot of Average Magnitude of Sags versus Days of Week (summer) shows the distribution of average magnitude of sags (in Volts) according to different days of a week. Amplitude represents the average magnitude of sags occurring in the same time period (hourly basis) during the summer.

Figure K48 The plot of Average Duration of Sags versus Day of Week (summer) shows the distribution of average duration of sags (in seconds) according to different days of a week. Amplitude represents the average duration of sags occurring in the same time period (hourly basis) during the summer.

Figure K49 The plot of Number of Sags versus Magnitude (summer) shows the distribution of number of sags according to different magnitude. Amplitude of each bar represents the total number of sags whose magnitudes are in a specific range (the magnitude interval is 10V).

Figure K50 The plot of Number of Sags versus Duration (summer) shows the distribution of number of sags according to different duration. Amplitude of each bar represents the total number of sags whose durations are in a specific range (the duration interval is 0.05 seconds).

Figure K51 The plot Number of Sags versus Time of Day (summer), maximum power swing day) shows the distribution of number of sags according to different times in a day. Only the data of maximum power swing days (Wednesdays on this site) are included, and amplitude of each bar represents the total number of sags occurring in the same time period (hourly basis) during the summer.

Figure K52 The plot of Average Magnitude of Sags versus Time of Day (summer, maximum power swing day) shows the distribution of average magnitude of sags (in Volts) according to different times in a day. Only the data of maximum power swing days (Wednesdays on this site) are included, and amplitude of each bar represents the average magnitude of sags occurring in the same time period (hourly basis) during the summer.

Figure K53 The plot of Average Duration of Sags versus Time of Day (summer, maximum power swing day) shows the distribution of average duration of sags (in seconds) according to different times in a day. Only the data of maximum power swing days (Wednesdays on this site) are included, and amplitude of each bar represents the average duration of sags occurring in the same time period (hourly basis) during the summer.

3.1.2.3 Surge

Winter

Figure K54 The plot of Number of Surges versus Day of Week (winter) shows the distribution of number of surges according to different days of a week. Amplitude of each bar represents the total number of surges occurred in the same time period (hourly basis) during the winter.

Figure K55 The plot of Average Magnitude of Surges versus Day of Week (winter) shows the distribution of average magnitude of surges (in Volts) according to different days of a week. Amplitude represents the average magnitude of surges occurred in the same time period (hourly basis) during the winter.

Figure K56 The plot of Average Duration of Surges versus Day of Week (winter) shows the distribution of average duration of surges (in seconds) according to different days of a week. Amplitude of each bar represents the average duration of surges occurring in the same time period (hourly basis) during the winter.

Figure K57 The plot of Number of Surges versus Magnitude (winter) shows the distribution of number of surges according to different magnitude. Amplitude of each bar represents the total number of surges whose magnitudes are in a specific range (the magnitude interval is 0.5 V).

Figure K58 The plot of Number of Surges versus Duration (winter) shows the distribution of number of surges according to different duration. Amplitude of each bar represents the total number of surges whose durations are in a specific range (the duration interval is 0.1 seconds).

Figure K59 The plot of Number of Surges versus Day of Week (summer) shows the distribution of number of surges according to different days of a week. Amplitude of each bar represents the total number of surges occurring in the same time period (hourly basis) during the summer.

Figure K60 The plot of Average Magnitude of Surges versus Day of Week (summer) shows the distribution of average magnitude of surges (in Volts) according to different days of a week. Amplitude represents the average magnitude of surges occurring in the same time period (hourly basis) during the summer.

Figure K61 The plot of Average Duration of Surges versus Day of Week (summer) shows the distribution of average duration of surges (in seconds) according to different days of a week. Amplitude represents the average duration of surges occurring in the same time period (hourly basis) during the summer.

Figure K62 The plot of Number of Surges versus Magnitude (summer) shows the distribution of number of surges according to different magnitude. Amplitude of each bar represents the total number of surges whose magnitudes are in a specific range (the magnitude interval is 0.5 V).

Figure K63 The plot of Number of Surges versus Duration (summer) shows the distribution of number of surges according to different duration. Amplitude of each bar represents the total number of surges whose durations are in a specific range (the duration interval is 0.1 seconds).

Figure K64 The plot of Number of Surges versus Time of Day (summer, minimum power swing day) shows the distribution of number of surges according to different times in a day. Only the data of minimum power swing days (Saturdays on this site) are included, and amplitude of each bar represents the total number of surges occurring in the same time period (hourly basis) during the summer.

Figure K65 The plot of Average Magnitude of Surges versus Time of Day (summer, minimum power swing day) shows the distribution of average magnitude of surges (in Volts) according to different times in a day. Only the data of minimum power swing days (Saturdays on this site) are included, and amplitude represents the average magnitude of surges occurring in the same time period (hourly basis) during the summer.

Figure K66 The plot of Average Duration of Surges versus Time of Day (summer, minimum power swing day) shows the distribution of average duration of surges (in seconds) according to different times in a day. Only the data of minimum power swing days (Saturdays on this site) are included, and amplitude of each bar represents the average duration of surges occurring in the same time period (hourly basis) during the summer.

Figure K67 The plot of Number of Surges versus Time of Day (summer, maximum power swing day) shows the distribution of number of surges according to different time in a day. Only the data of maximum power swing days (Wednesdays on this site) are included, and amplitude of each bar represents the total number of surges occurring in the same time period (hourly basis) during the summer.

Figure K68 The plot of Average Magnitude of Surges versus Time of Day (summer, maximum power swing day) shows the distribution of average magnitude of surges (in Volts) according to different times in a day. Only the data of maximum power swing days (Wednesdays on this site) are included, and amplitude of the line represents the average magnitude of surges occurring in the same time period (hourly basis) during the summer.

Figure K69 The plot of Average Duration of Surges versus Time of Day (summer, maximum power swing day) shows the distribution of average duration of surges (in seconds) according to different times in a day. Only the data of maximum power swing days (Wednesdays on this site) are included, and amplitude of each bar represents the average duration of surges occurring in the same time period (hourly basis) during the summer.

3.1.2.4 Frequency Disturbances

Winter

Figure K70 The plot of Number of Frequency Disturbances versus Day of Week (winter) shows the distribution of number of frequency disturbances according to different days of a week. Amplitude of each bar represents the total number of frequency disturbances occurring in the same time period (hourly basis) during the winter.

Figure K71 The plot of Average Magnitude of Frequency Disturbances versus Day of Week (winter) shows the distribution of average magnitude of frequency disturbances (in Hz) according to different days of a week. Amplitude represents the average magnitude of frequency disturbances occurring in the same time period (hourly basis) during the winter.

Figure K72 The plot of Number of Frequency Disturbances versus Frequency (winter) shows the distribution of number of frequency disturbances according to different frequency. Amplitude of each bar represents the total number of frequency disturbances whose frequencies are in a specific range (the frequency interval is 0.5 Hz).

Figure K73 The plot of Number of Frequency Disturbances versus Time of Day (winter, maximum power swing day) shows the distribution of number of frequency disturbances according to different times in a day. Only the data of maximum power swing days (Fridays on this site) are included, and amplitude of each bar represents the total number of frequency disturbances occurring in the same time period (hourly basis) during the winter.

Figure K74 The plot of Average Maximum of Frequency Disturbances versus Time of Day (winter, maximum power swing day) shows the distribution of average magnitude of frequency disturbances (in Hz) according to different times in a day. Only the data of maximum power swing days (Tuesdays on this site) are included and amplitude represents the average magnitude of frequency disturbances occurring in the same time period (hourly basis) during the winter.

Summer

Figure K75 The plot of Number of Frequency Disturbances versus Day of Week (summer) shows the distribution of number of frequency disturbances according to different days of a week. Amplitude of each bar represents the total number of frequency disturbances occurring in the same time period (hourly basis) during the summer.

Figure K76 The plot of Average Magnitude of Frequency Disturbances versus Day of Week (summer) shows the distribution of average magnitude of frequency disturbances (in Hz) according to different days of a week. Amplitude represents the average magnitude of frequency disturbances occurring in the same time period (hourly basis) during the summer.

Figure K77 The plot of Number of Frequency Disturbances versus Frequency (summer) shows the distribution of number of frequency disturbances according to different magnitude. Amplitude of each bar represents the total number of frequency disturbances whose frequencies are in a specific range (the frequency interval is 0.5 Hz).

Figure K78 The plot of Number of Frequency Disturbances versus Time of Day (summer, minimum power swing day) shows the distribution of number of frequency disturbances according to different times in a day. Only the data of minimum power swing days (Saturdays on this site) are included, and amplitude of each bar represents the total number of frequency disturbances occurring in the same time period (hourly basis) during the summer.

Figure K79 The plot of Average Magnitude of Frequency Disturbances versus Time of Day (summer, minimum power swing day) shows the distribution of average magnitude of frequency disturbances (in Hz) according to different times in a day. Only the data of minimum power swing days (Saturdays on this site) are included, and amplitude represents the average magnitude of frequency disturbances occurring in the same time period (hourly basis) during the summer.

Figure 80 The plot of Number of Frequency Disturbances versus Time of Day (summer, maximum power swing day) shows the distribution of number of frequency disturbances according to different times in a day. Only the data of maximum power swing days (Wednesdays on this site) are included, and amplitude of each bar represents the total number of frequency disturbances occurring in the same time period (hourly basis) during the summer.

Figure K81 The plot of Average Magnitude of Frequency Disturbances versus Time of Day (summer, maximum power swing day) shows the distribution of average magnitude of frequency disturbances (in Hz) according to different times in a day. Only the data of maximum power swing days (Wednesdays on this site) are included, and amplitude represents the average magnitude of frequency disturbances occurring in the same time period (hourly basis) during the summer.

3.1.2.5 Voltages

Winter

Figure K82 The plot of Number of Over Voltage Events versus Voltage (winter) shows the distribution of number of over-voltage disturbances according to different voltage. Amplitude of each bar represents the total number of voltage disturbances whose magnitudes are in a specific range (the voltage interval is 0.2v).

Figure K83 The plot of Number of Under Voltage Events versus Voltage (winter) shows the distribution of number of under-voltage disturbances according to different voltage. Amplitude of each bar represents the total number of voltage disturbances whose magnitudes are in a specific range (the voltage interval is 10v).

Summer

Figure K84 The plot of Number of Over Voltage Events versus Voltage (summer) shows the distribution of number of over-voltage disturbances according to different voltage. Amplitude of each bar represents the total number of voltage disturbances whose magnitudes are in a specific range (the voltage interval is 0.2v).

Figure K85 The plot of Number of Under Voltage Events versus Voltage (summer) shows the distribution of number of under-voltage disturbances according to different voltage. Amplitude of each bar represents the total number of voltage disturbances whose magnitudes are in a specific range (the voltage interval is 10v).

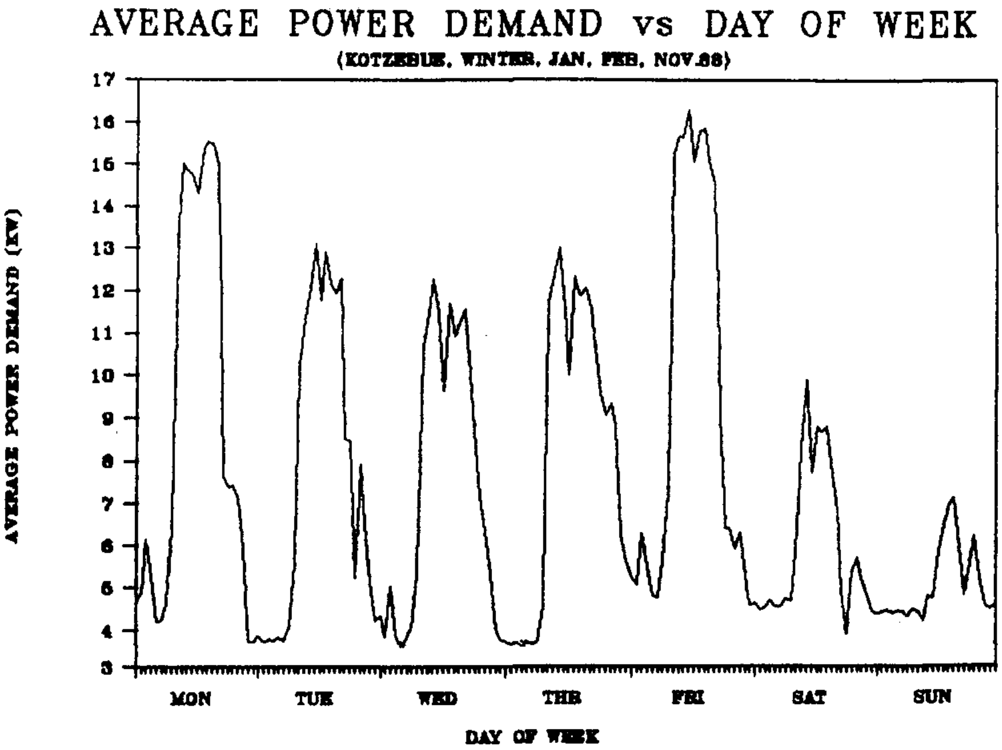


Figure K1

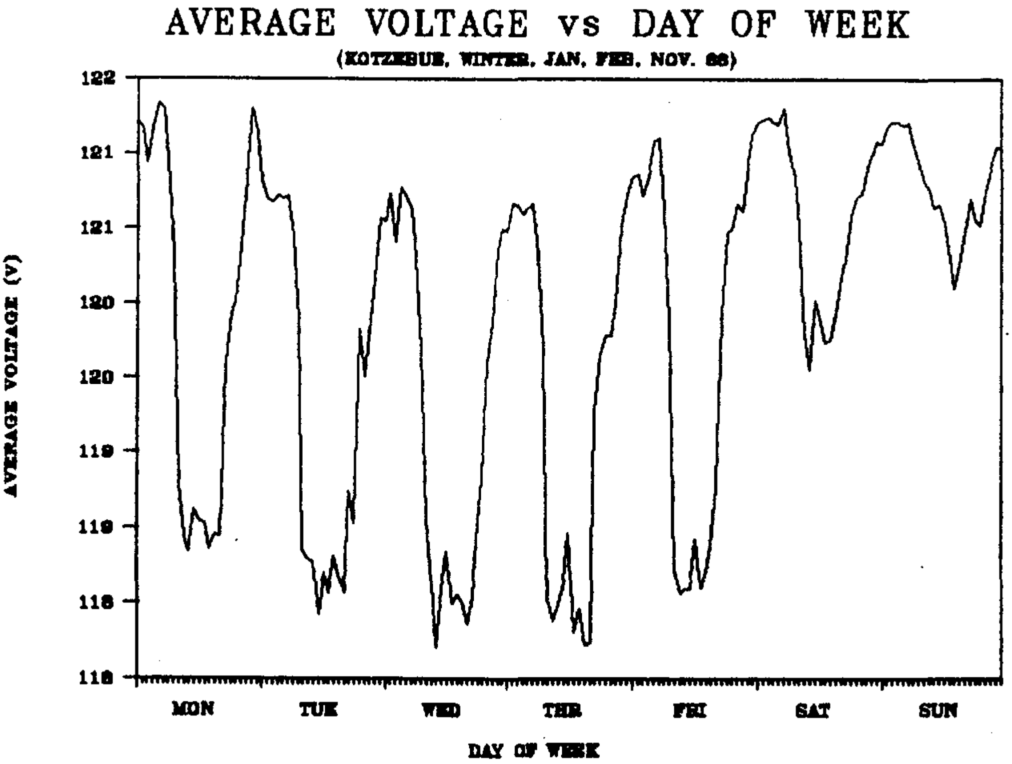


Figure K2

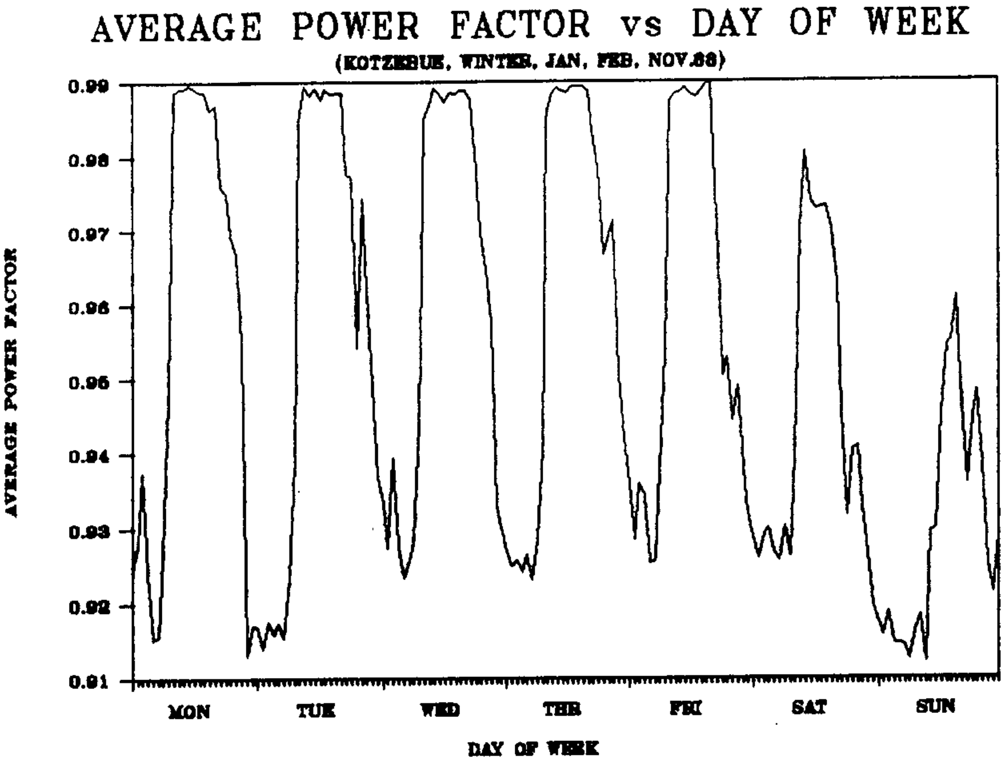


Figure K3

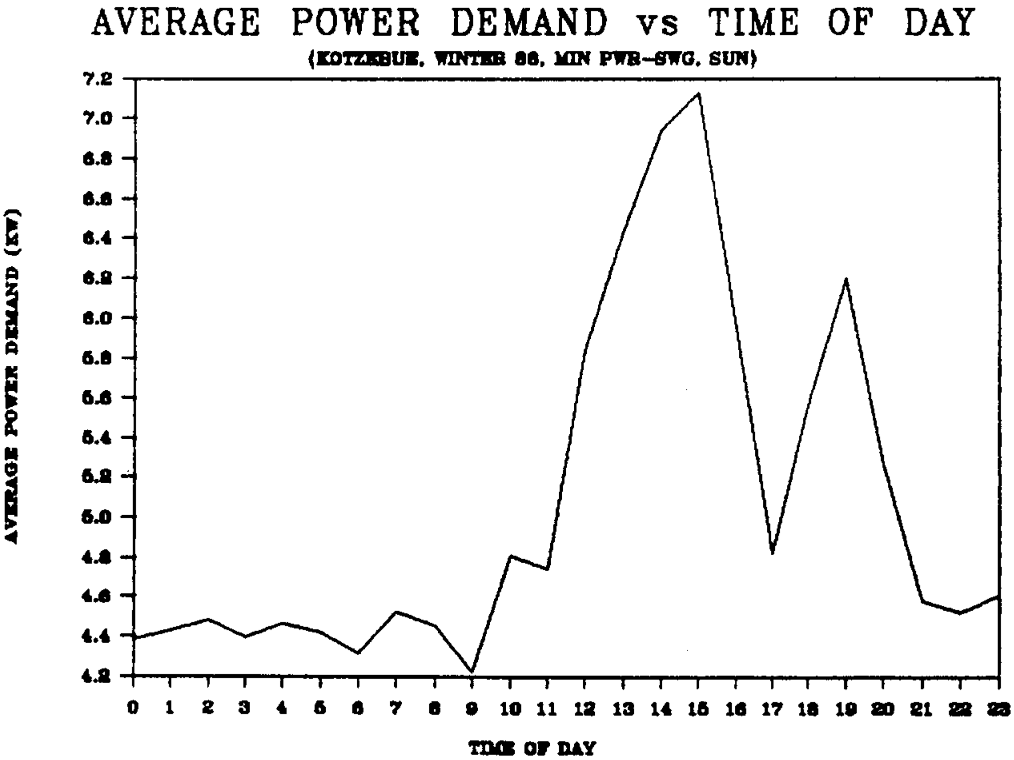


Figure K4

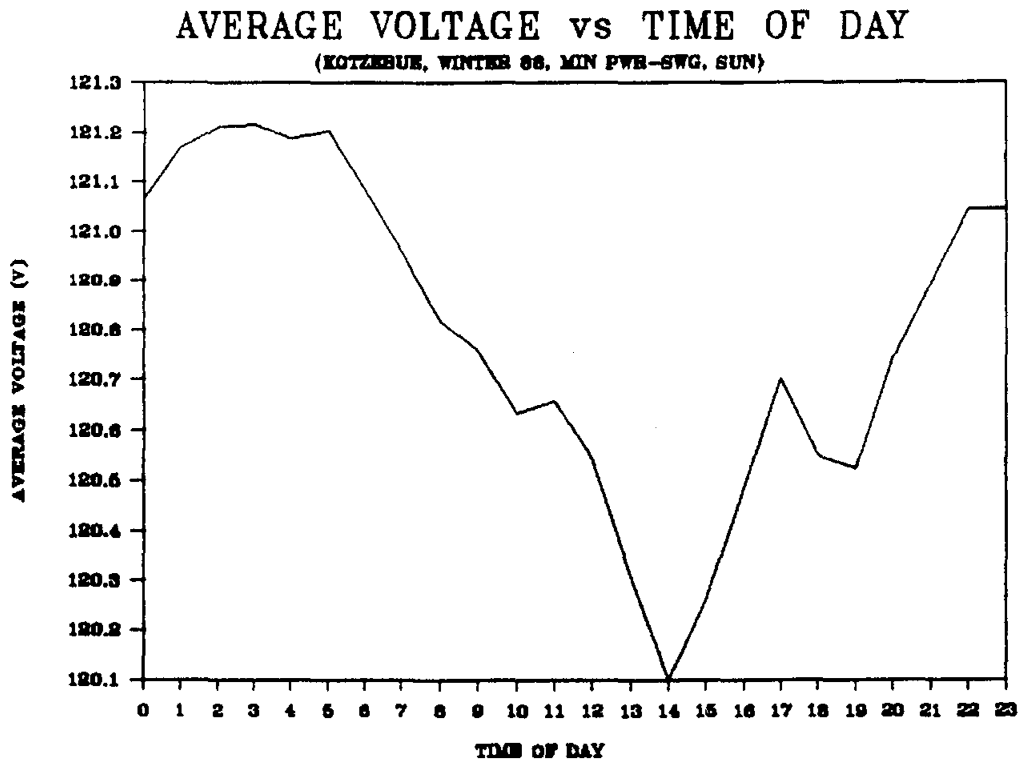


Figure K5

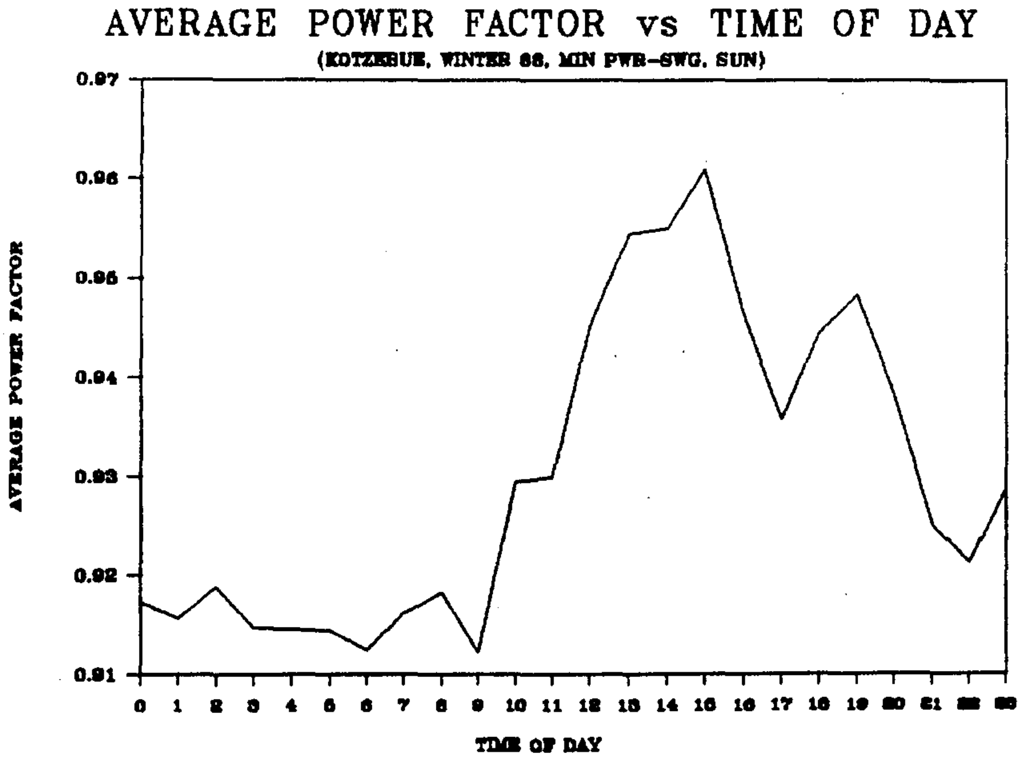


Figure K6

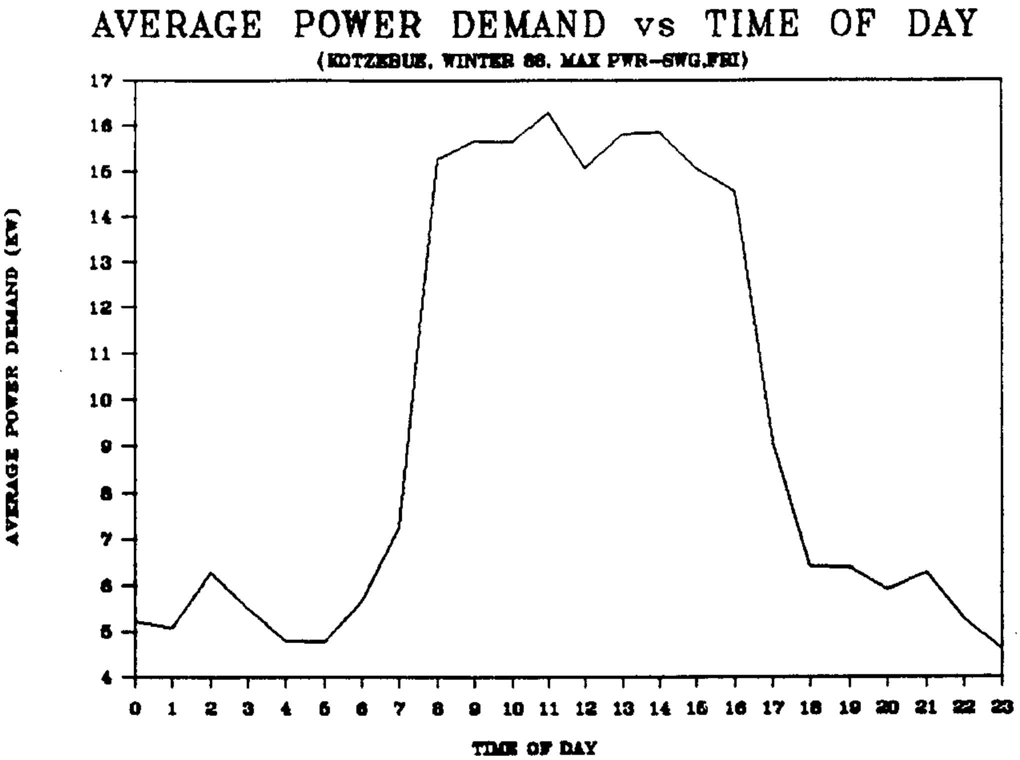


Figure K7

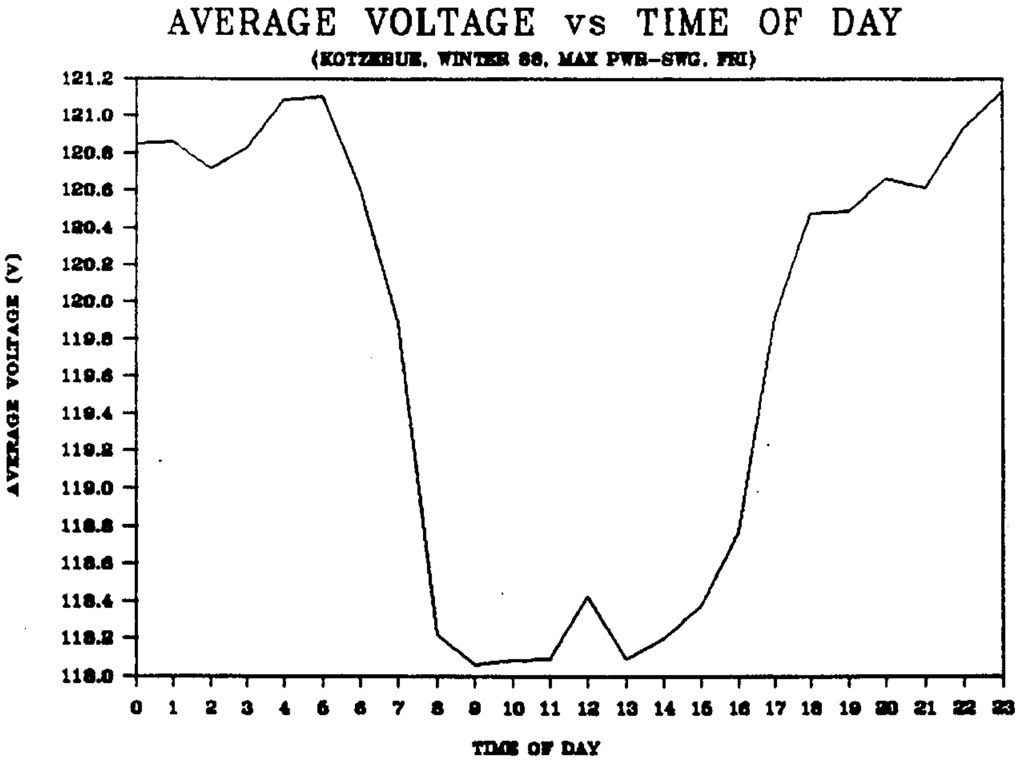


Figure K8

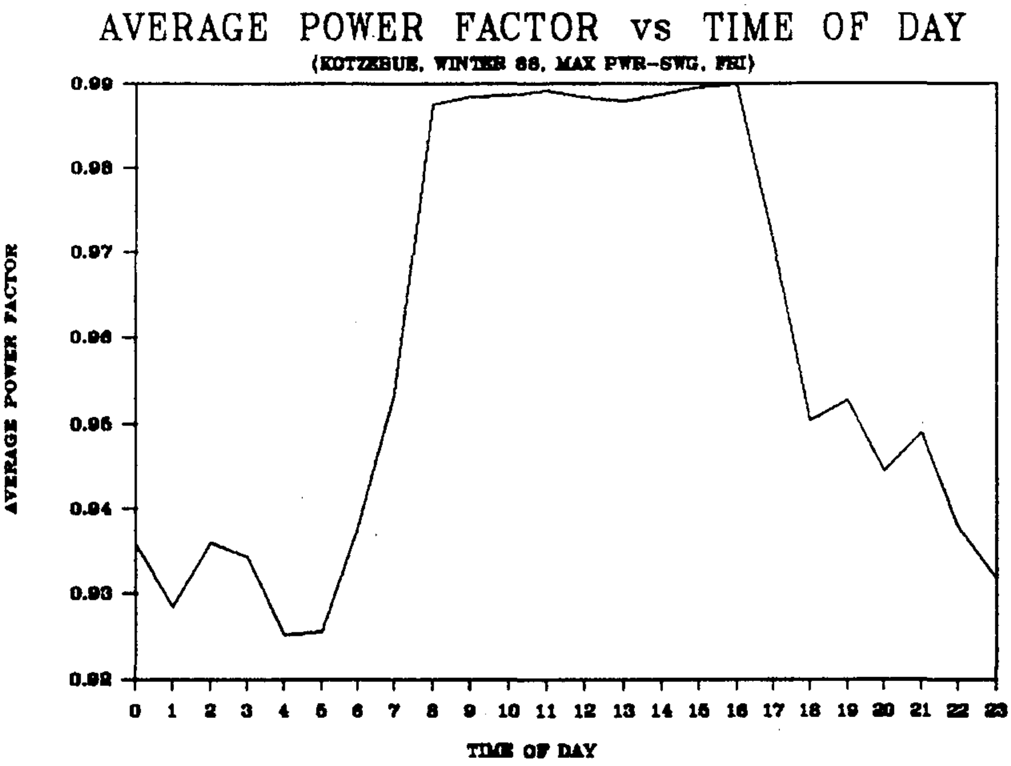


Figure K9

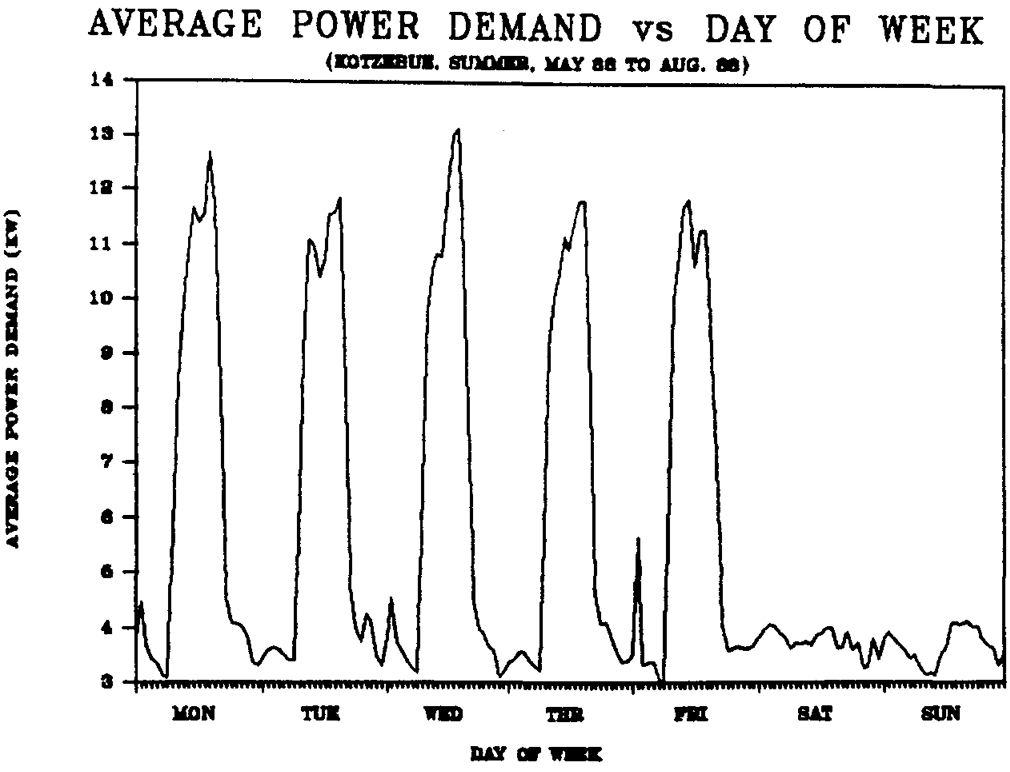


Figure K10

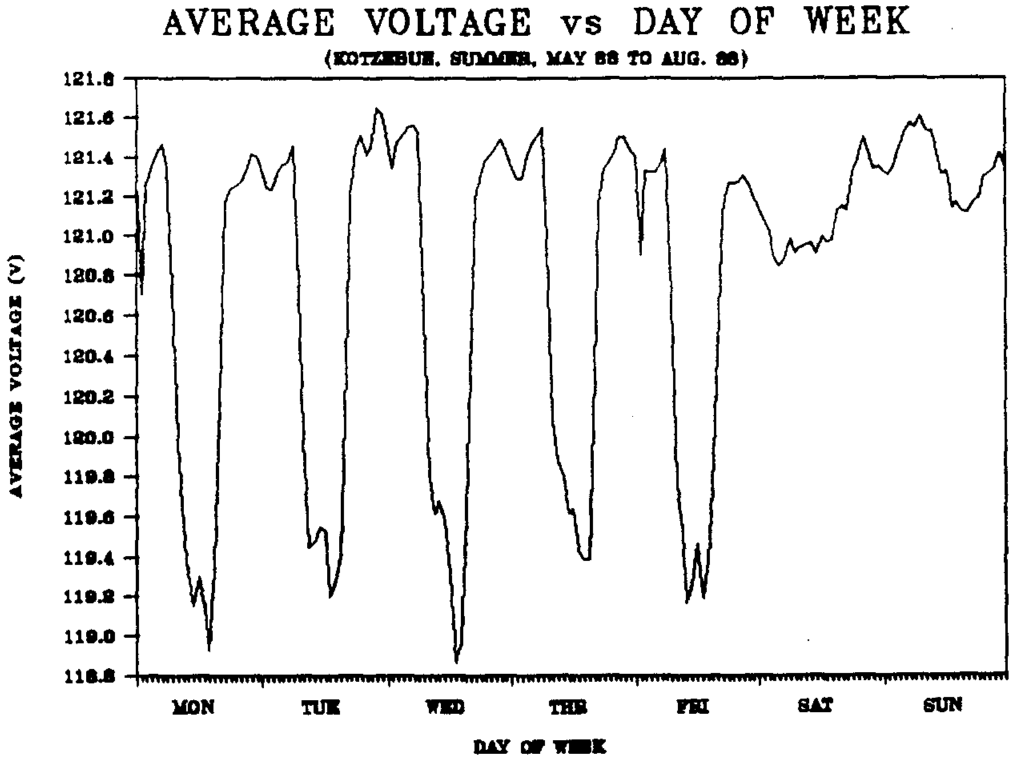


Figure K11

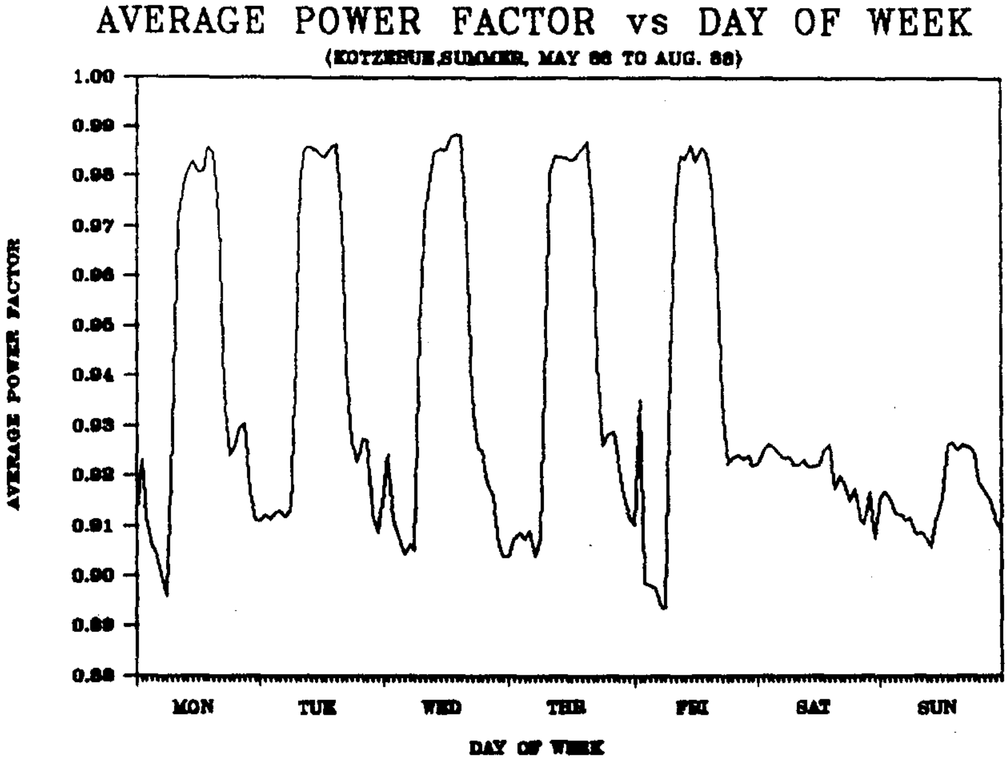


Figure K12

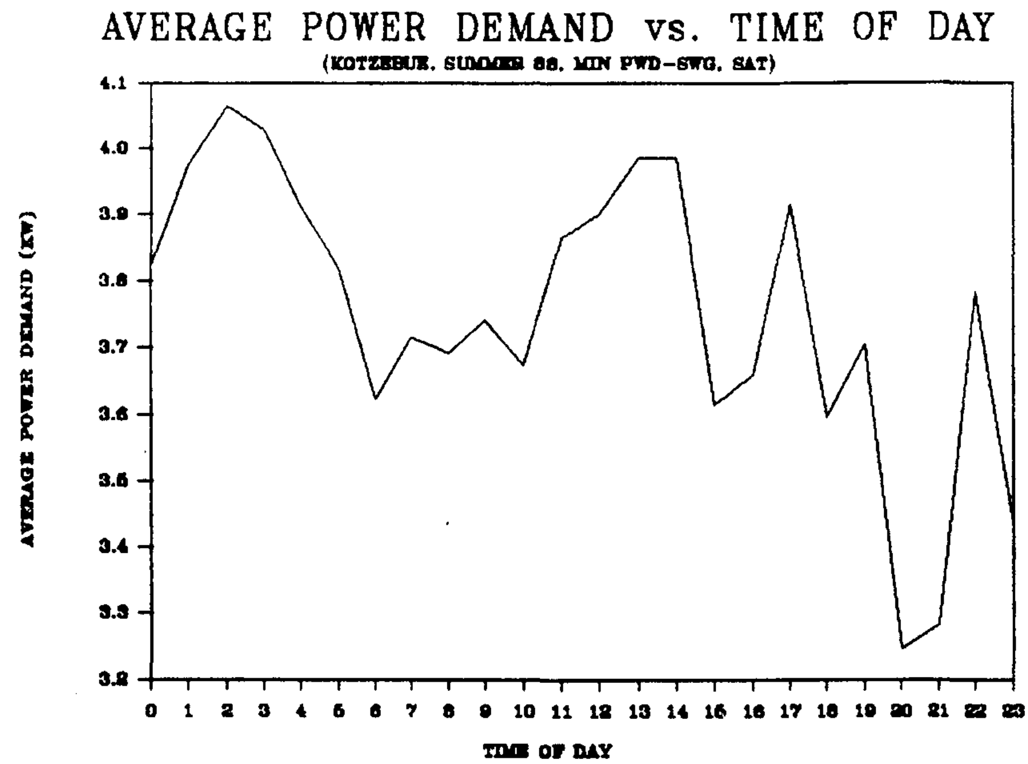


Figure K13

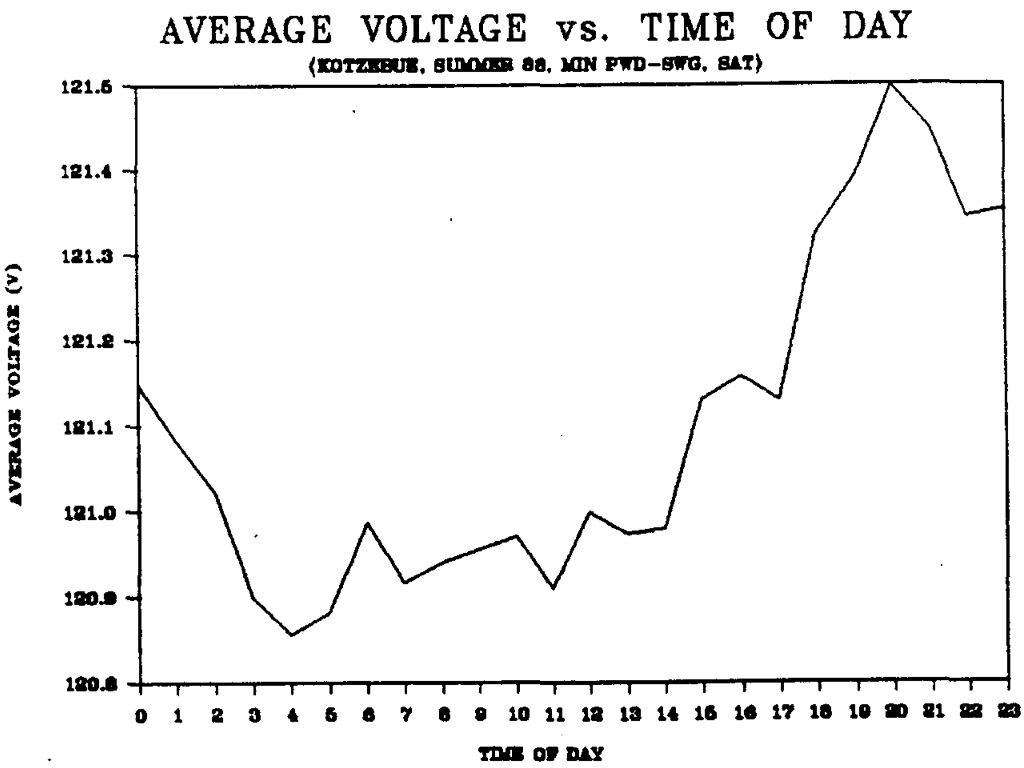


Figure K14

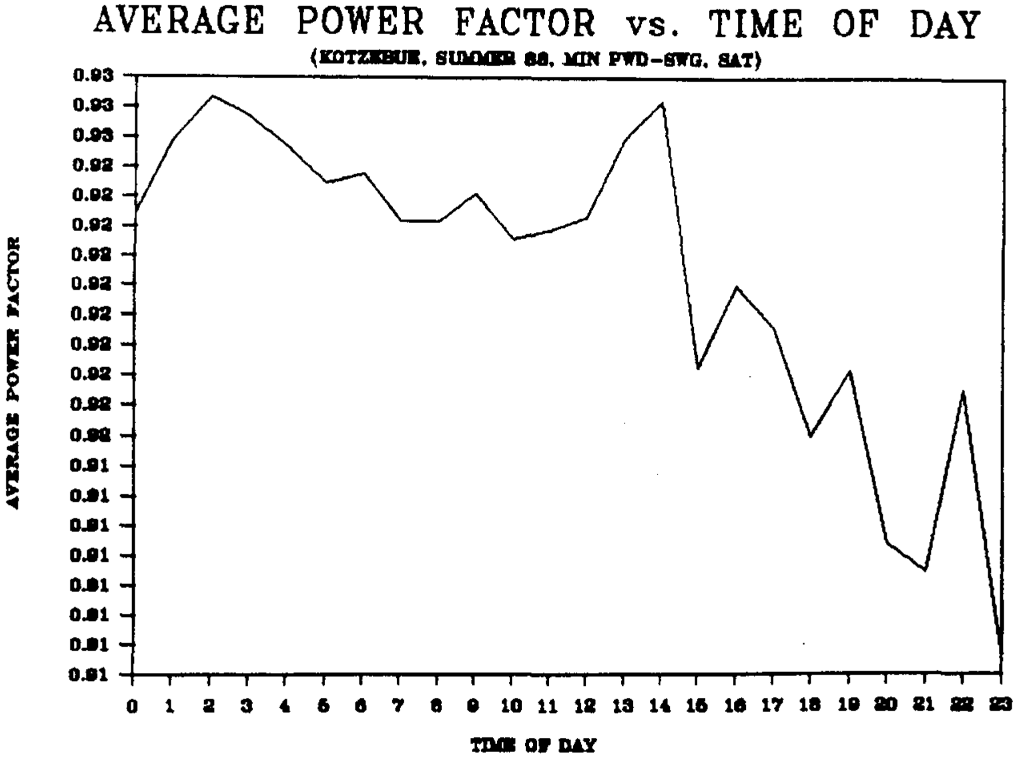


Figure K15

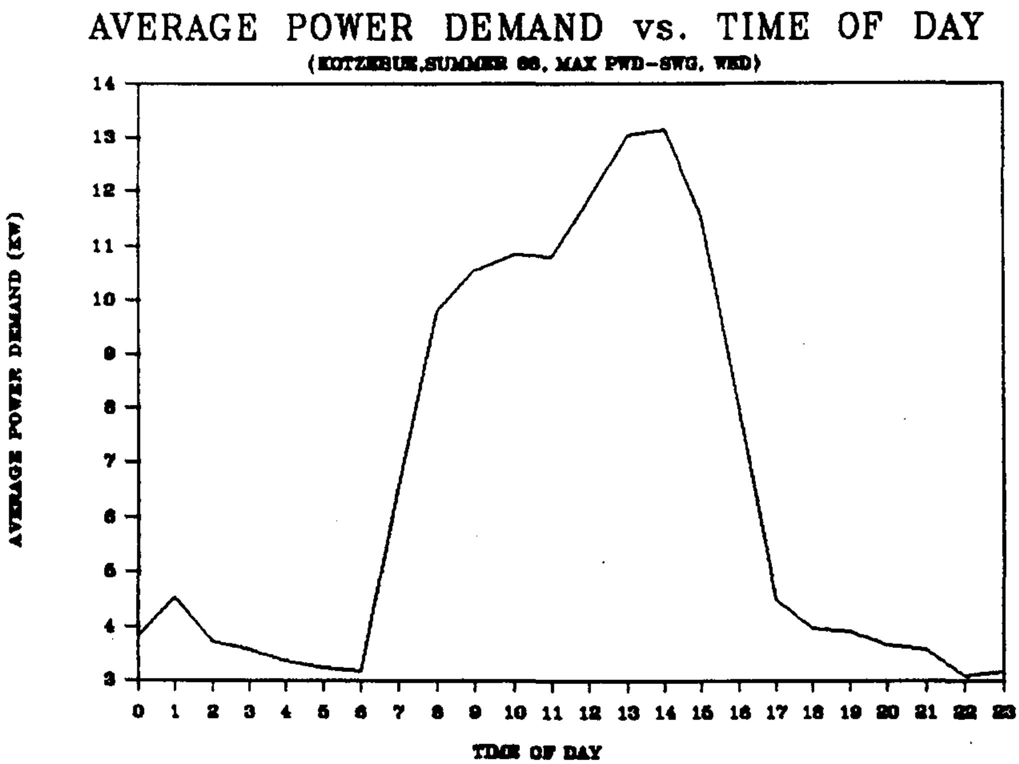


Figure K16

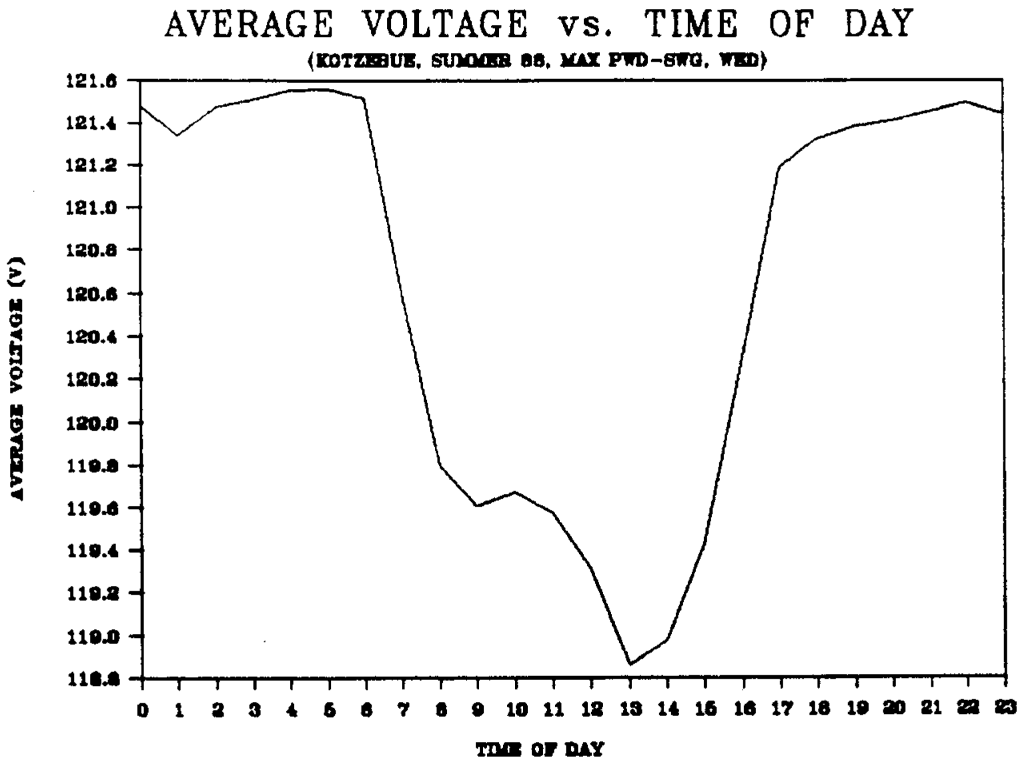


Figure K17

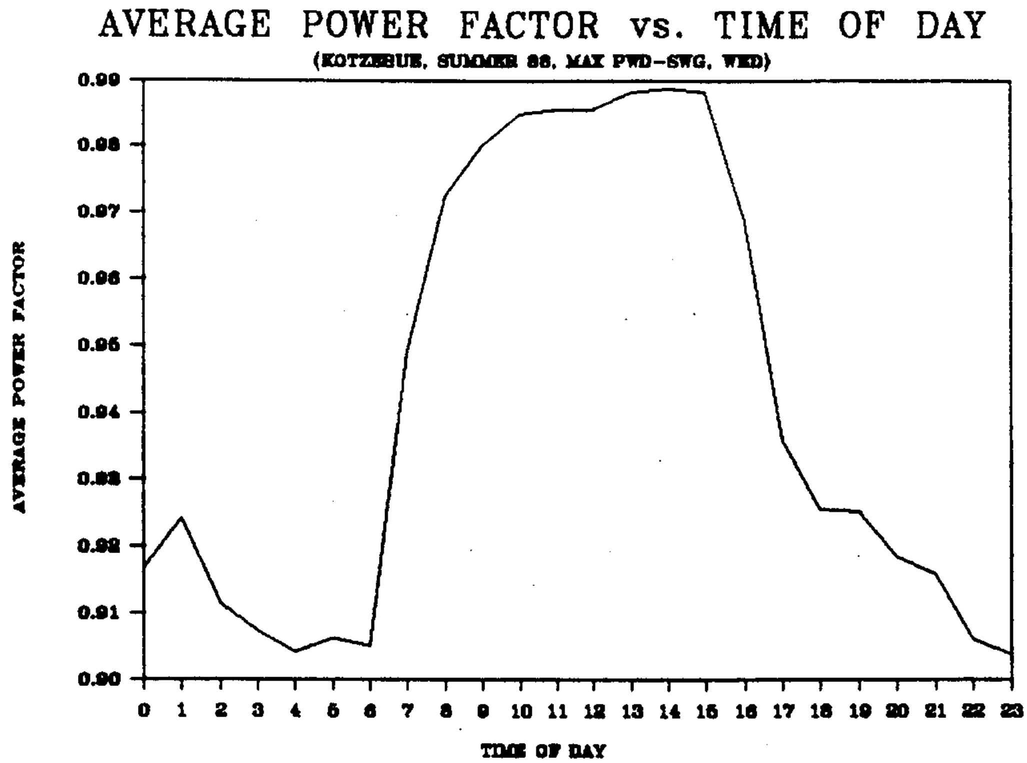


Figure K18

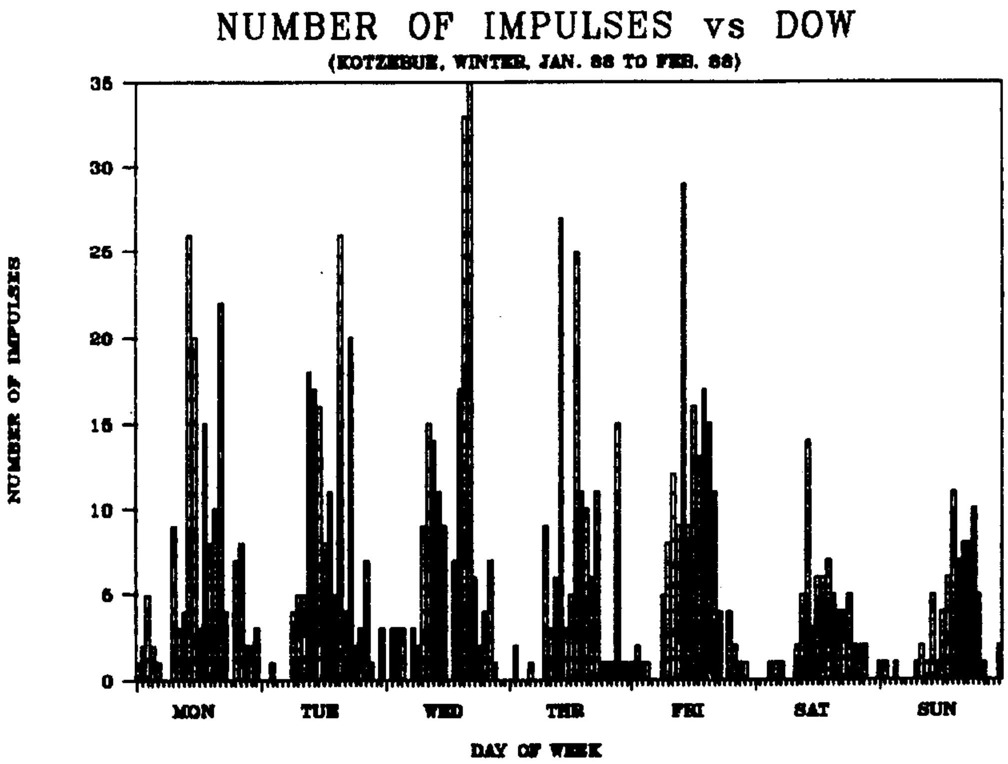


Figure K19

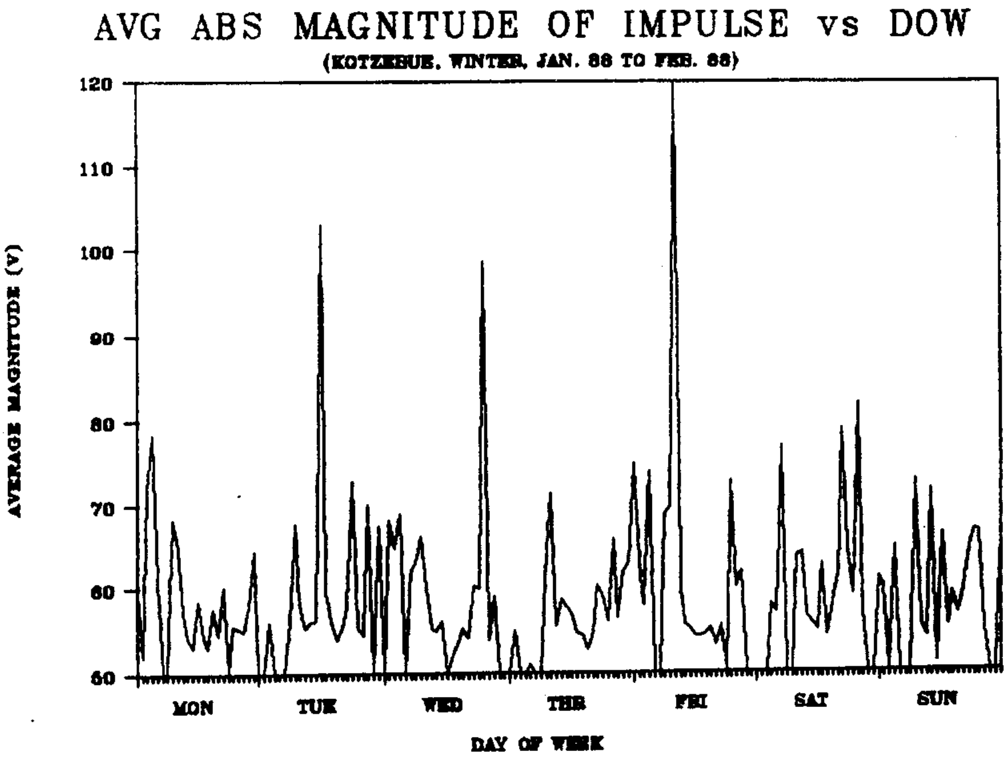


Figure K20

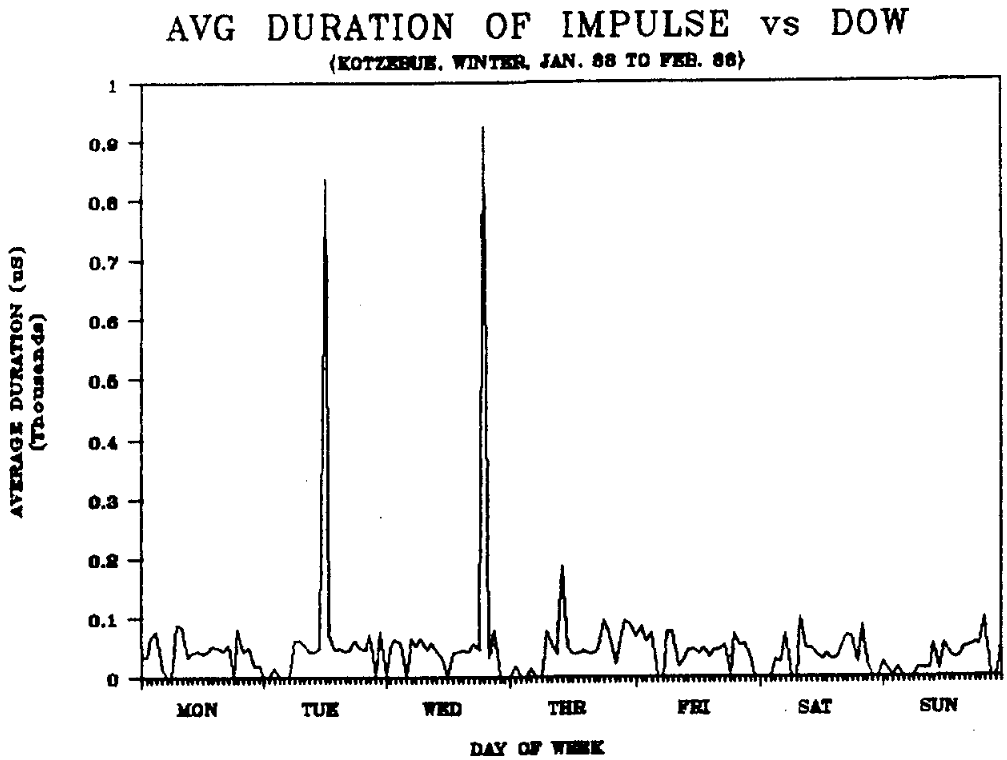


Figure K21

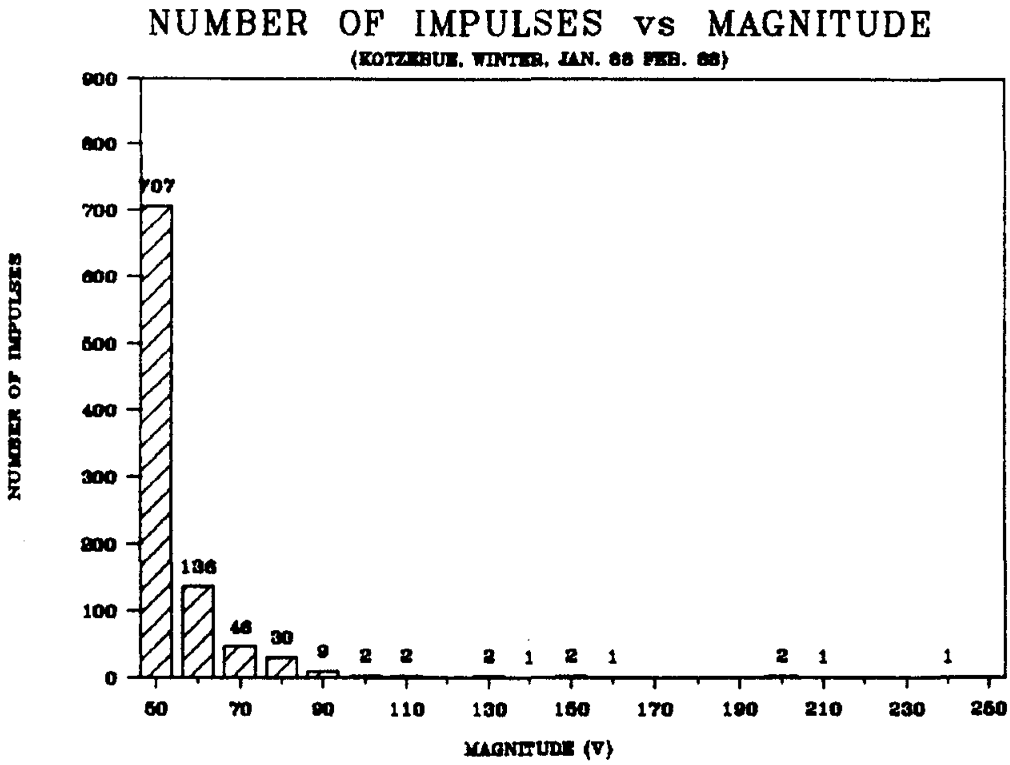


Figure K22

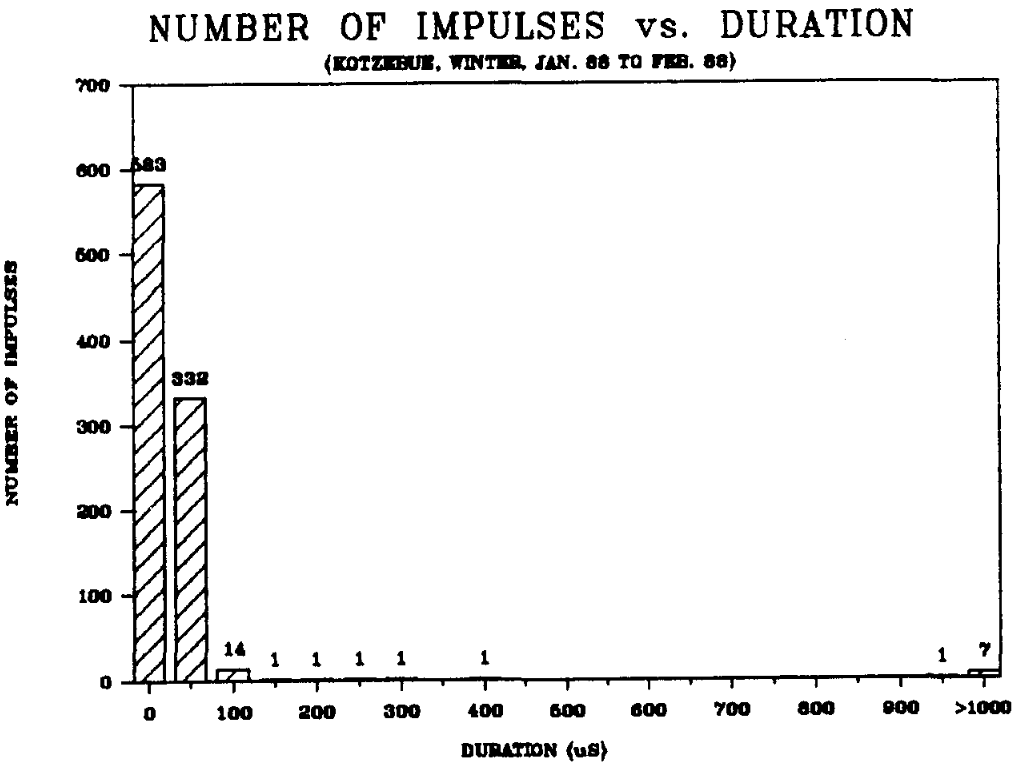


Figure K23

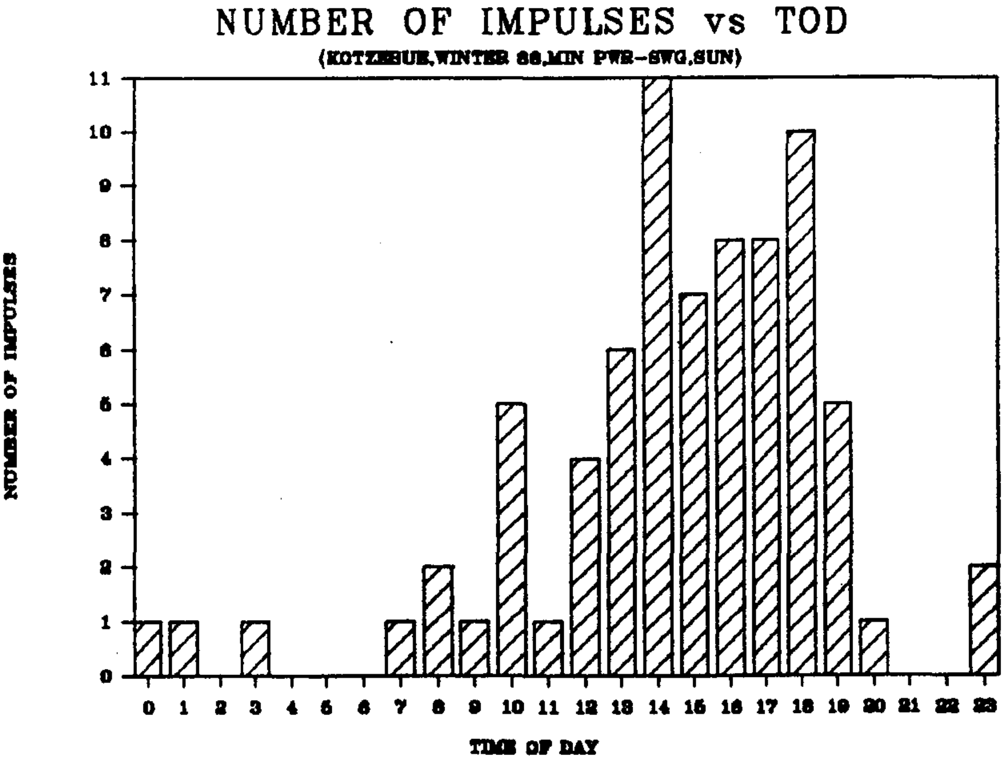


Figure K24

AVG ABS MAGNITUDE OF IMPULSE vs TOD

(KOTZEBUE,WINTER 88,MIN PWR-SWG,SUN)

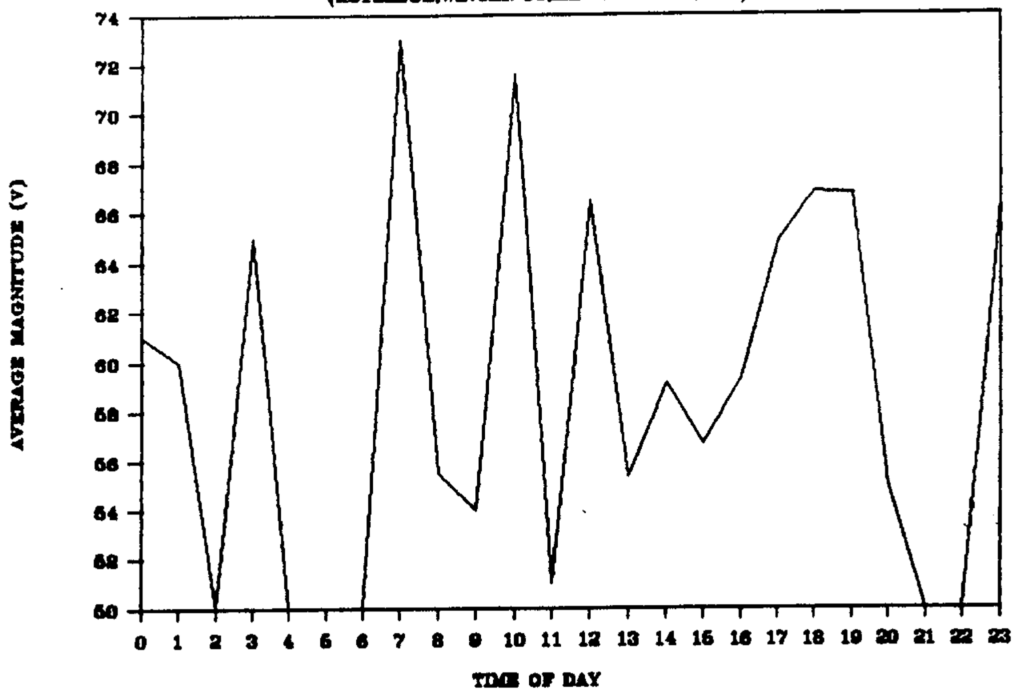


Figure K25

AVERAGE DURATION OF IMPULSE vs TOD

(KOTZEBUE,WINTER 88,MIN PWR-SWG,SUN)

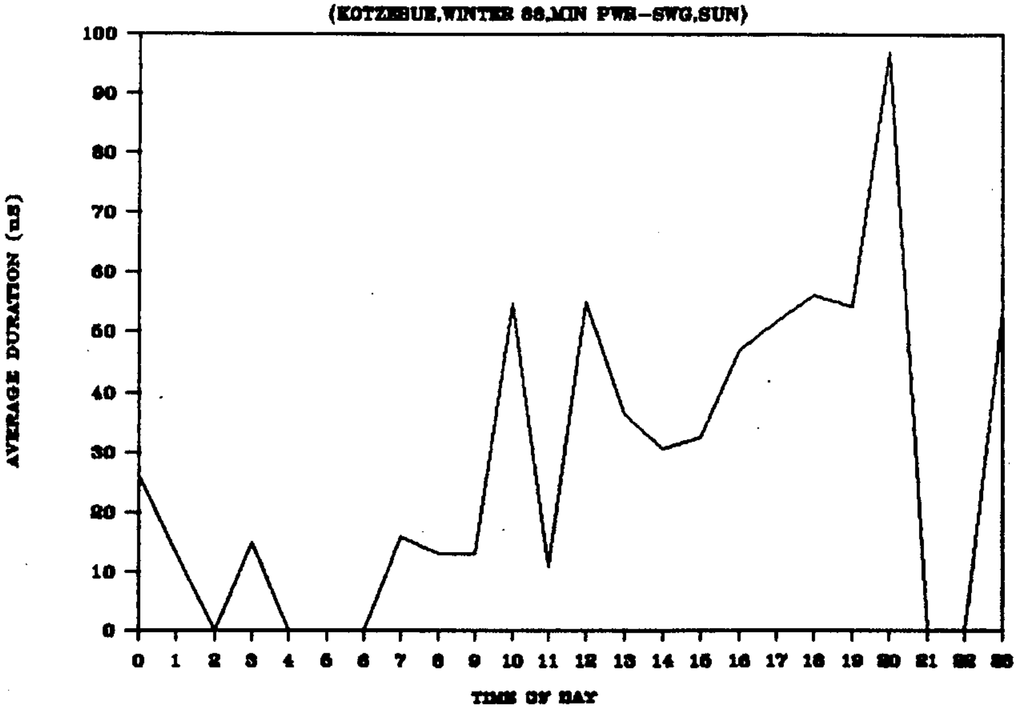


Figure K26

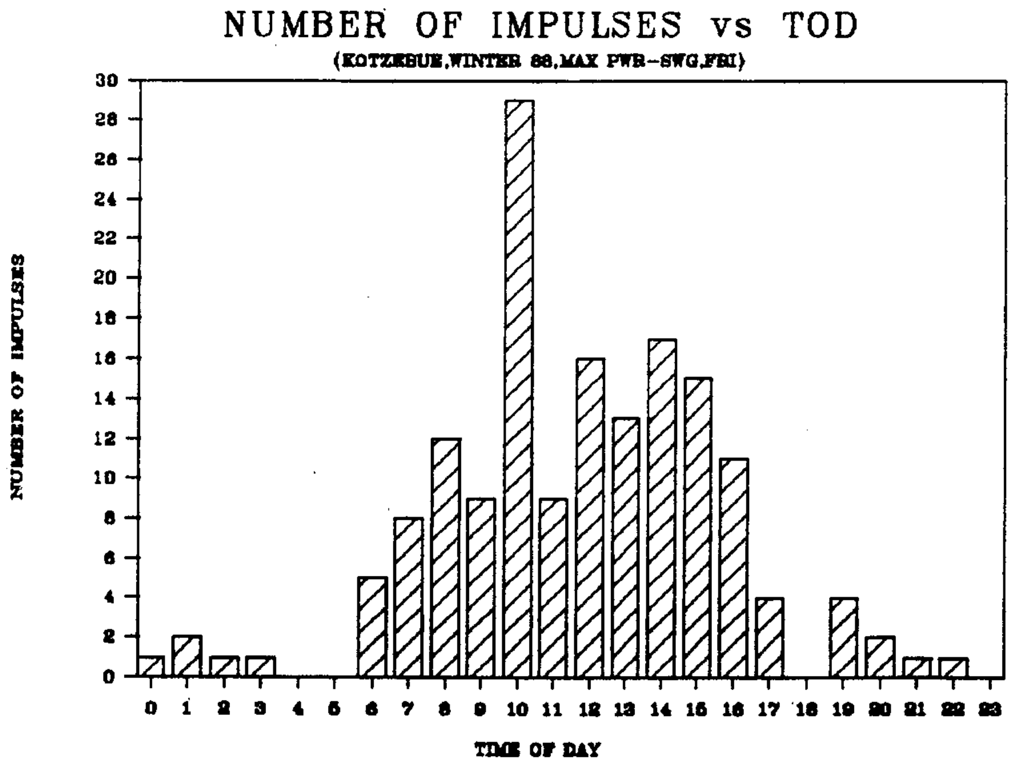


Figure K27

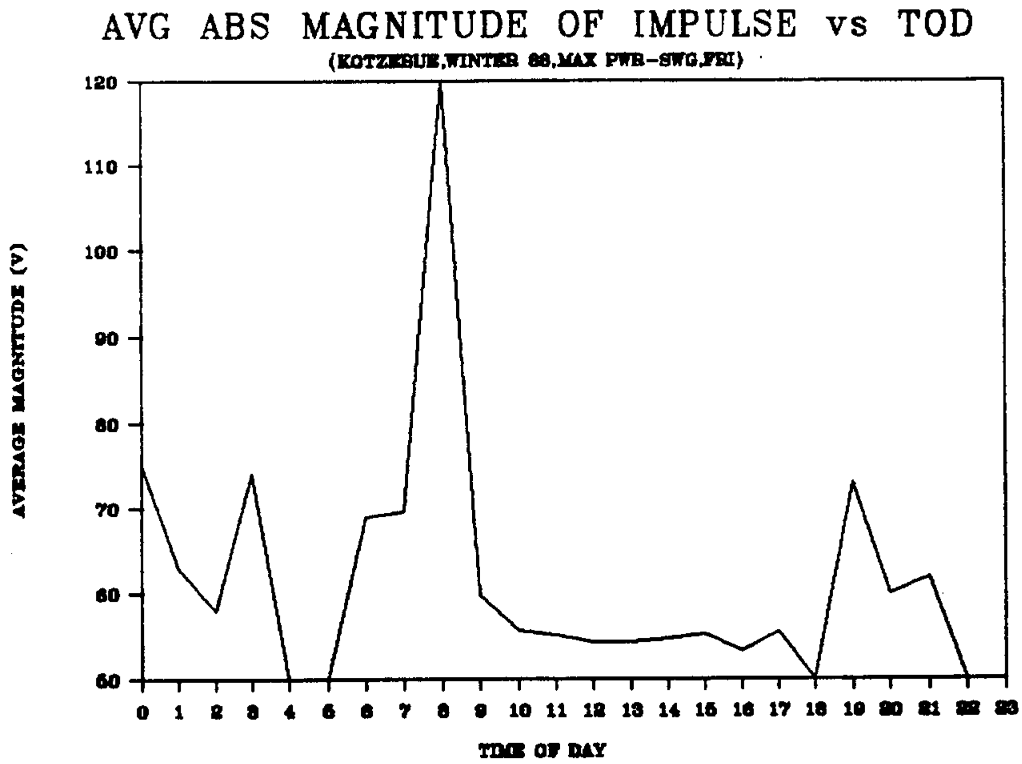


Figure K28

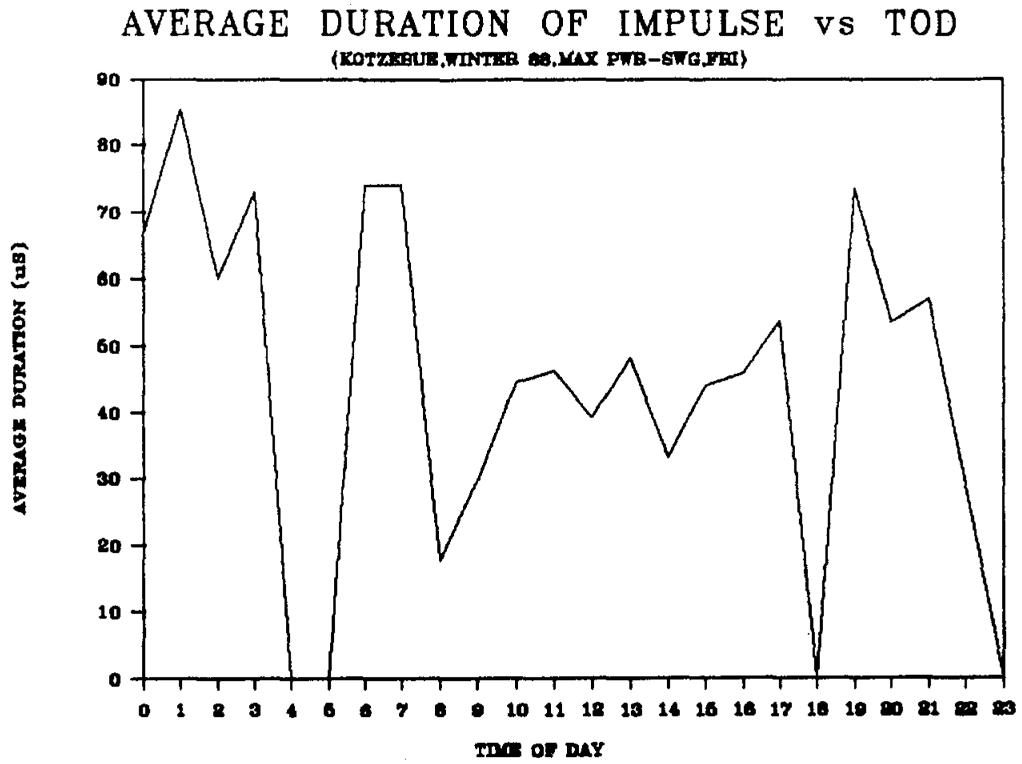


Figure K29

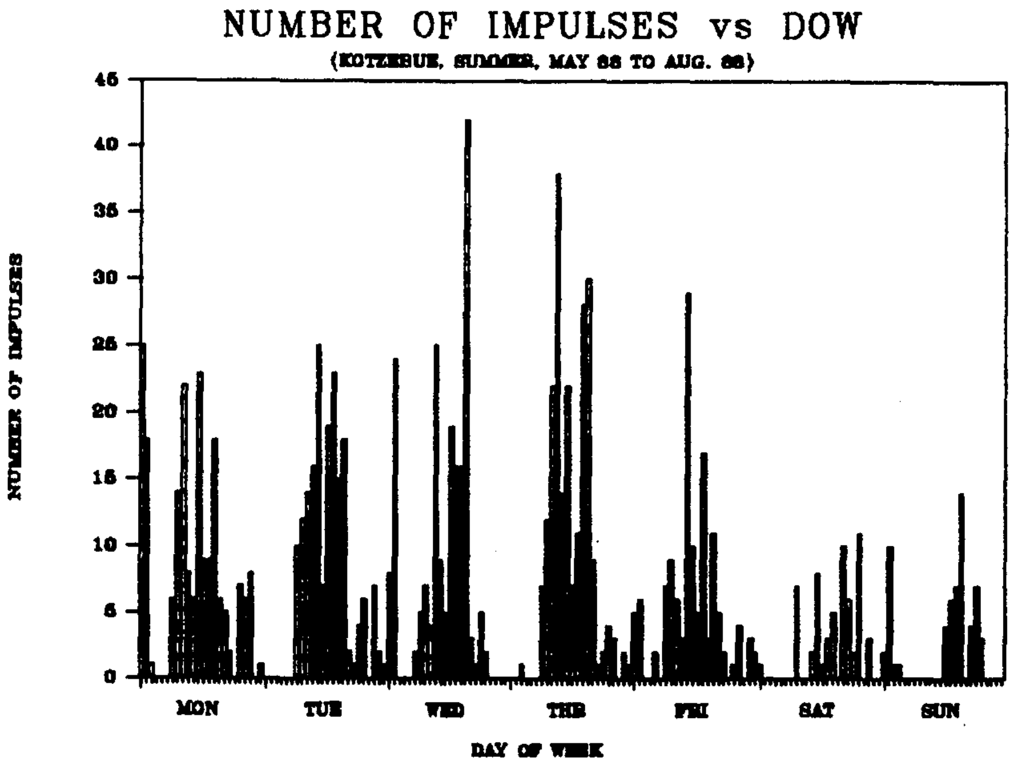


Figure K30

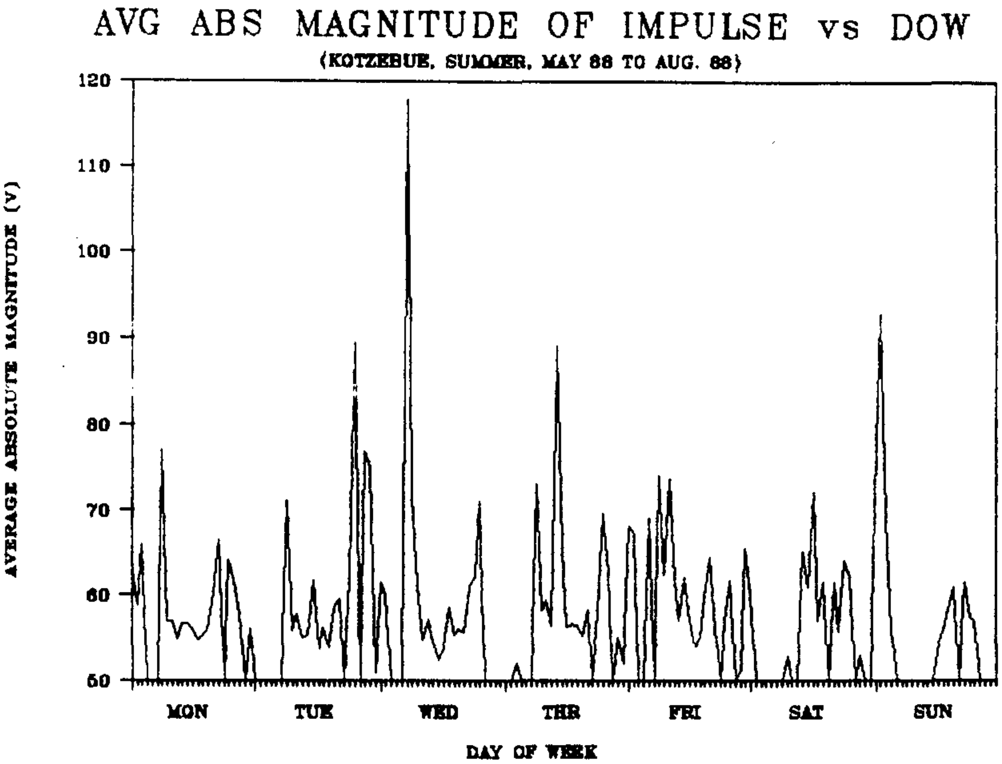


Figure K31

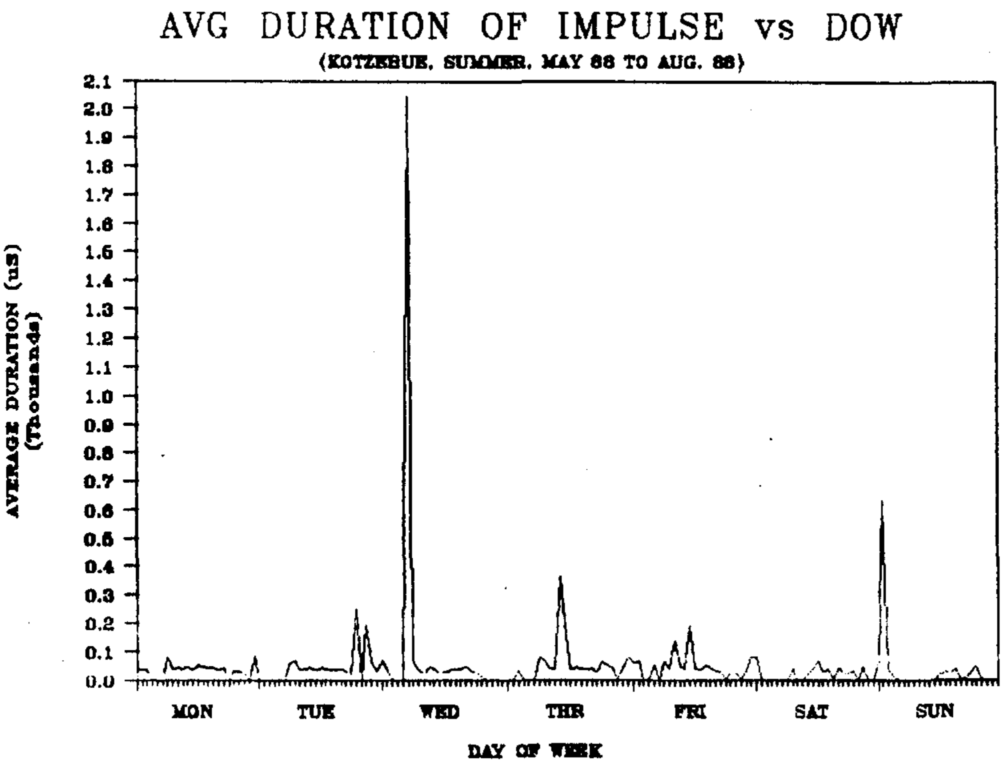


Figure K32

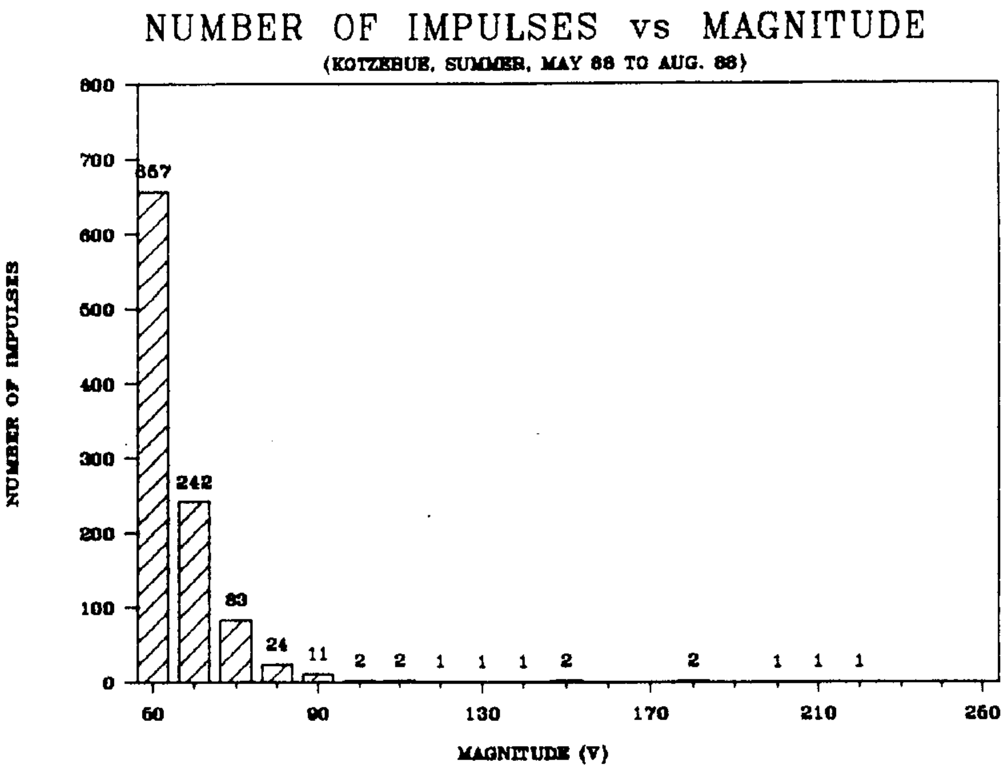


Figure K33

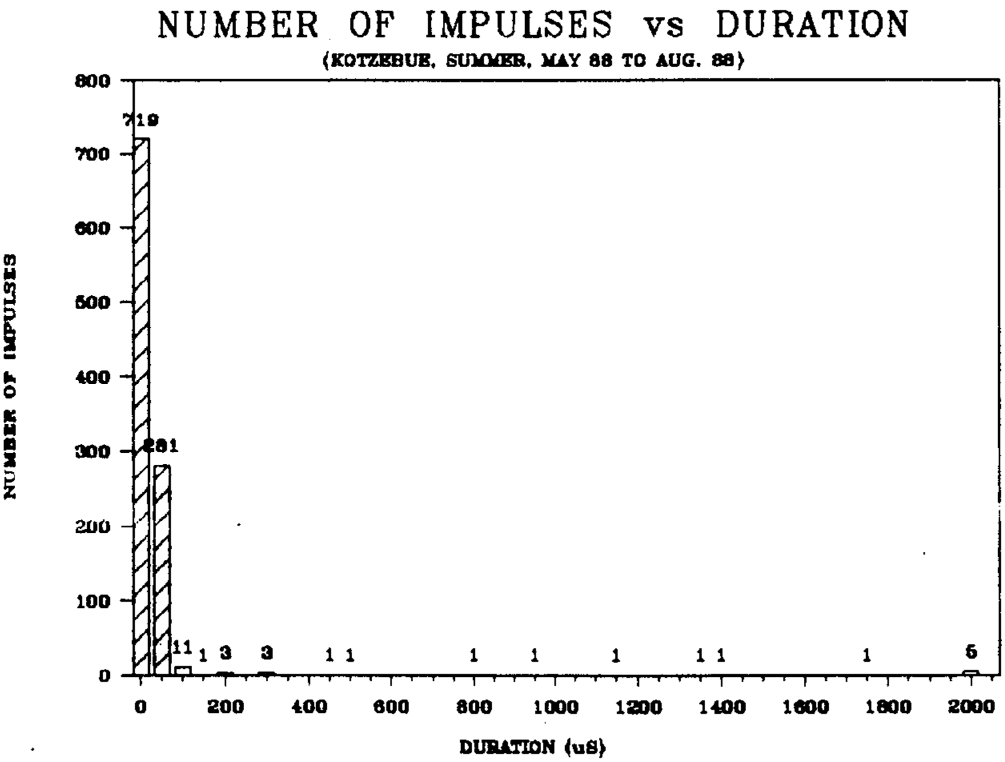


Figure K34

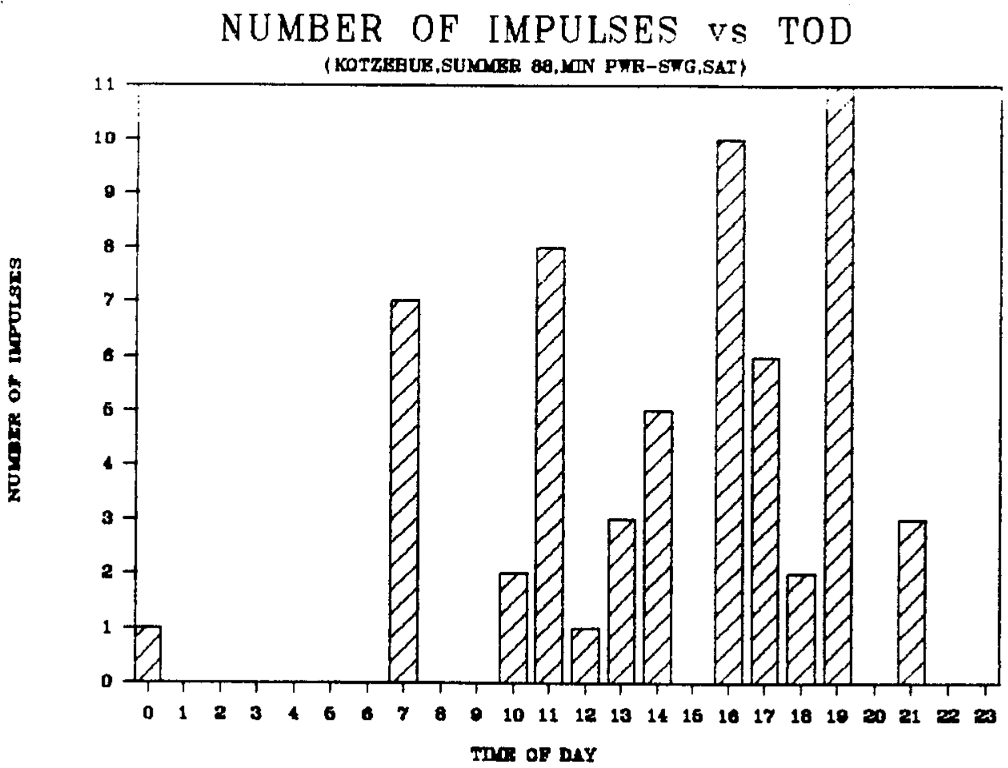


Figure K35

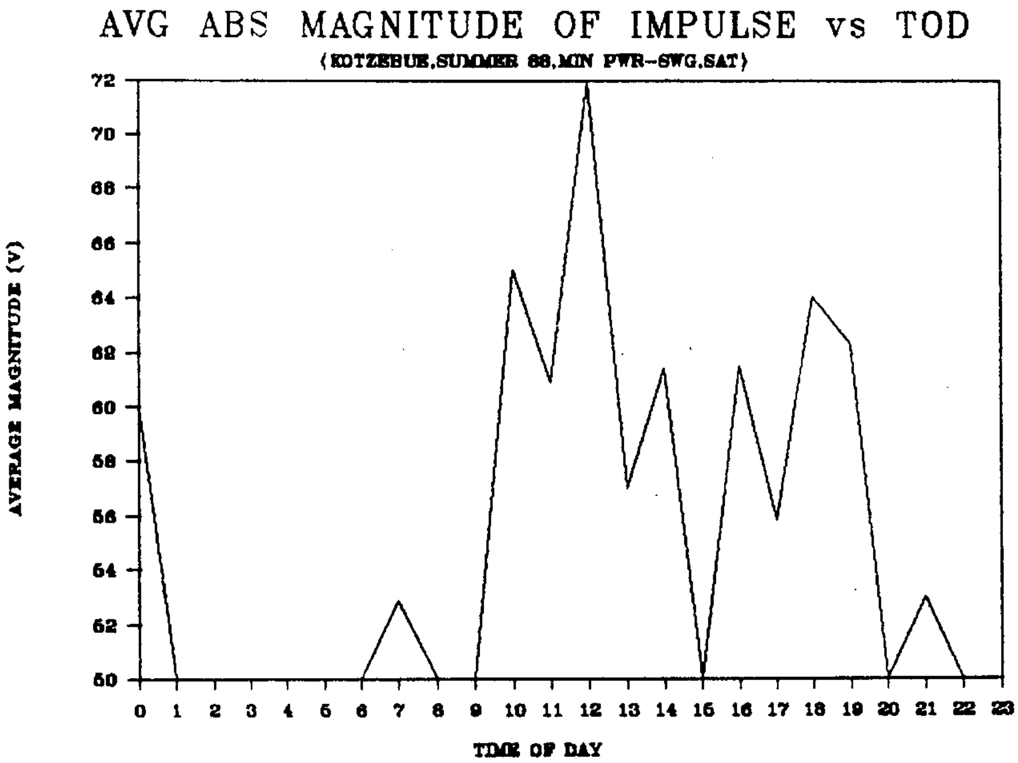


Figure K36

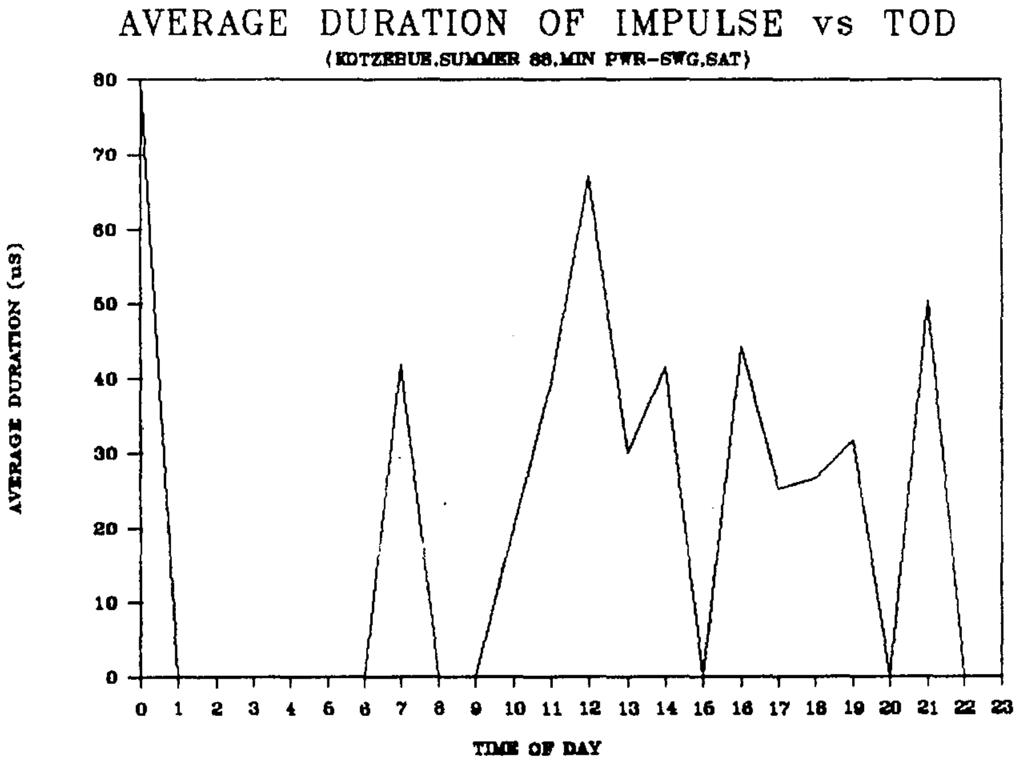


Figure K37

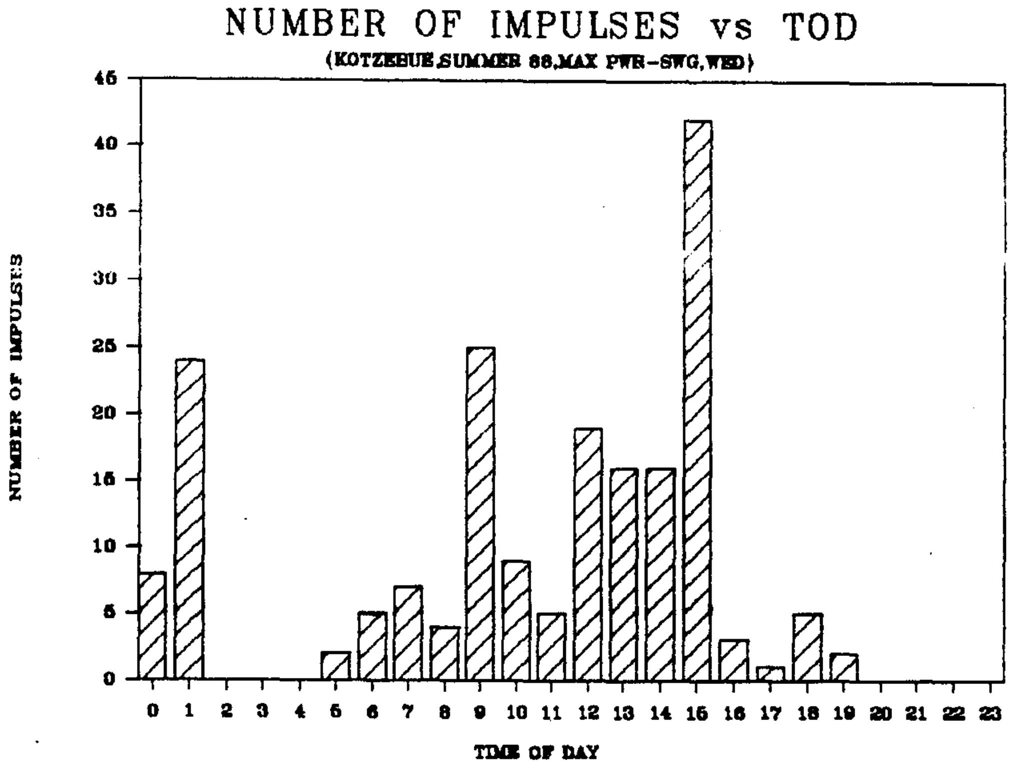


Figure K38

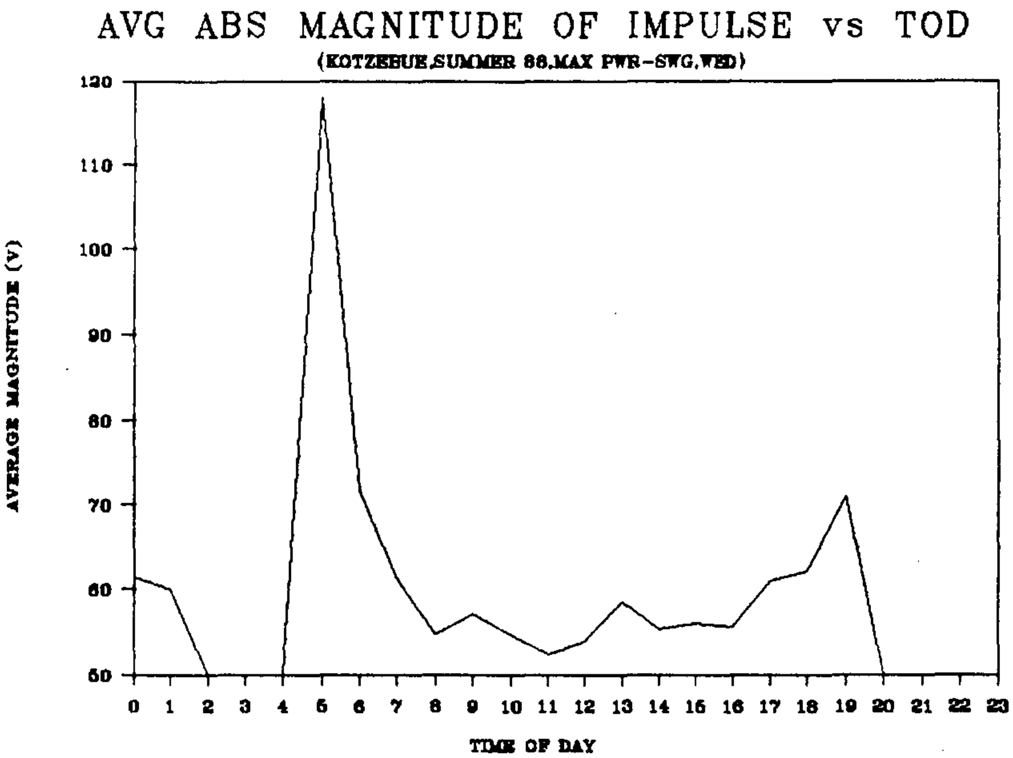


Figure K39

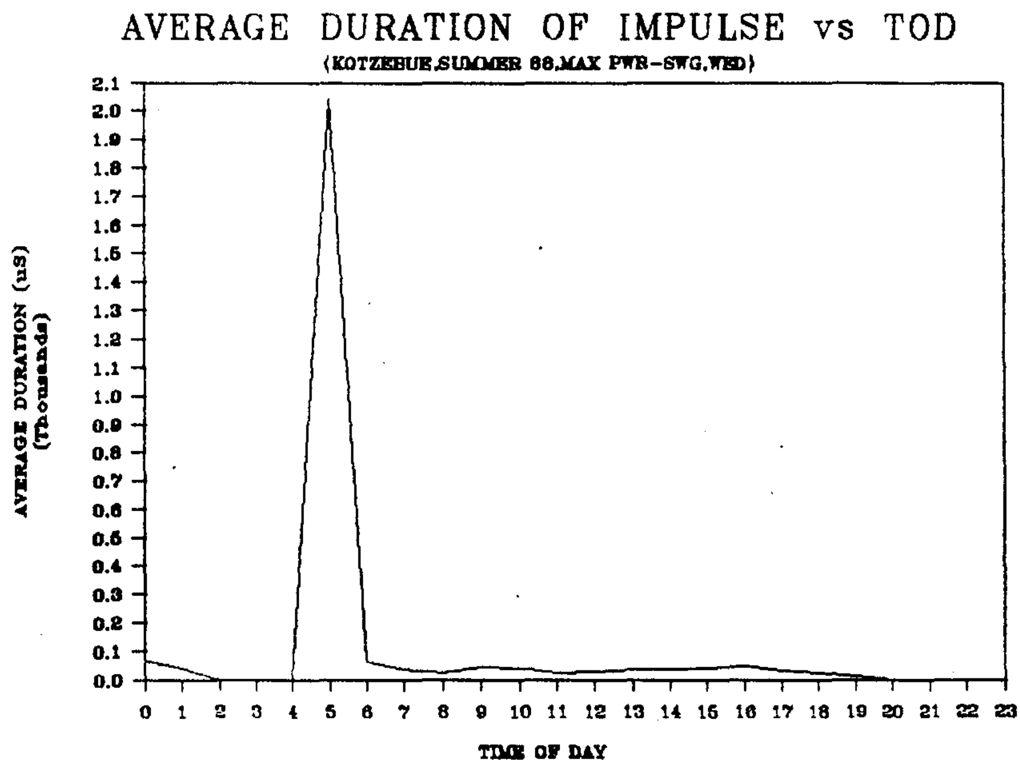


Figure K40

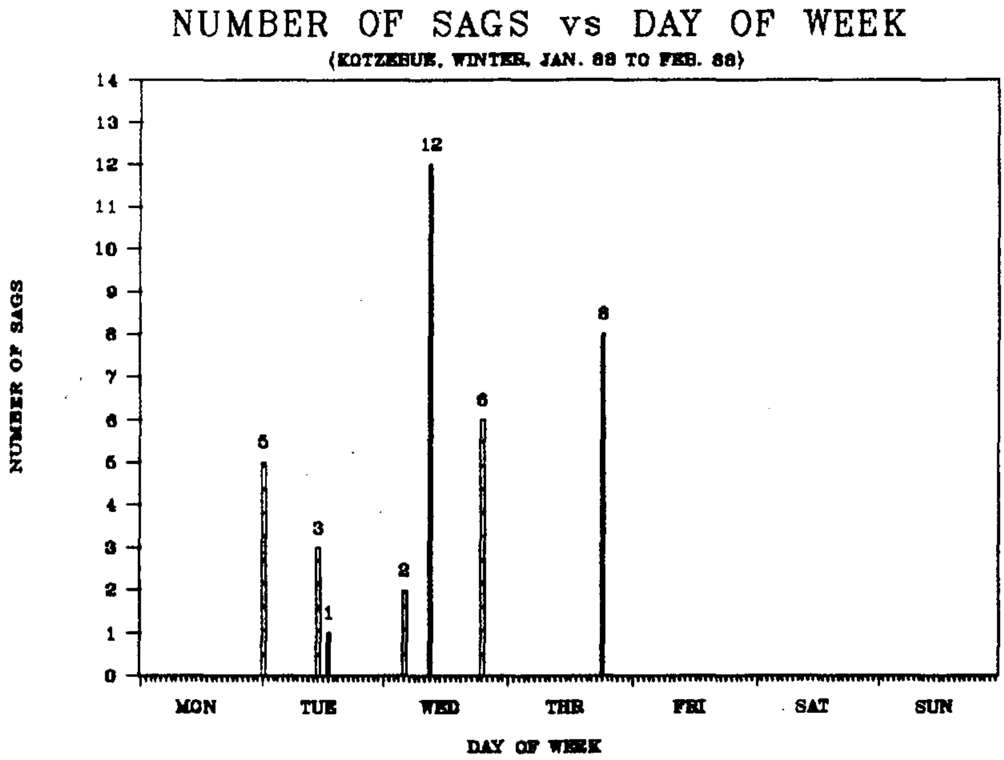


Figure K41

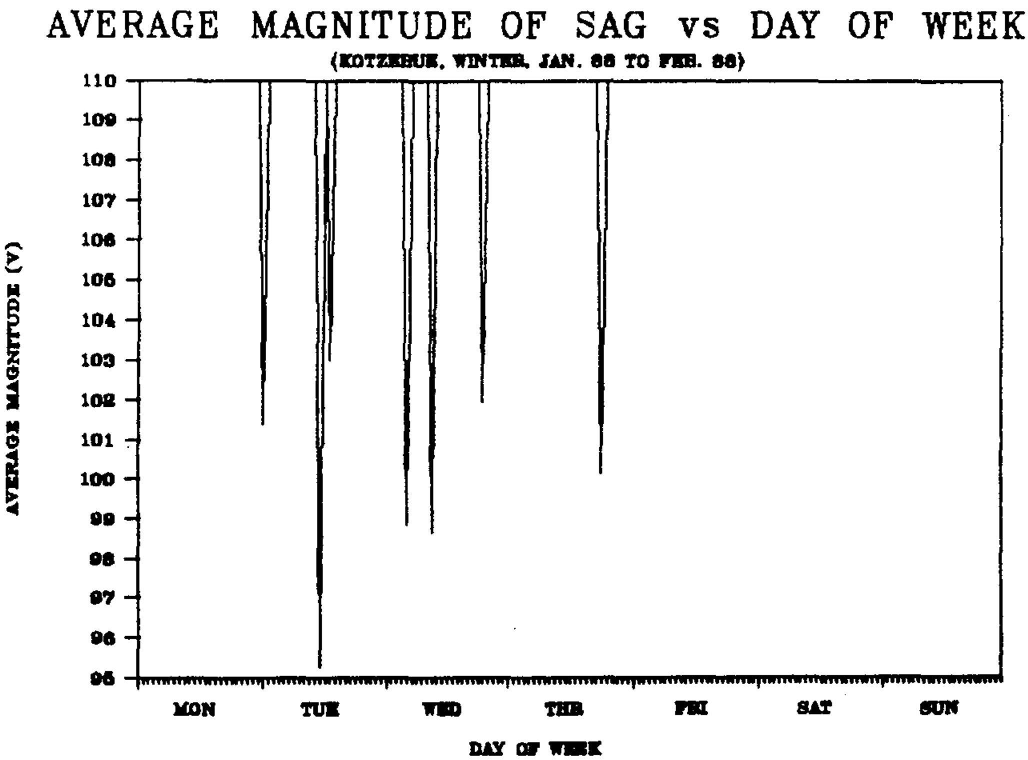


Figure K42

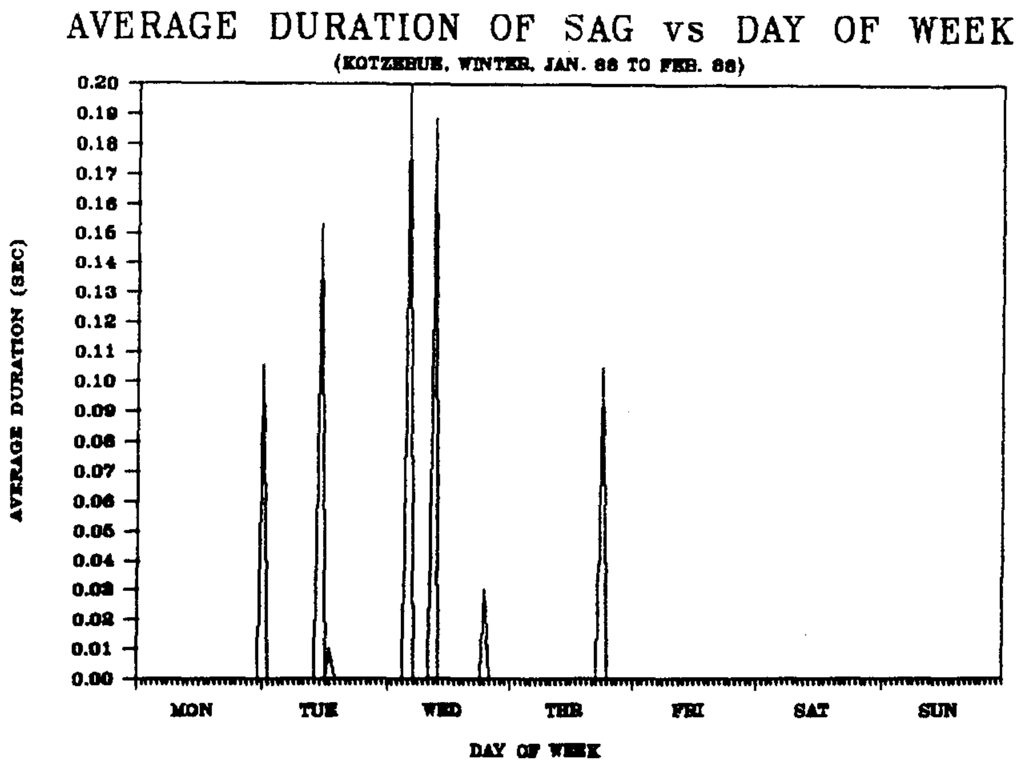


Figure K43

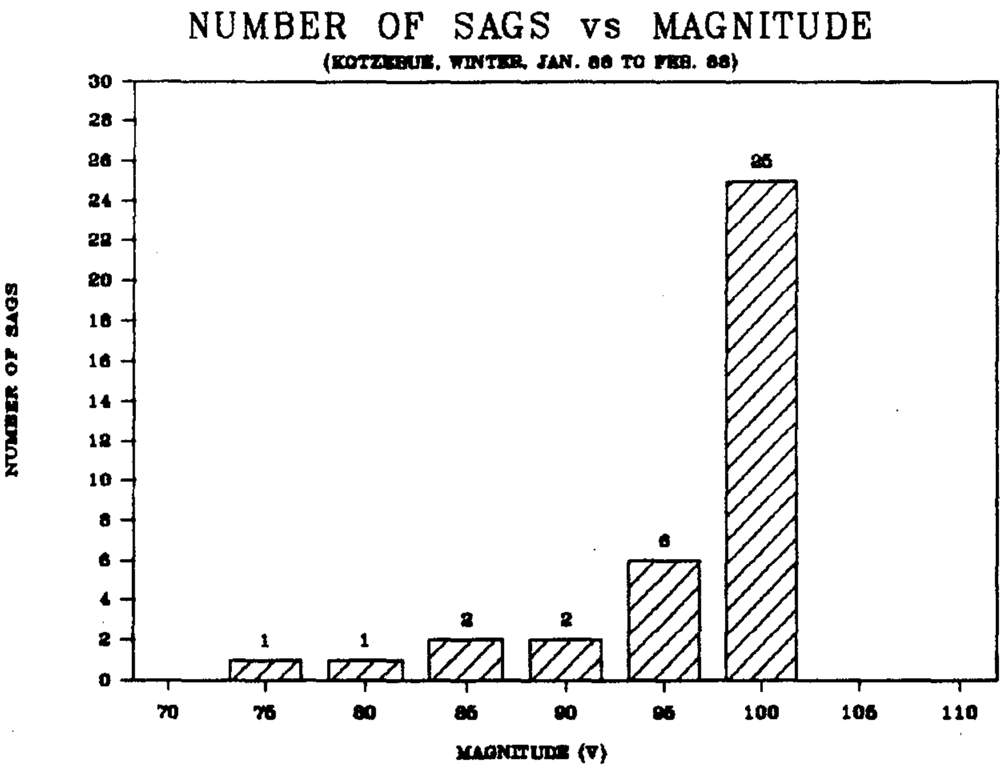


Figure K44

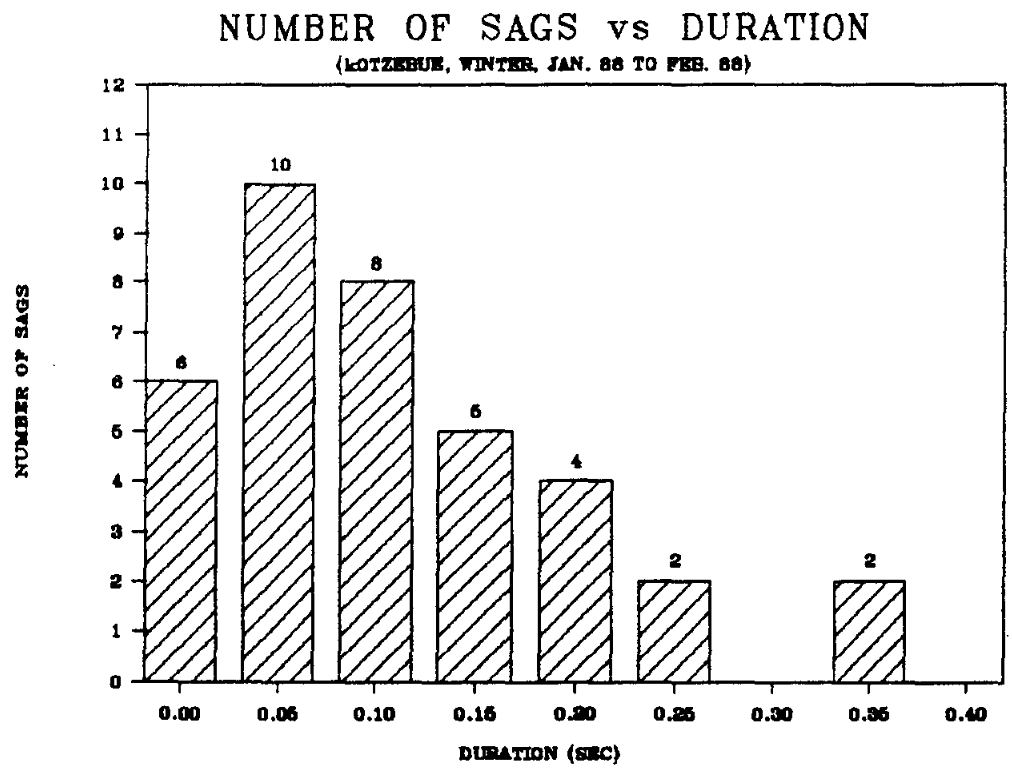


Figure K45

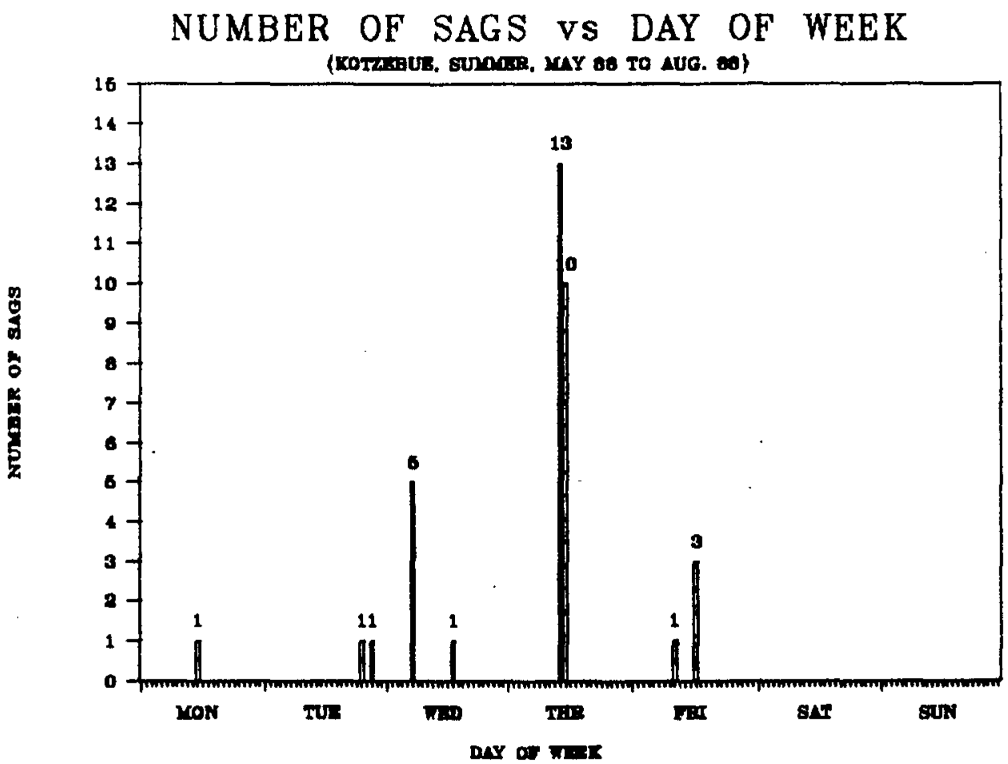


Figure K46

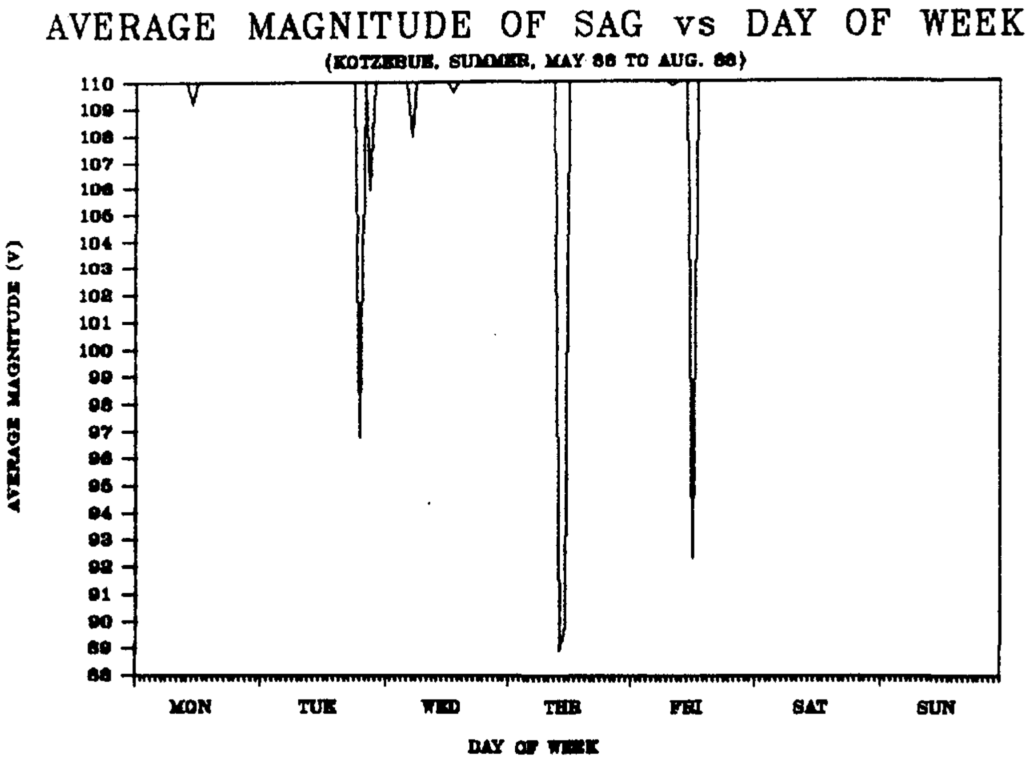


Figure K47

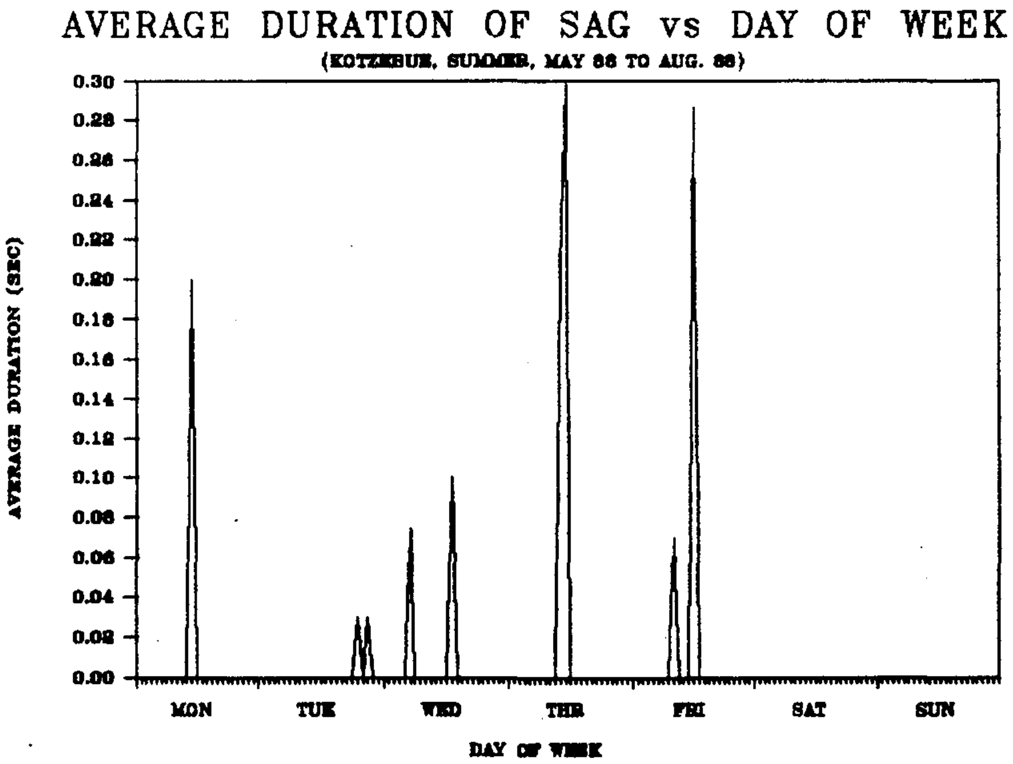


Figure K48

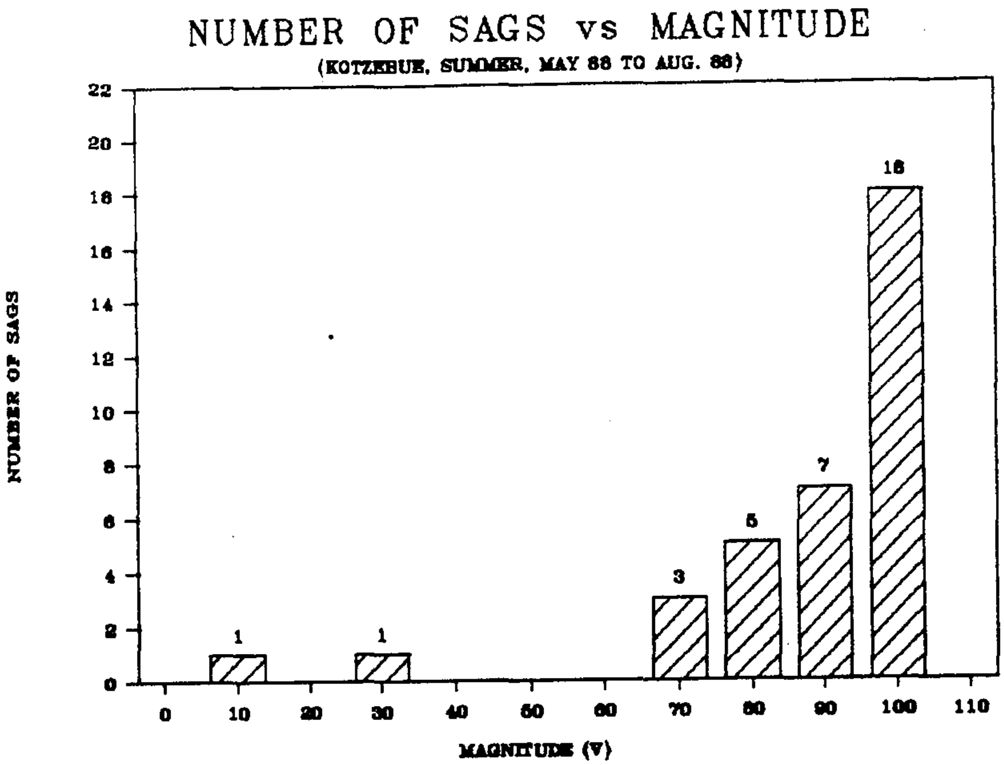


Figure K49

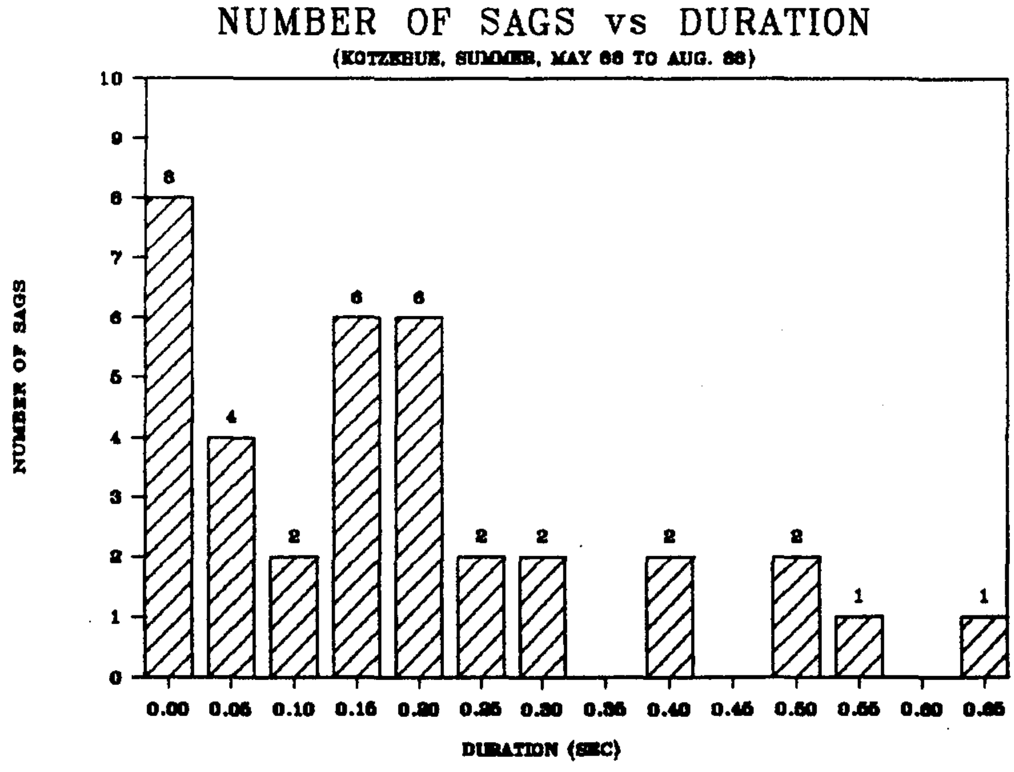


Figure K50

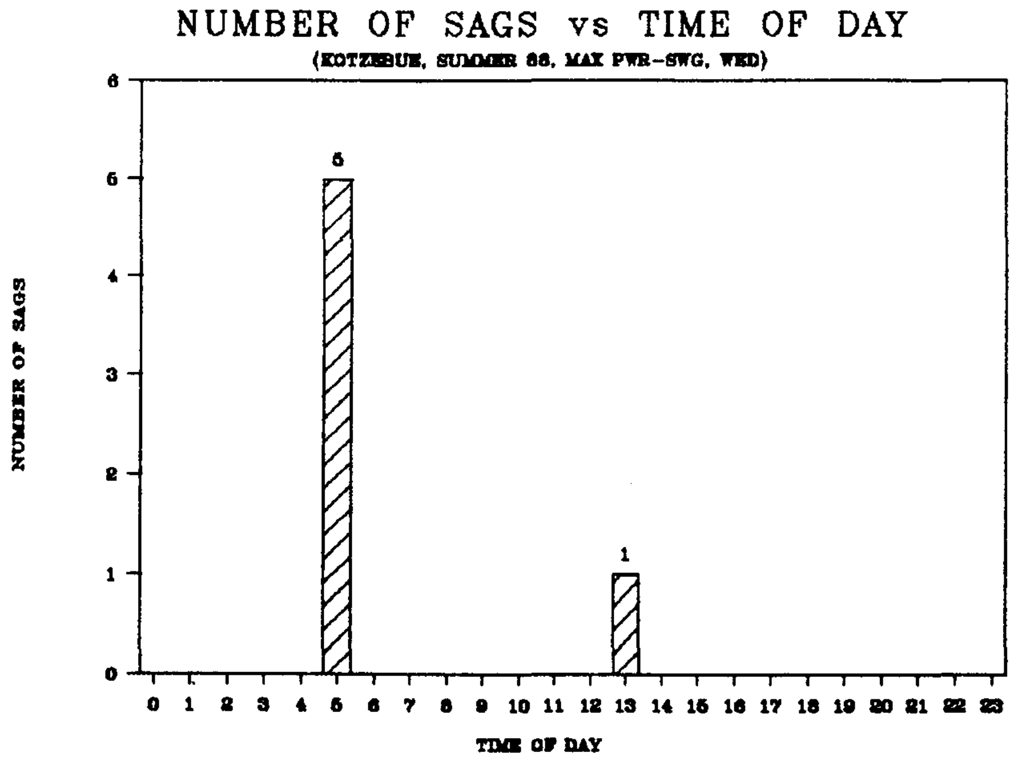


Figure K51

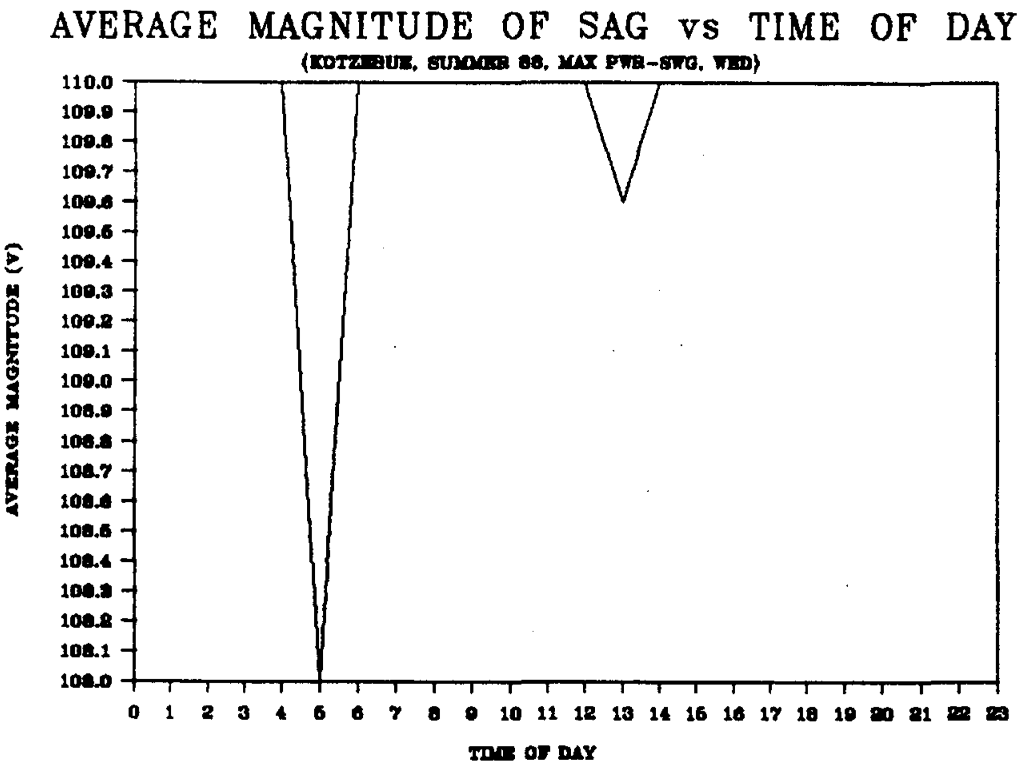


Figure K52

AVERAGE DURATION OF SAG vs TIME OF DAY

(KOTZEBUE, SUMMER 88, MAX PWR-SWG, WED)

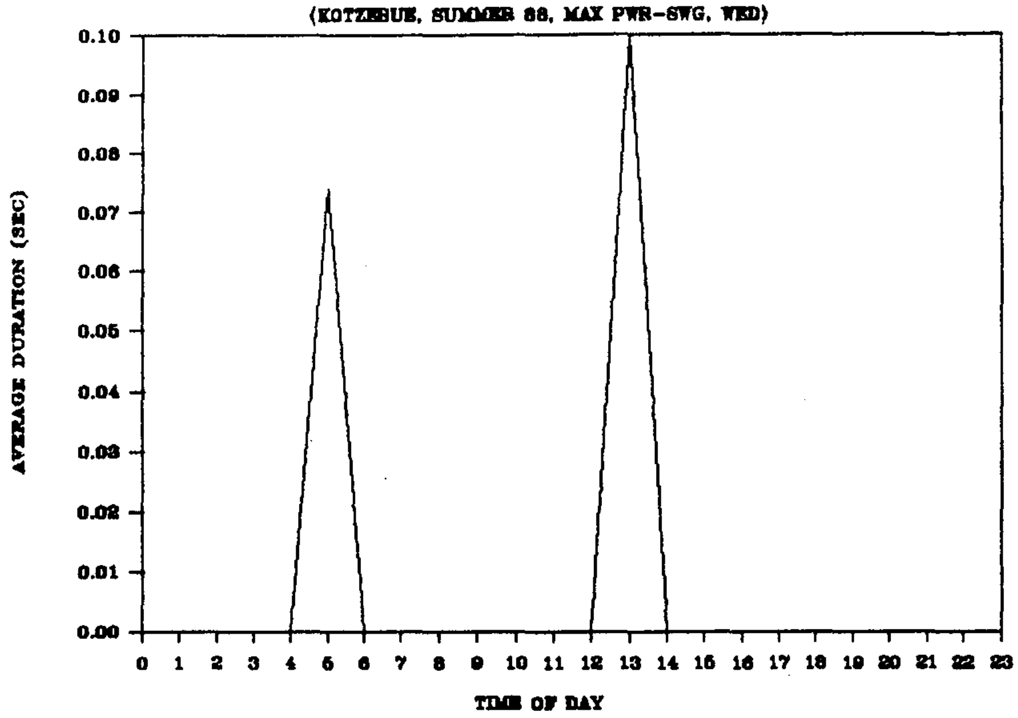


Figure K53

NUMBER OF SURGES vs DAY OF WEEK

(KOTZEBUE, WINTER, JAN. 88 TO FEB. 88)

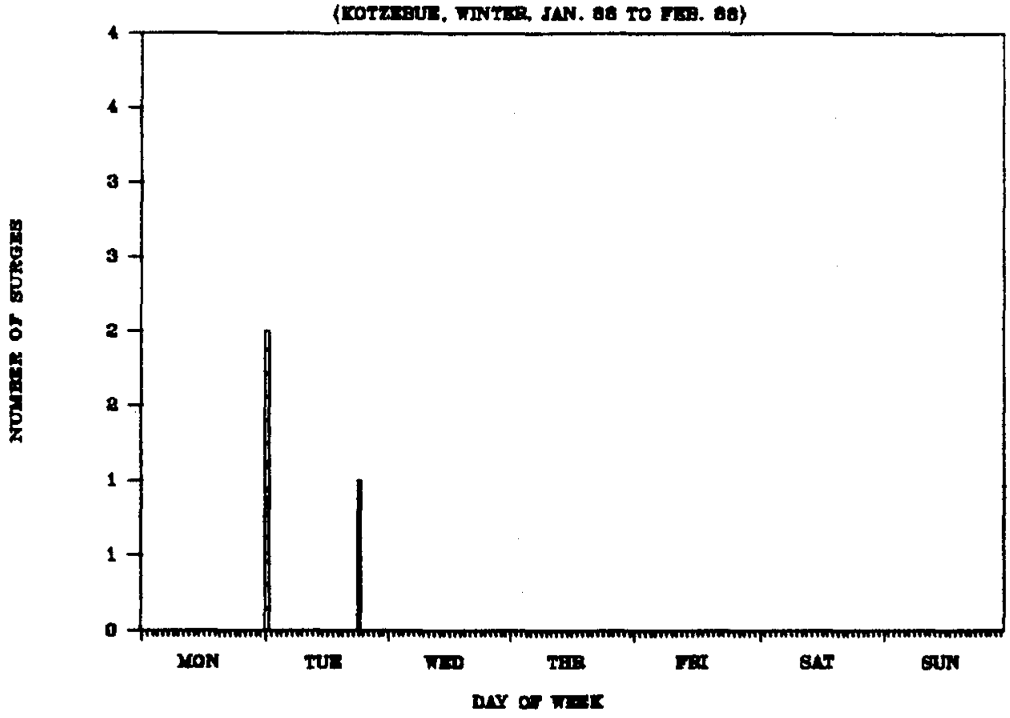


Figure K54

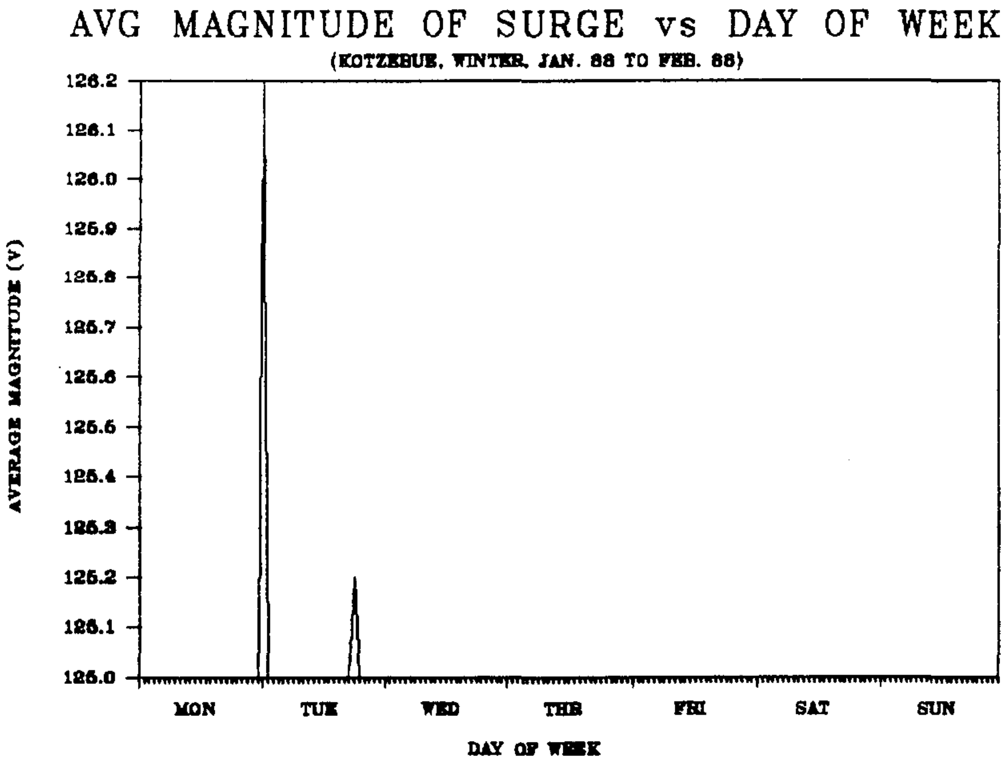


Figure K55

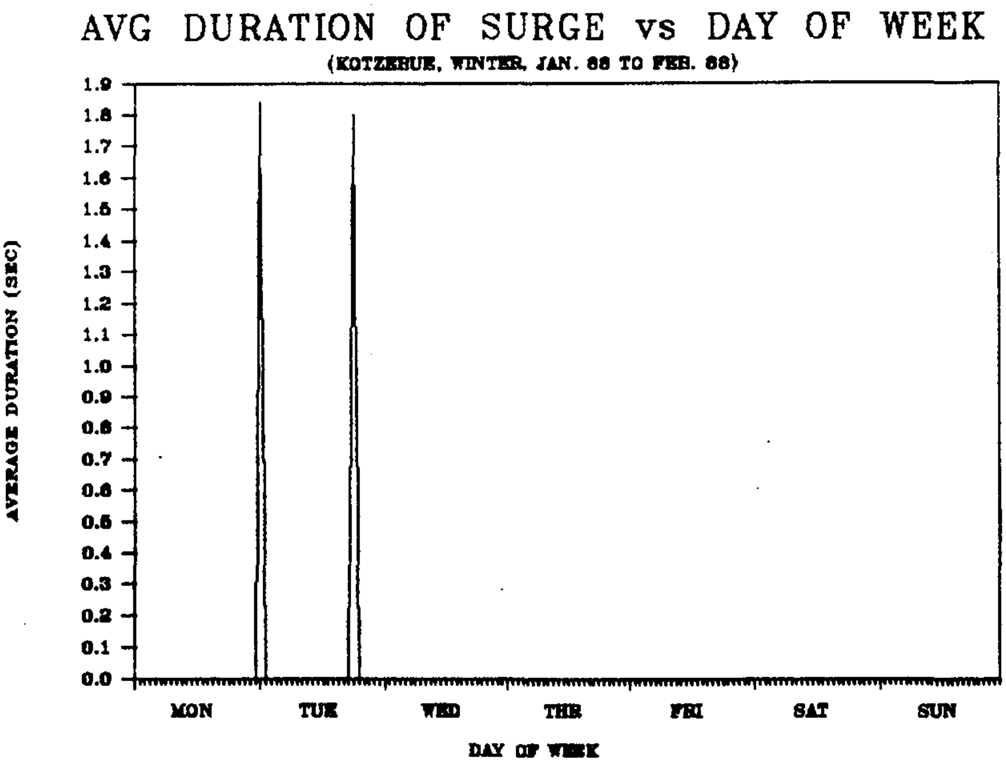


Figure K56

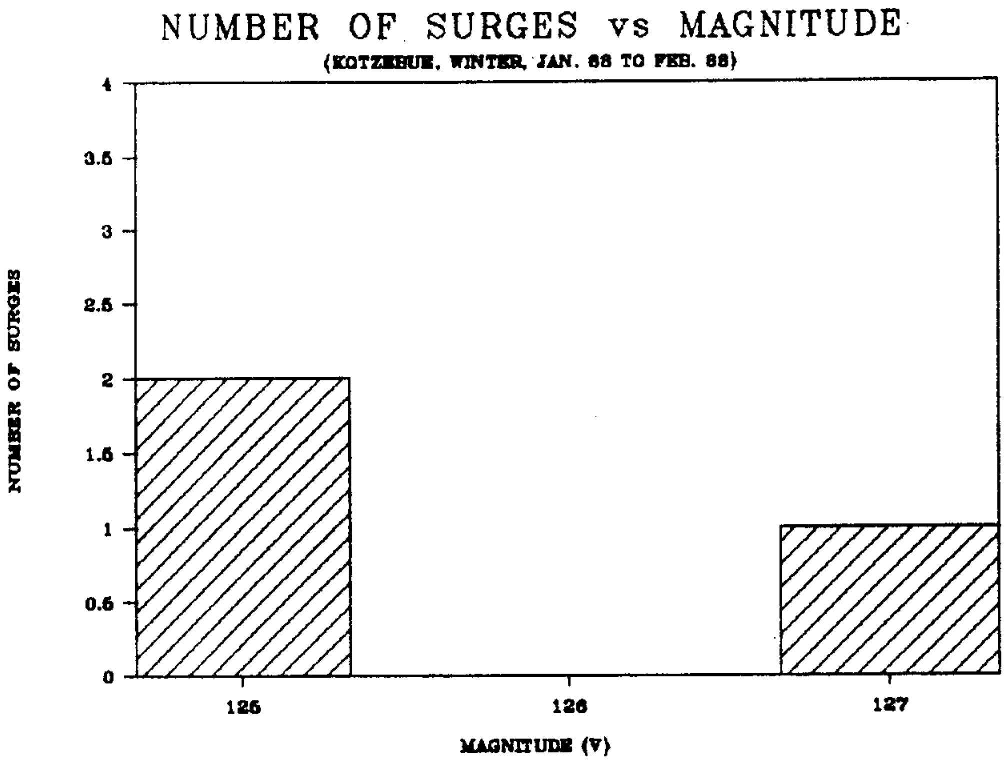


Figure 57

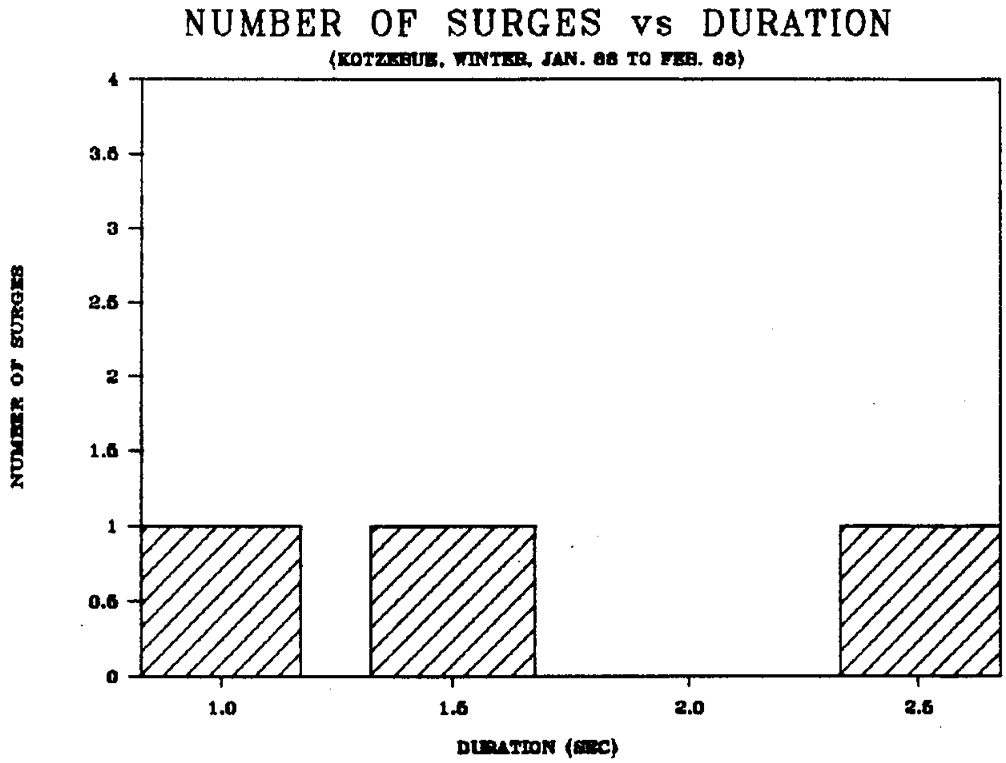


Figure K58

NUMBER OF SURGES vs DAY OF WEEK

(KOTZEBUE, SUMMER, MAY 88 TO AUG. 88)

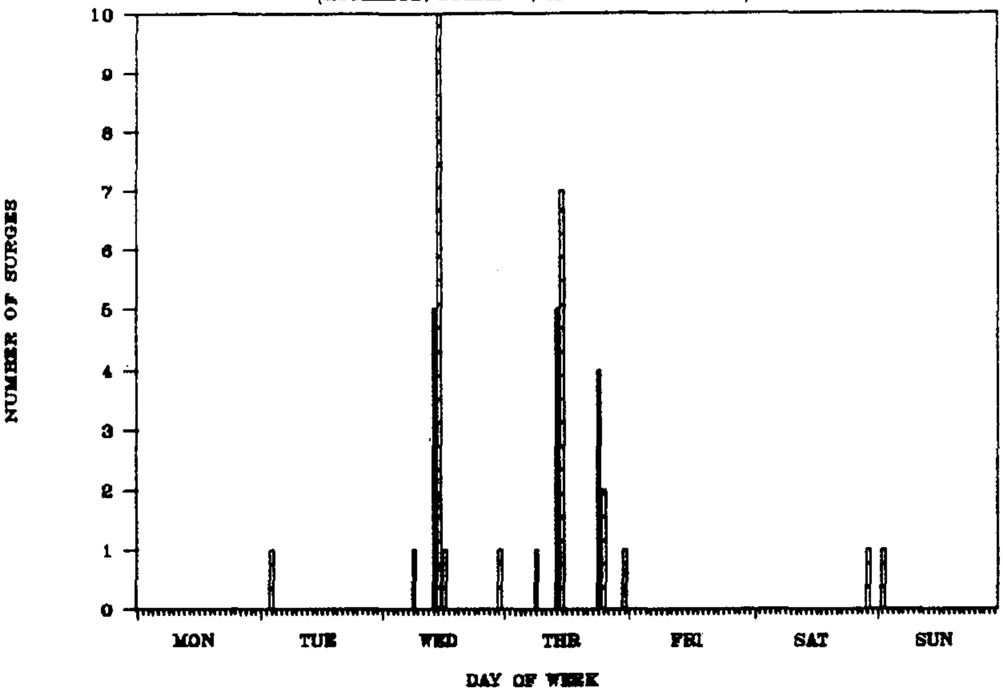


Figure K59

AVG MAGNITUDE OF SURGE vs DAY OF WEEK

(KOTZEBUE, SUMMER, MAY 88 TO AUG. 88)

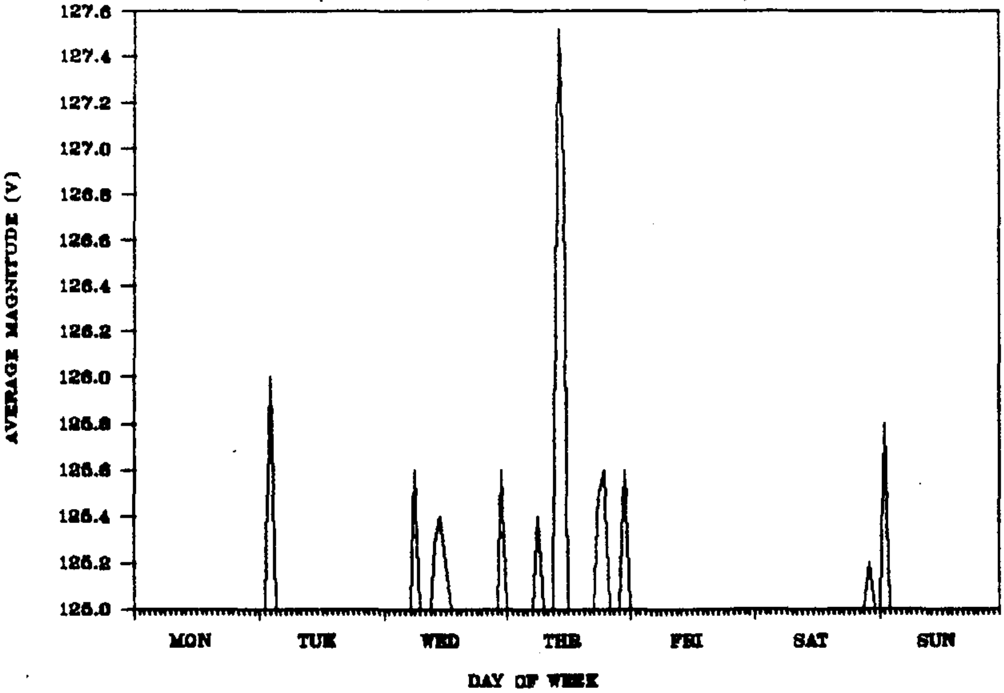


Figure K60

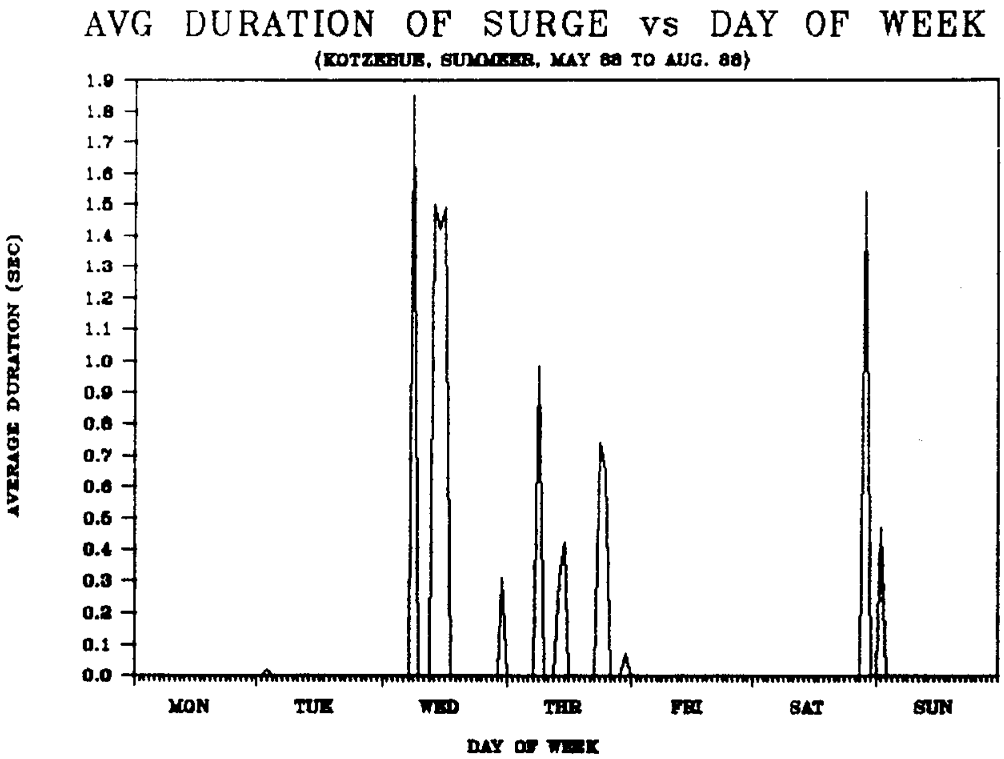


Figure K61

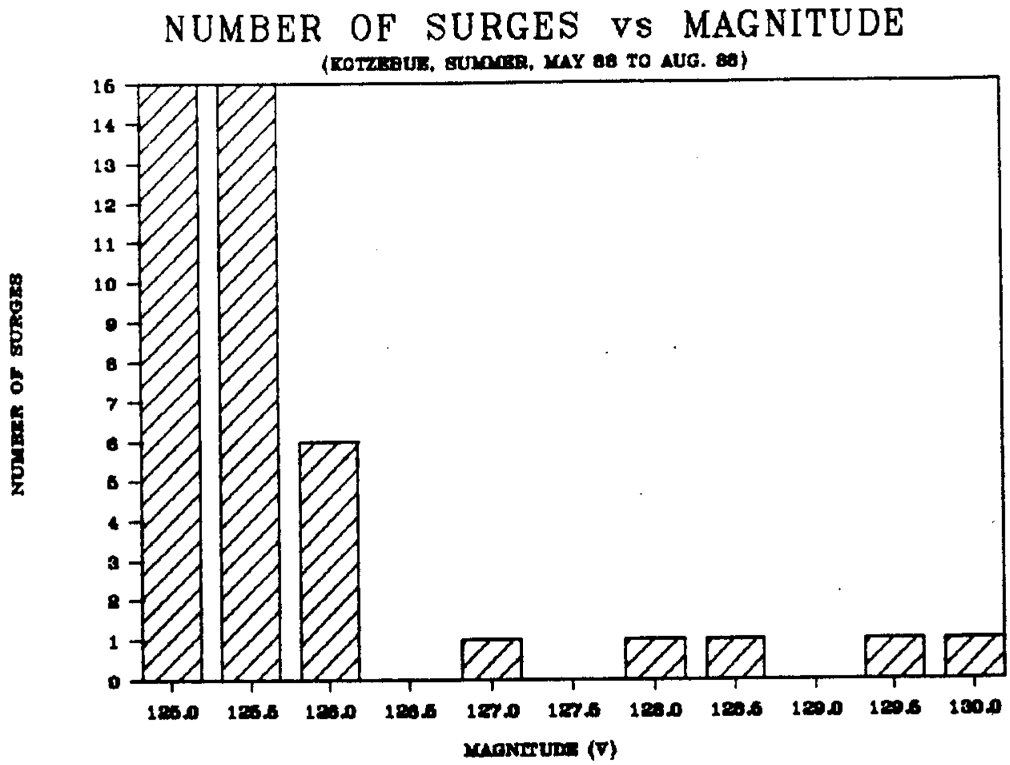


Figure K62

NUMBER OF SURGES vs DURATION

(KOTZEBUE, SUMMER, MAY 86 TO AUG. 86)

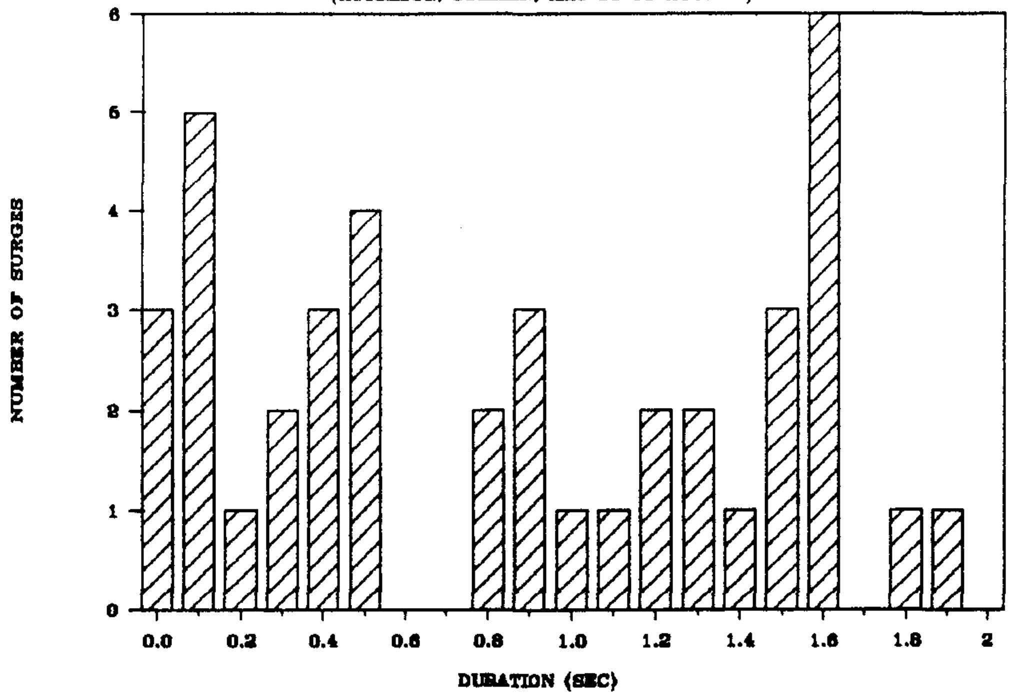


Figure K63

NUMBER OF SURGES vs TIME OF DAY

(KOTZEBUE, SUMMER 86, MIN PWR-SWG, SAT)

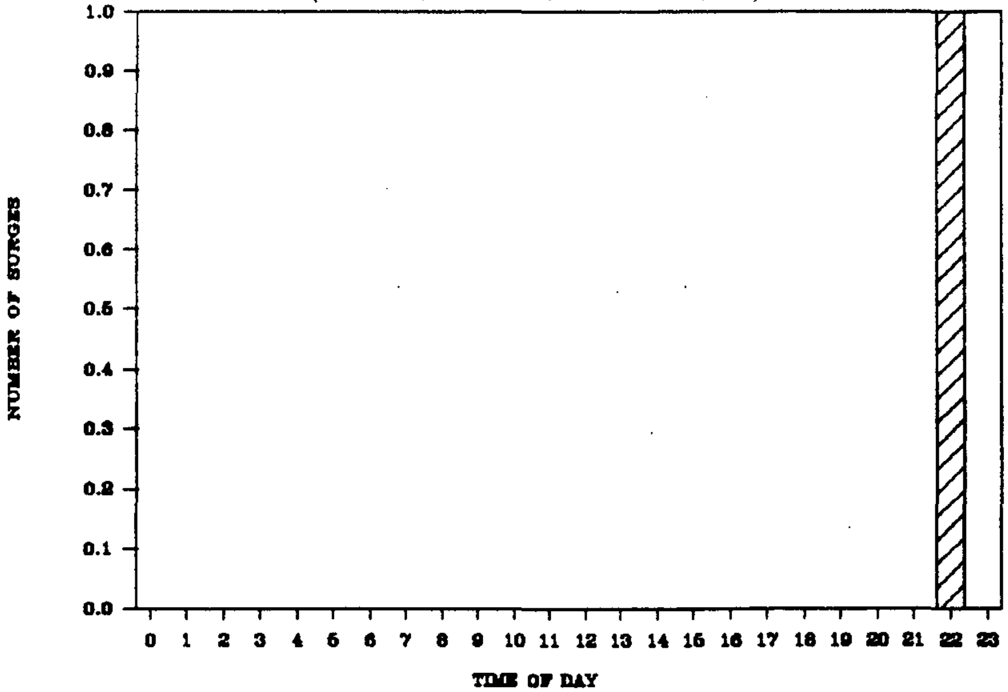


Figure K64

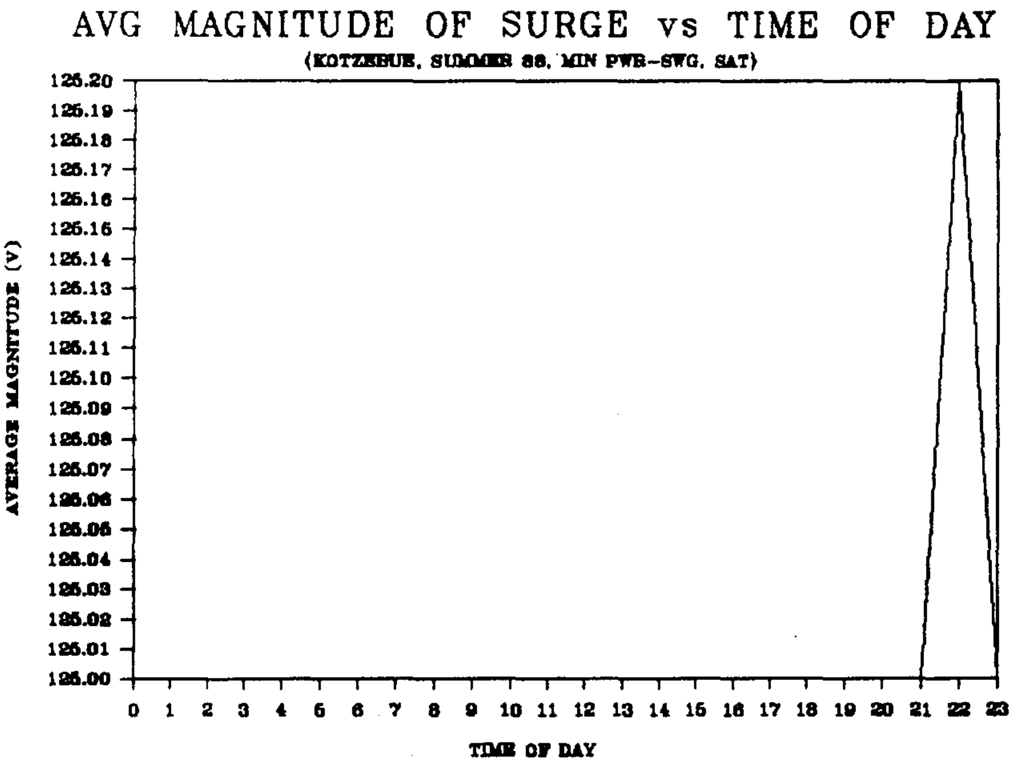


Figure K65

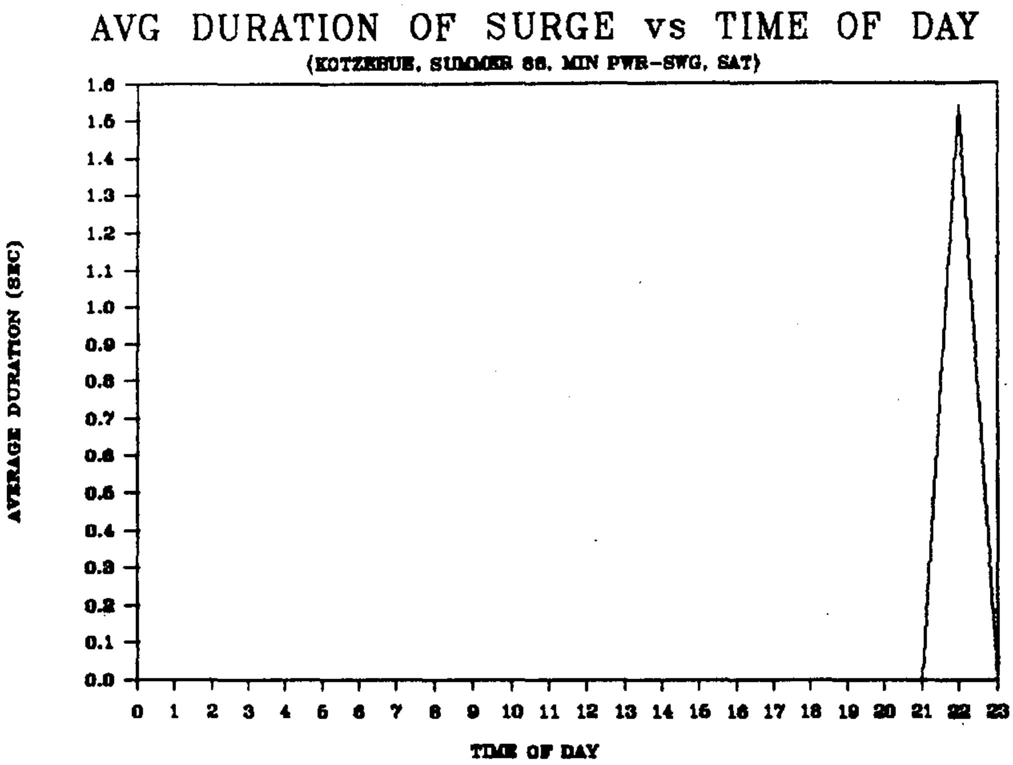


Figure K66

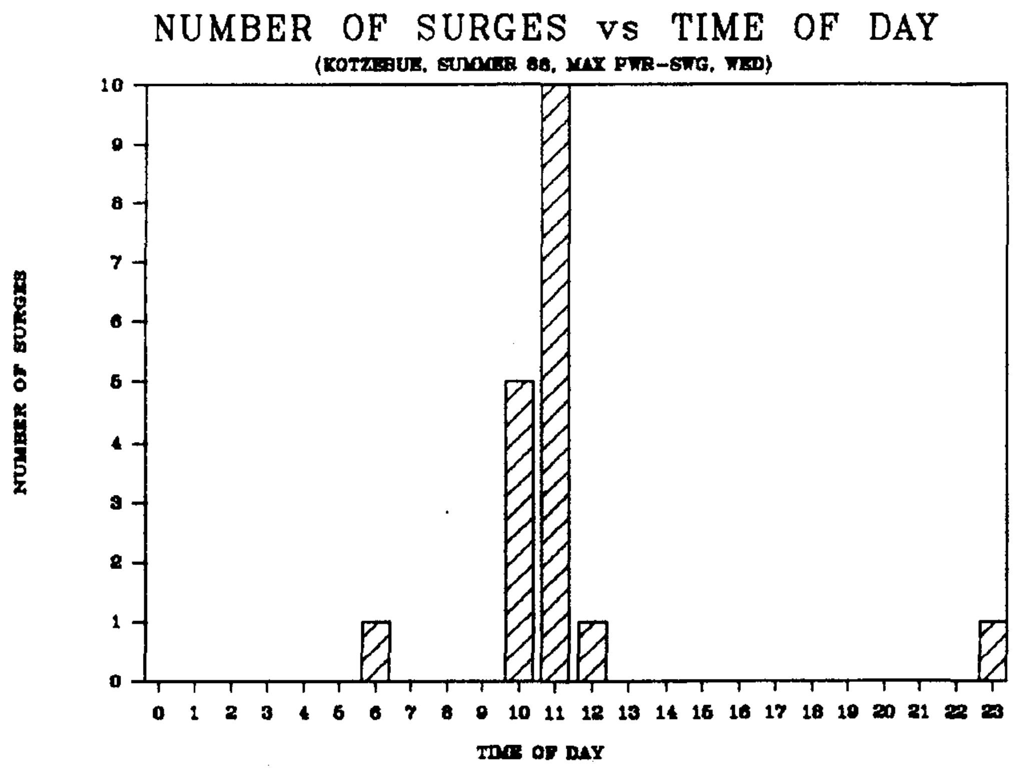


Figure K67

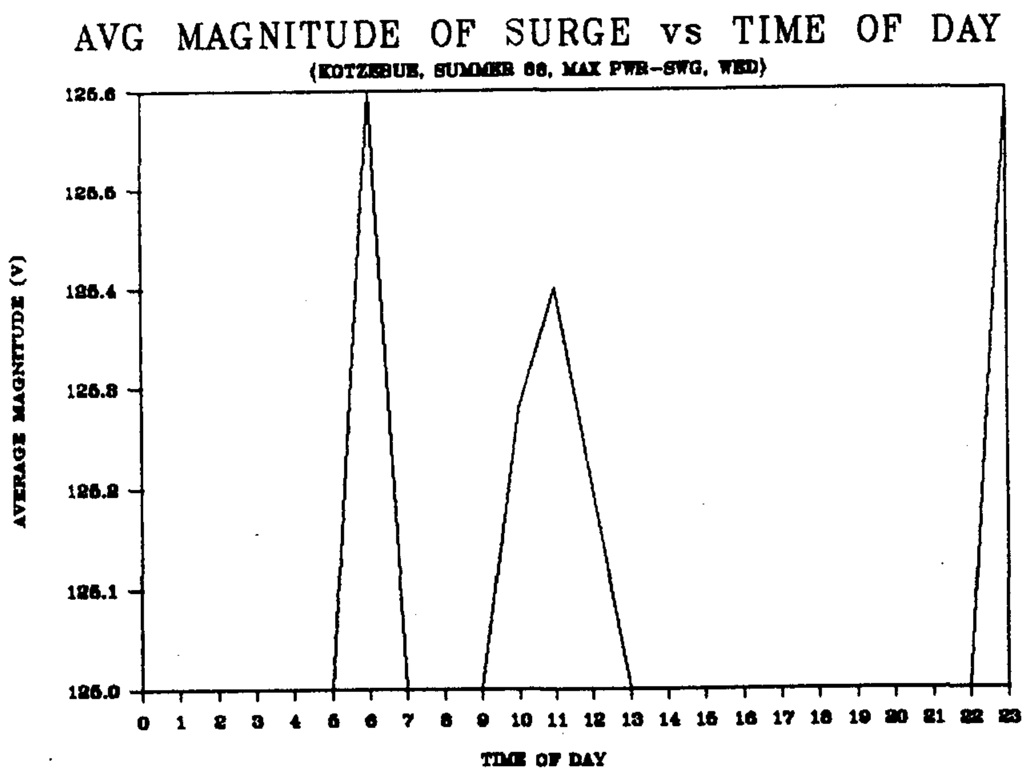


Figure K68

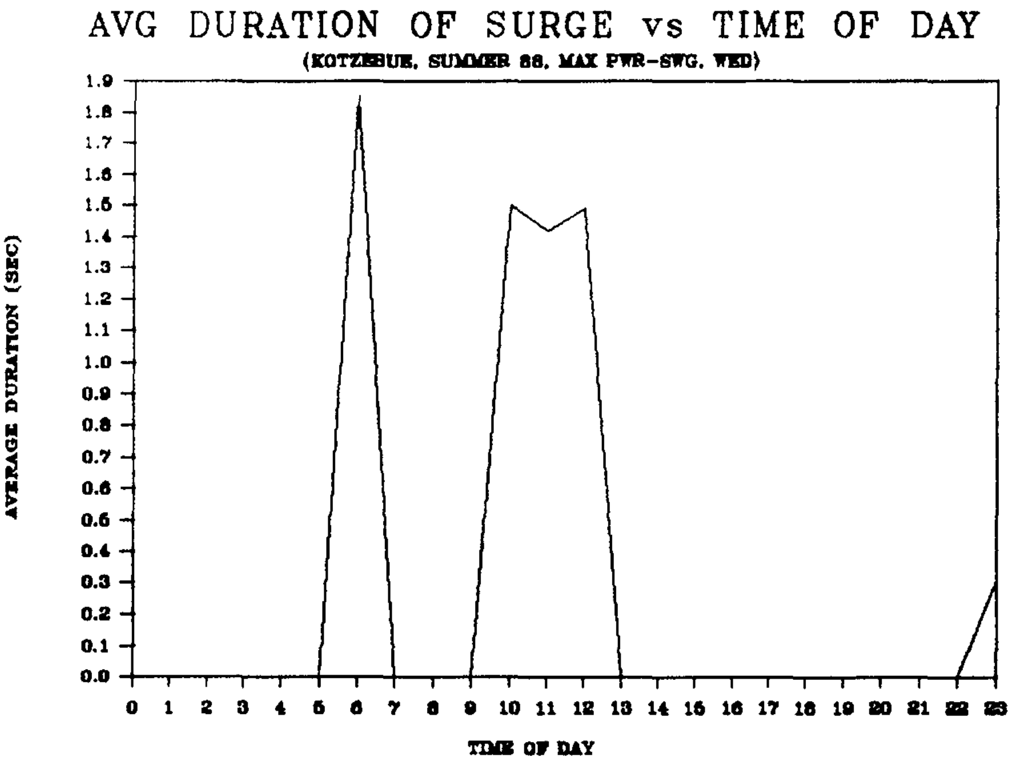


Figure K69

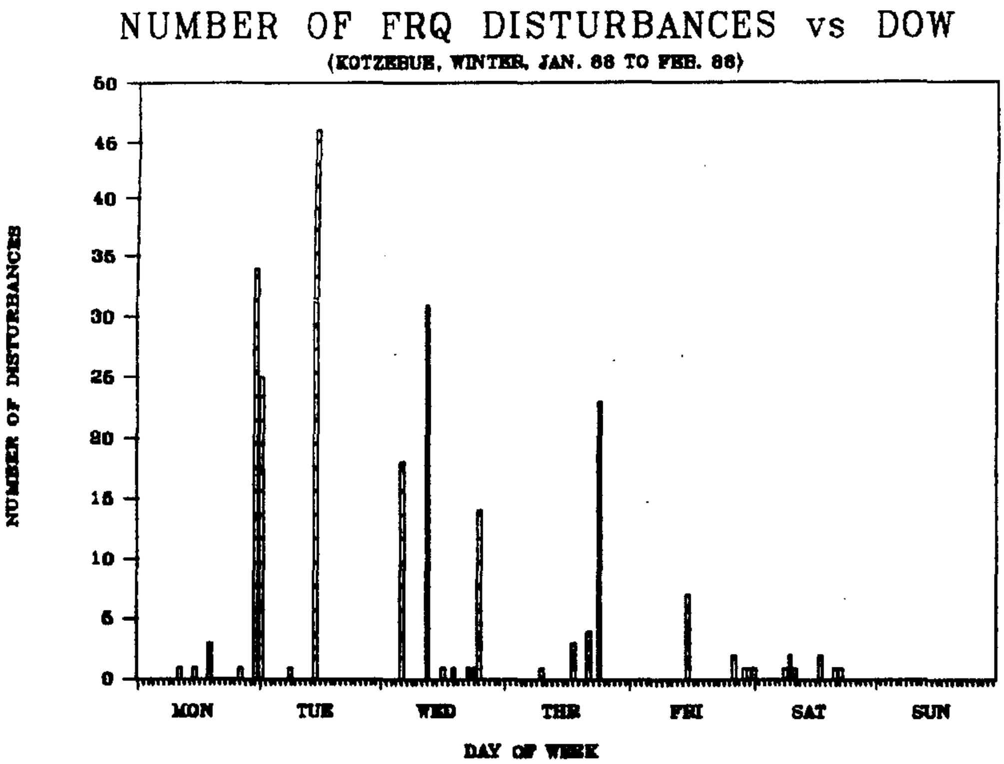


Figure K70

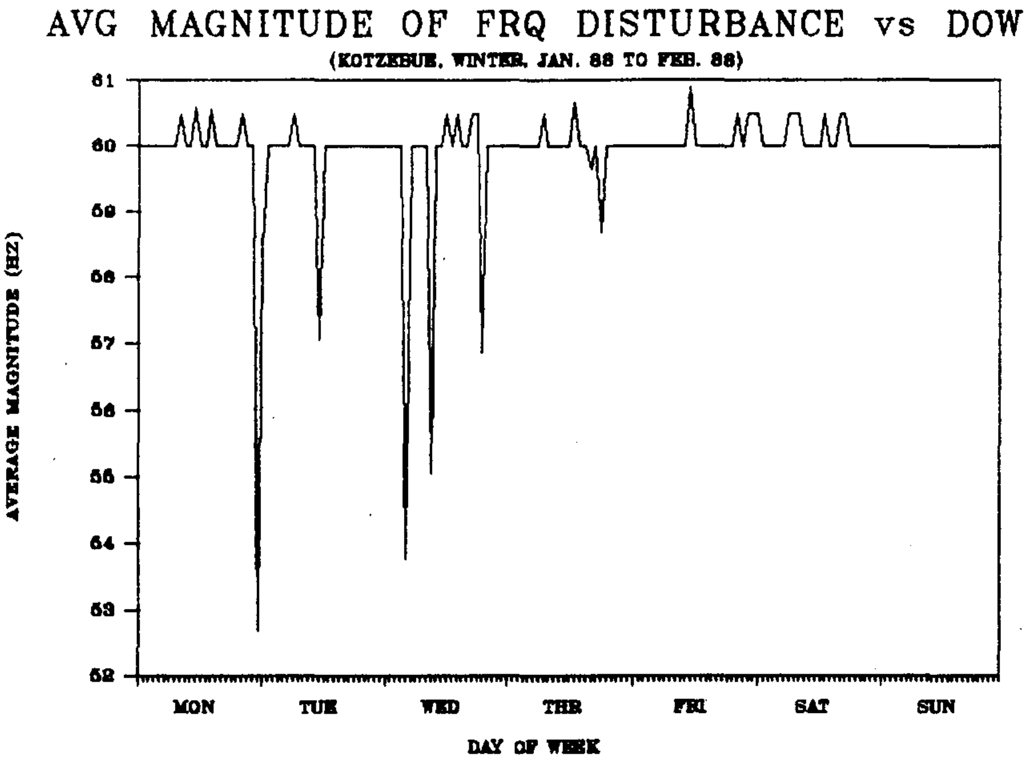


Figure K71

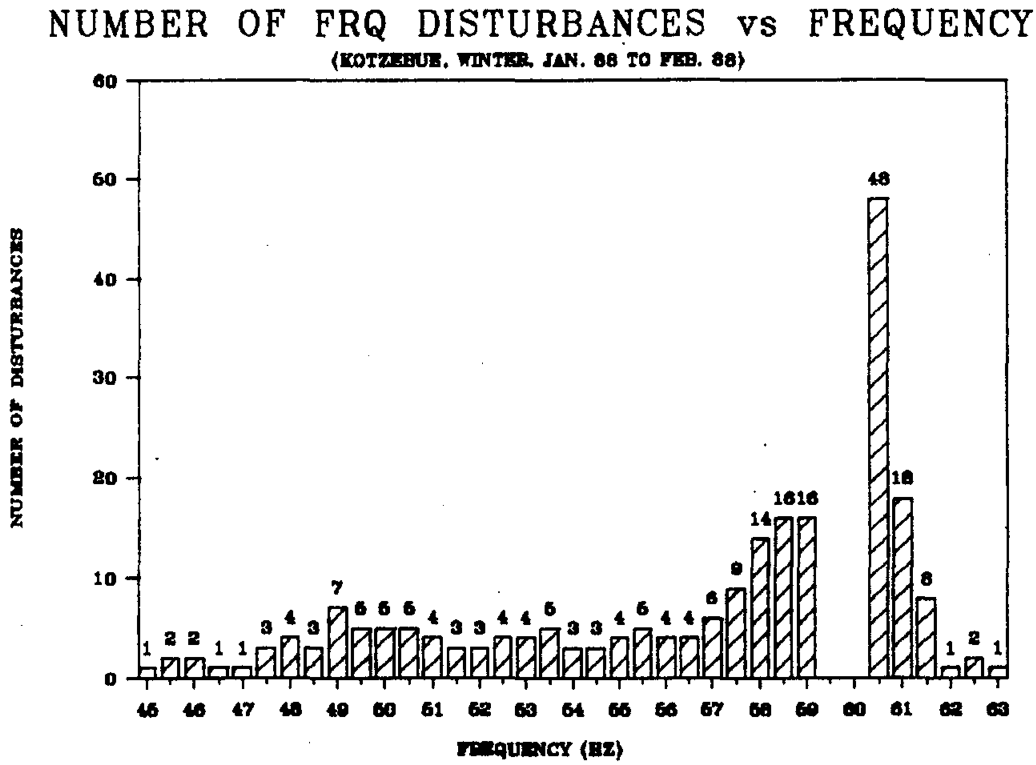


Figure K72

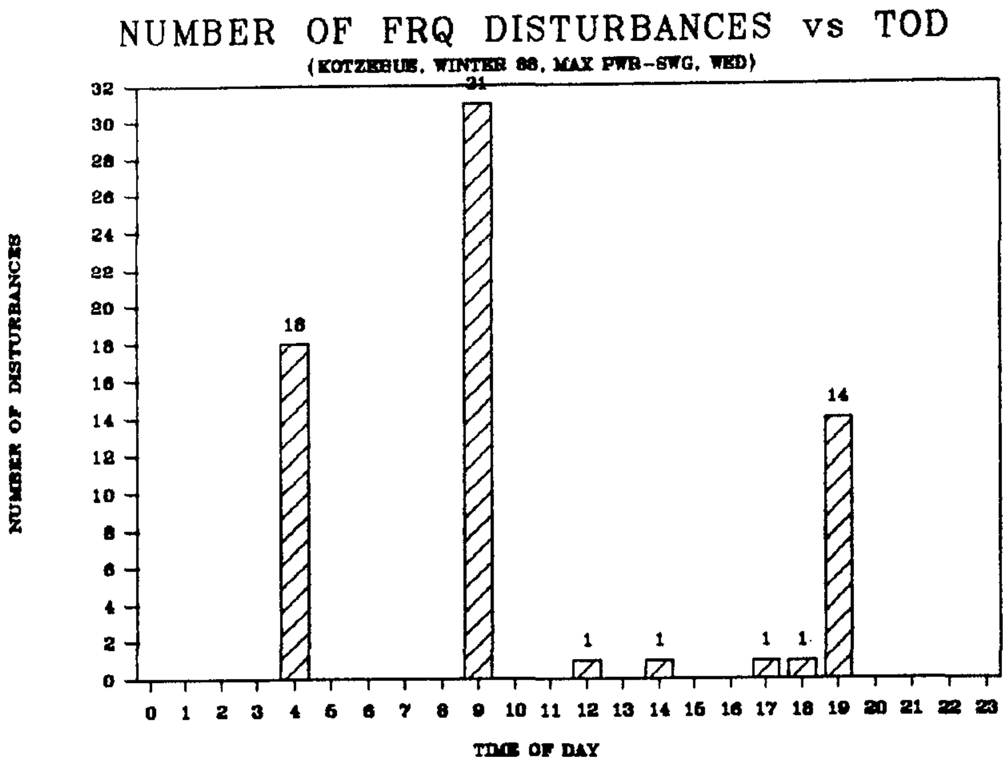


Figure K73

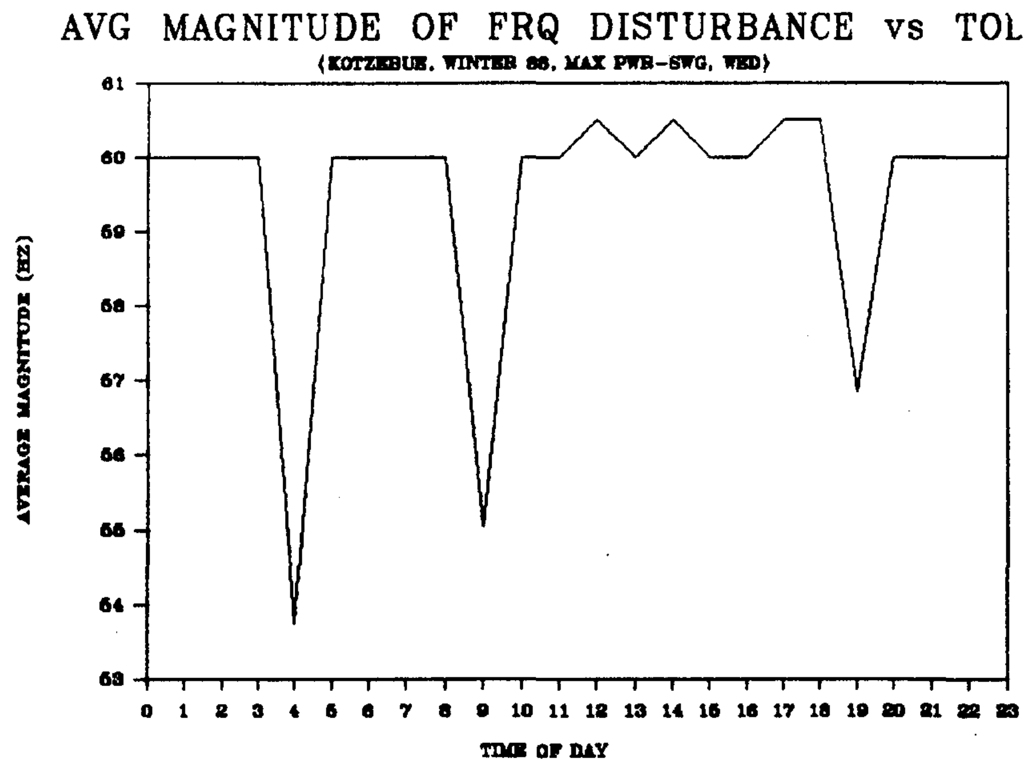


Figure K74

NUMBER OF FRQ DISTURBANCES vs DOW

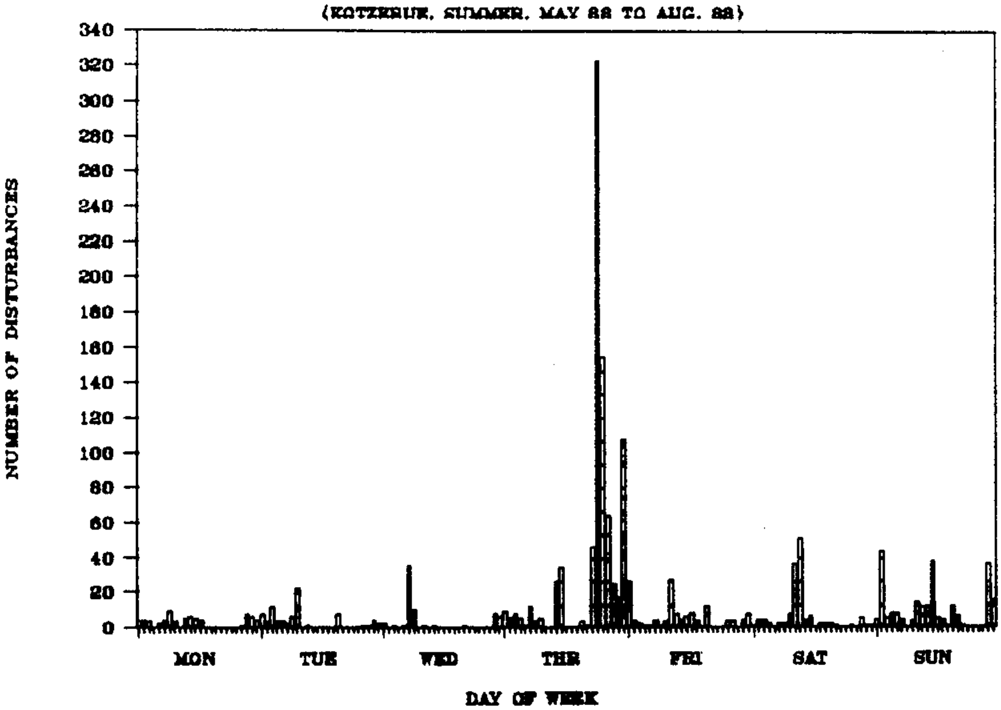


Figure K75

AVG MAGNITUDE OF FRQ DISTURBANCE vs DOW

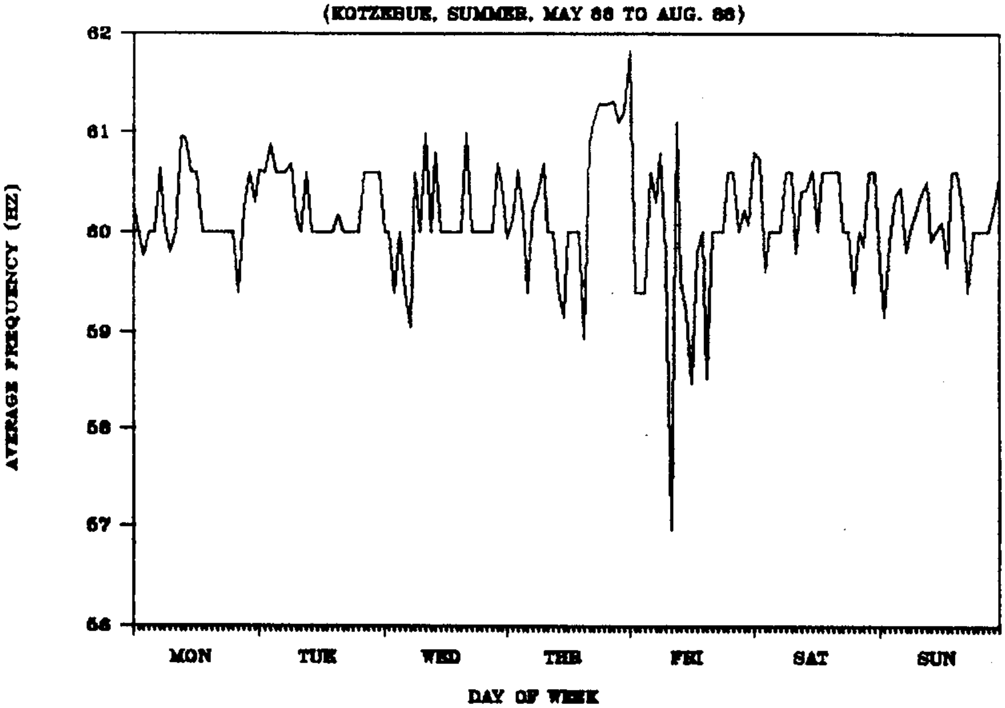


Figure K76

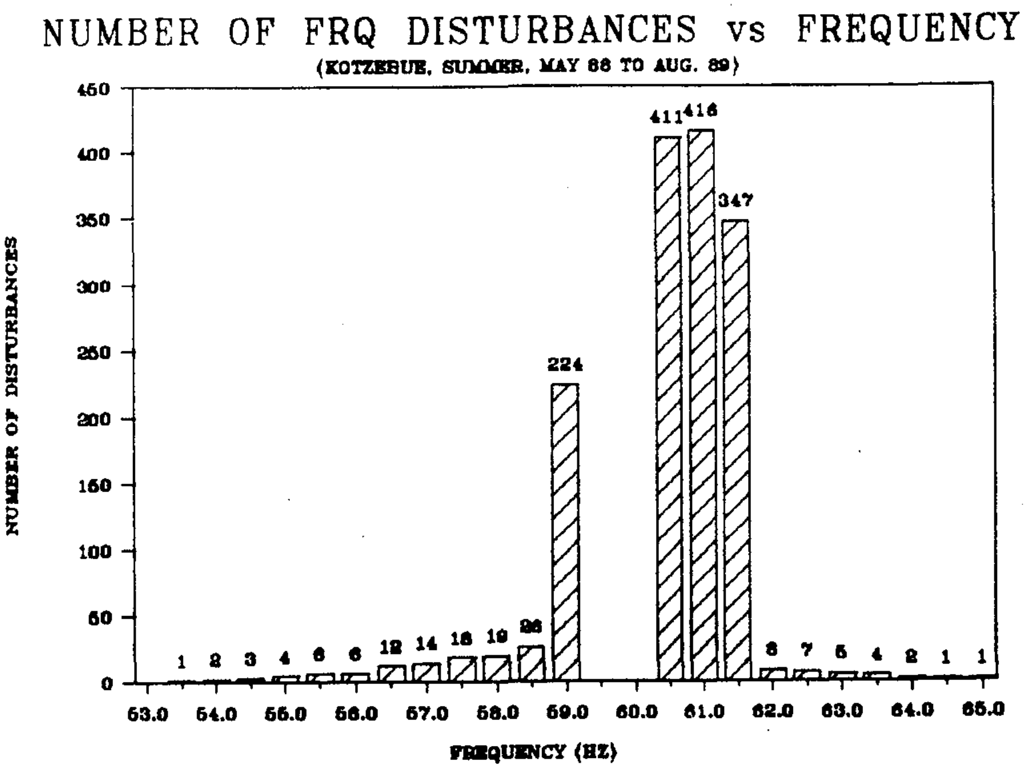


Figure K77

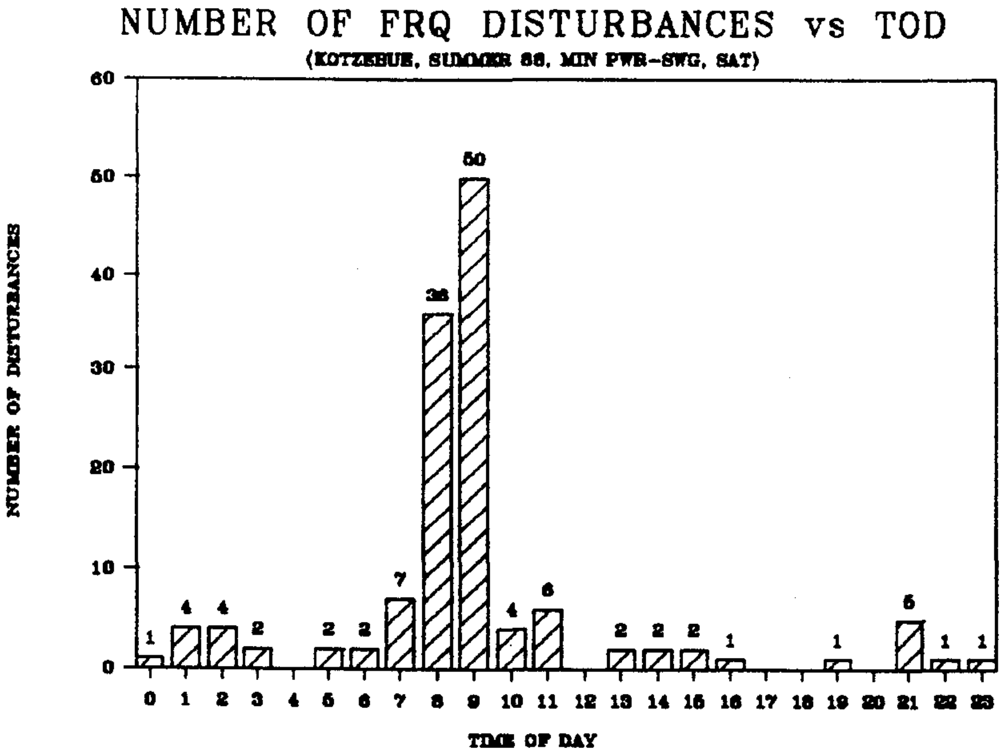


Figure K78

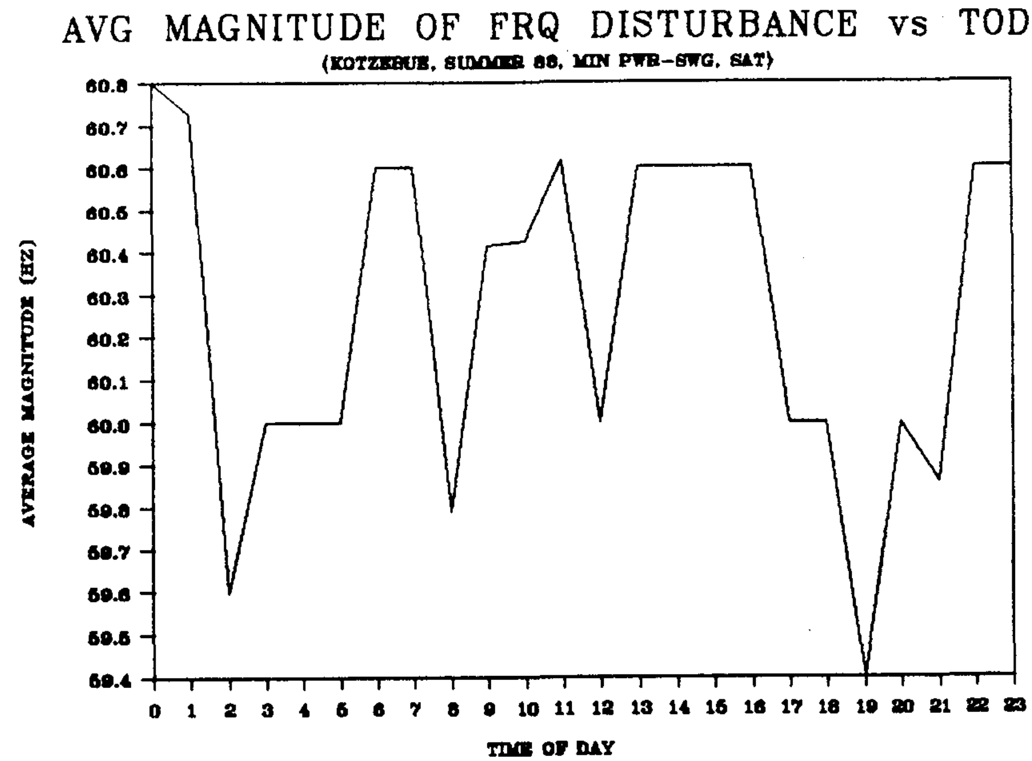


Figure K79

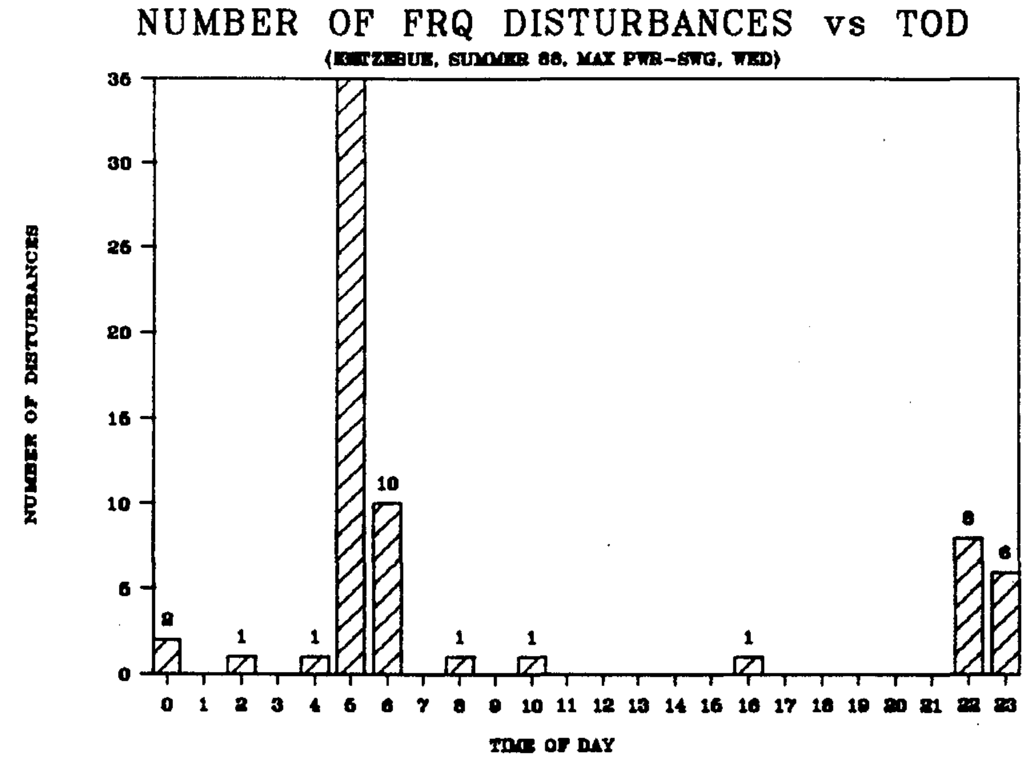


Figure K80

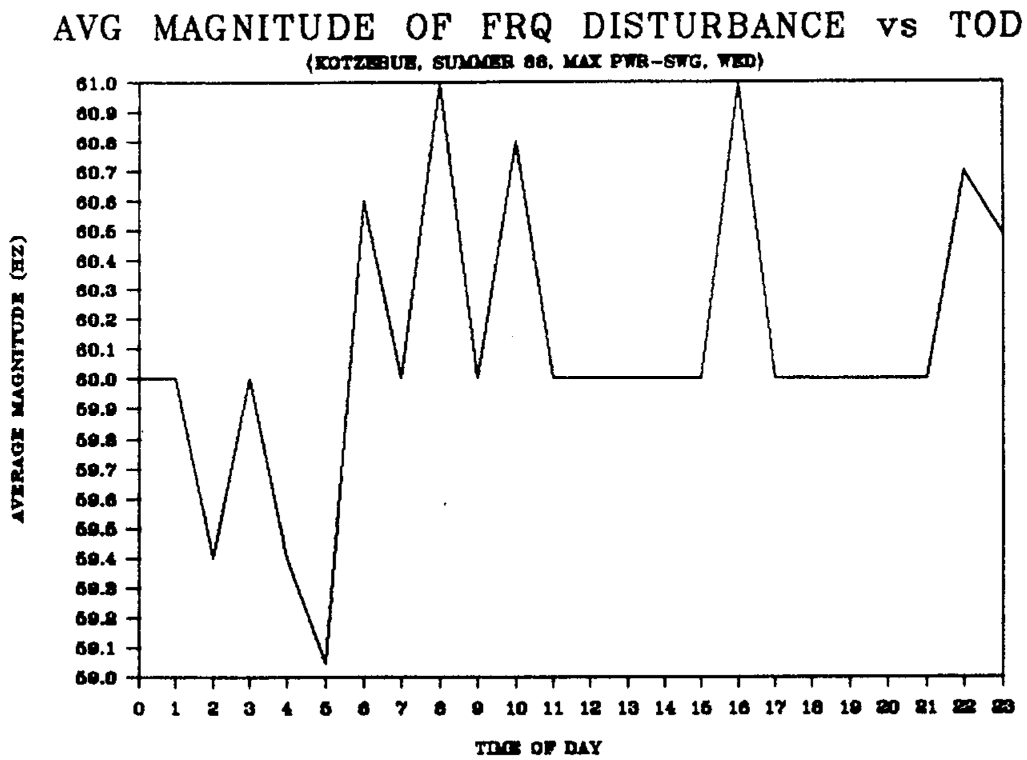


Figure K81

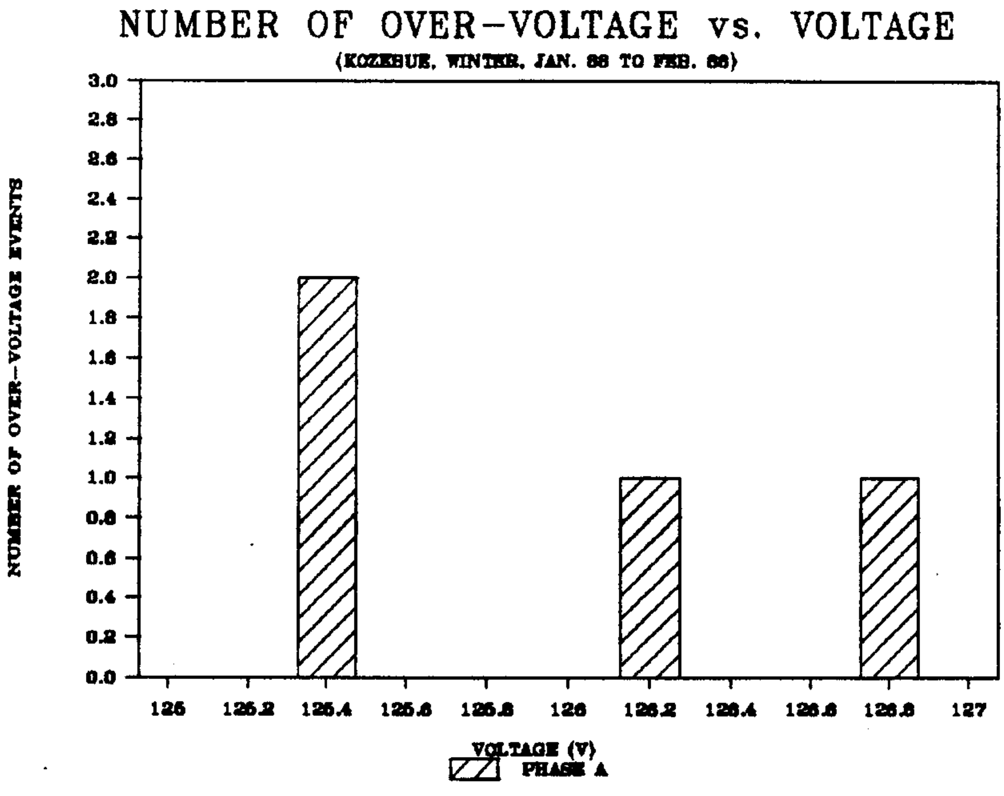


Figure K82

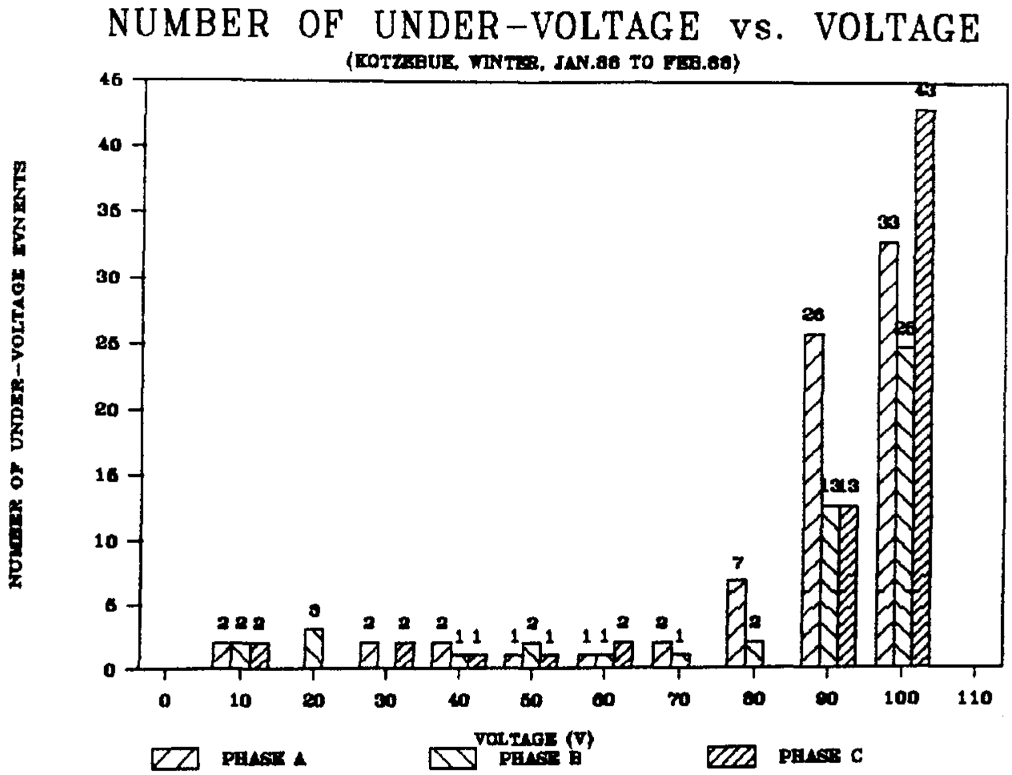


Figure K83

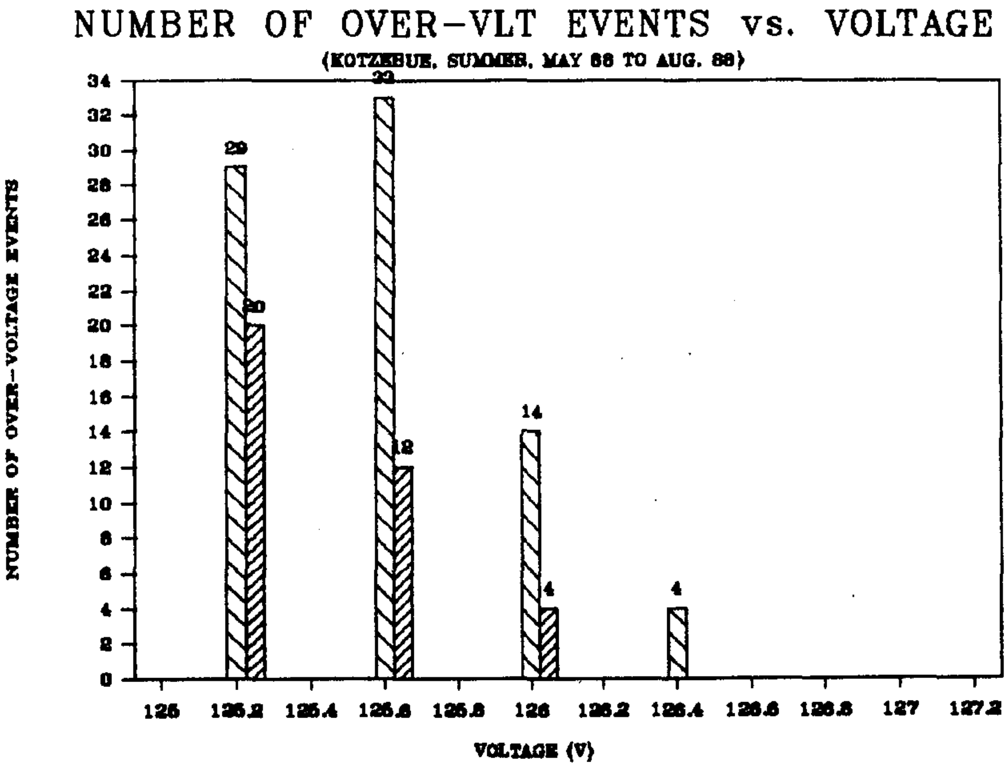


Figure K84

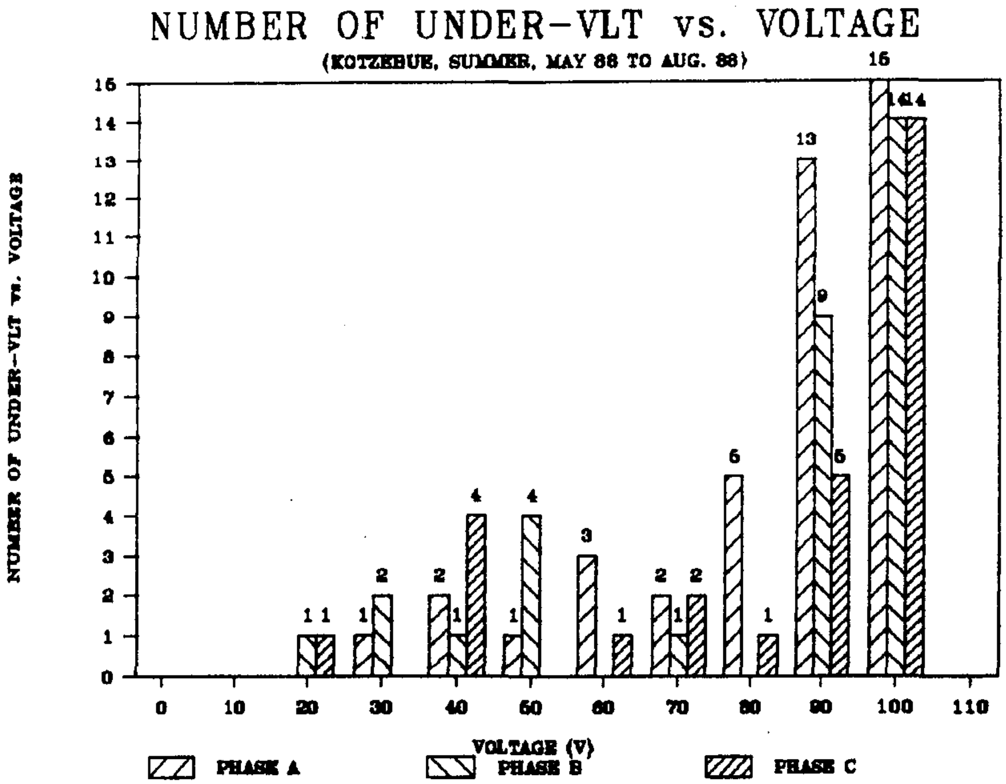

NUMBER OF UNDER-VLT vs. VOLTAGE
(KOTZEBUE, SUMMER, MAY 88 TO AUG. 88)
NUMBER OF UNDER-VLT vs. VOLTAGE
VOLTAGE (V)
PHASE A
PHASE B
PHASE C

Figure K85

3.2 Tazlina site

Electric power disturbance data for the Tazlina site are presented in Figure T1 through Figure T102. As in the previous section, figure descriptions are given first as a group followed by the figures themselves.

Figures T1 through T18 show data from the Dranetz Model 808 electric power/demand analyzer. Figures T1 through T9 give results for the winter season while Figures T10 through T18 provide similar information for the summer. All remaining figures present data provided by the Dranetz Model 626 universal disturbance analyzer. Figures T19 through T40 show winter and summer voltage impulse data, Figures T41 through T62 give winter and summer voltage sag data, Figures T63 through T84 provide winter and summer voltage surge data, Figures T85 through T98 give winter and summer frequency disturbances, and Figures T99 through T102 show overvoltage and undervoltage information.

FIGURE DESCRIPTIONS

3.2.1 808:

Winter

Figure T1. The plot of Average Power Demand versus Day of Week (winter) shows the distribution of average power demand (in KW) according to different days of a week. Amplitude of the line represents the average power demands (hourly basis) during the winter.

Figure T2. The plot of Average Voltage versus Day of Week (winter) shows the distribution of average voltage (in Volts) according to different days of a week. Amplitude represents average voltages occurring in the same time period (hourly basis) during the winter.

Figure T3. The plot of Average Power Factor versus Day of Week (winter) shows the distribution of average power factor according to different days of a week. Amplitude represents the average power factor (hourly basis) during the winter.

Figure T4. The plot of Average Power Demand versus Time of Day (winter, minimum power swing day) shows the distribution of average power demand (in KW) according to different times in a day. Only the data of minimum power swing days (Sundays on this site) are included, and amplitude represents the average power demand (hourly basis during the winter.

Figure T5. The plot of Average Voltage versus Time of Day (winter, minimum power swing day) shows the distribution of average voltage (in Volts) according to different times in a day. Only the data of minimum power swing days (Sundays on this site) are included, and amplitude represents the average voltage (hourly basis) during the winter.

Figure T6. The plot of Average Power Factor versus Time of Day (winter, minimum power swing day) shows the distribution of average power factor according to different times in a day. Only the data of minimum power swing days (Sundays on this site) are included, and amplitude represents the average power factor (hourly basis) during the winter.

Figure T7. The plot of Average Power Demand versus Time of Day (winter, maximum power swing day) shows the distribution of average power demand (in KW) according to different times in a day. Only the data of maximum power swing days (Tuesdays on this site) are included, and amplitude represents the average power demand (hourly basis) during the winter.

Figure T8. The plot of Average Voltage versus Time of Day (winter, maximum power swing day) shows the distribution of average voltage (in Volts) according to different times in a day. Only the data of maximum power swing days (Tuesdays on this site) are included, and amplitude represents the average voltage (hourly basis) during the winter.

Figure T9. The plot of Average Power Factor versus Time of Day (winter, maximum power swing day) shows the distribution of average power factor according to different times in a day. Only the data of maximum power swing days (Tuesdays on this site) are included, and amplitude represents the average power factor (hourly basis) during the winter.

Summer

Figure T10. The plot of Average Power Demands versus Day of Week (summer) shows the distribution of average power demands (in

KW) according to different days of a week. Amplitude of the line represents the average power demands (hourly basis) during the summer.

Figure T11. The plot of Average Voltage versus Day of Week (summer) shows the distribution of average voltages (in Volts) according to different days of a week. Amplitude represents the average voltages (hourly basis) during the summer.

Figure T12. The plot of Average Power Factor versus Day of Week (summer) shows the distribution of average power factor according to different days of a week. Amplitude represents the average power factor (hourly basis) during the summer.

Figure T13. The plot of Average Power Demand versus Time of Day (summer, minimum power swing day) shows the distribution of average power demand (in KW) according to different times in a day. Only the data of minimum power swing days (Saturdays on this site) are included, and amplitude represents the average power demand (hourly basis) during the summer.

Figure T14. The plot of Average Voltage versus Time of Day (summer, minimum power swing day) shows the distribution of average voltage (in Volts) according to different times in a day. Only the data of minimum power swing days (Saturdays on this site) are included, and amplitude represents the average voltage (hourly basis) during the summer.

Figure T15. The plot of Average Power Factor versus Time of Day (summer, minimum power swing day) shows the distribution of average power factor according to different times in a day. Only the data of minimum power swing days (Saturdays on this site) are included, and amplitude represents the average power factor (hourly basis) during the summer.

Figure T16. The plot of Average Power Demand versus Time of Day (summer, maximum power swing day) shows the distribution of average power demand (in KW) according to different times in a day. Only the data of maximum power swing days (Thursdays on this site) are included, and amplitude represents the average power demand (hourly basis) during the summer.

Figure T17. The plot of Average Voltage versus Time of Day (summer maximum power swing day) shows the distribution of average voltage (in Volts) according to different times in a day. Only the data of maximum power swing days (Thursdays on this site) are included, and amplitude represents the average voltage (hourly basis) during the summer.

Figure T18. The plot of <u>Average Power Factor versus Time of Day</u> (summer maximum power swing day) shows the distribution of average power factor according to different times in a day. Only the data of maximum power swing days (Thursdays on this site) are included, and amplitude represents the average power factor (hourly basis) during the summer.

3.2.2 626:

3.2.2.1 Impulse

Winter

Figure T19. The plot of Number of Impulses versus Days of Week (winter) shows the distribution of number of impulses according to different days of a week. Amplitude of each bar represents the total number of impulses occurring in the same period (hourly basis) during the winter.

Figure T20. The plot of Average Magnitude of Impulses versus Day of Week (winter) shows the distribution of average magnitude of impulses (in Volts) according to different days of a week. Amplitude of each bar represents the average magnitude of impulses occurring in the same time period (hourly basis) during the winter.

Figure T21 The plot of Average Duration of Impulses versus Day of Week (winter) shows the distribution of average duration of impulses (in microseconds) according to different days of a week. Amplitude of each bar represents the average duration of impulses occurring in the same time period (hourly basis) during the winter.

Figure T22 The plot of Number of Impulses verses Magnitude (winter) shows the distribution of number of impulses according to different magnitude. Amplitude of each bar represents the total number of impulses whose magnitudes are in a specific range (the magnitude interval is 10 V).

Figure T23 The plot of Number of Impulses versus Duration (winter) shows the distribution of number of impulses according to different duration. Amplitude of each bar represents the total number of impulses whose durations are in a specific range (the duration interval is 50 microseconds).

Figure T24 The plot of Number of Impulses versus Time of Day (winter, minimum power swing day) shows the distribution of number of impulses according to different times in a day. Only the data of minimum power swing days (Sundays on this site) are included, and amplitude of each bar represents the total number of impulses occurring in the same time period (hourly basis) during the winter.

Figure T25 The plot of Average Magnitude of Impulses versus Time of Day (winter, minimum power swing day) shows the distribution of average magnitude of impulses (in Volts) according to different times in a day. Only the data of minimum power swing days (Sundays on this site) are included, and amplitude represents the average magnitude of impulses occurring in the same time period (hourly basis) during the winter.

Figure T26 The plot of Average Duration of Impulses versus Time of Day (winter, minimum power swing day) shows the distribution of average duration of impulses (in microseconds) according to different times in a day. Only the data of minimum power swing days (Sundays on this site) are included, and amplitude of the line represents the average duration of impulses occurring in the same time period (hourly basis) during the winter.

Figure T27 The plot of Number of Impulses versus Time of Day (winter, minimum power swing day) shows the distribution of number of impulses according to different times in a day. Only the data of minimum power swing days (Tuesdays on this site) are included, and amplitude of each bar represents the total number of impulses occurring in the same time period (hourly basis) during the winter.

Figure T28 The plot of Average Magnitude of Impulses versus Time of Day (winter, minimum power swing day) shows the distribution of average magnitude of impulses (in Volts) according to different times in a day. Only the data of minimum power swing days (Tuesdays on this site) are included, and amplitude represents the average magnitude of impulses occurring in the same time period (hourly basis) during the winter.

Figure T29 The plot of Average Duration of Impulses versus Time of Day (winter, minimum power swing day) shows the distribution of average duration of impulses (in microseconds) according to different times in a day. Only the data of minimum power swing days (Tuesdays on this site) are included, and amplitude of the line represents the average duration of impulses occurring in the same time period (hourly basis) during the winter.

Summer

Figure T30 The plot of Number of Impulses versus Days of Week (summer) shows the distribution of number of impulses according to different days of a week. Amplitude of each bar represents the total number of impulses occurring in the same time period (hourly basis) during the summer.

Figure T31 The plot of Average Magnitude of Impulses versus Day of Week (summer) shows the distribution of average magnitude of impulses (in Volts) according to different days of a week. Amplitude of each bar represents the average magnitude of impulses occurring in the same time period (hourly basis) during the summer.

Figure T32 The plot of Average Duration of Impulses versus Day of Week (summer) shows the distribution of average duration of impulses (in microseconds) according to different days in a week. Amplitude of each bar represents the average duration of impulses occurring in the same time period (hourly basis) during the summer.

Figure T33 The plot of Number of Impulses versus Days of Week (summer) shows the distribution of number of impulses according to different magnitude. Amplitude of each bar represents the total number of impulses whose magnitudes are in a specific range (the magnitude interval is 10V).

Figure T34 The plot of Number of Impulses versus Duration (summer) shows the distribution of number of impulses according to different duration. Amplitude of each bar represents the total number of impulses whose durations are in a specific range (the duration interval is 50 microseconds).

Figure T35 The plot of Number of Impulses versus Time of Day (summer, minimum power swing day) shows the distribution of number of impulses according to different times in a day. Only the data of minimum power swing days (Saturdays on this site) are included, and amplitude of each bar represents the total number of impulses occurring in the same time period (hourly basis) during the summer.

Figure T36 The plot of Average Magnitude of Impulses versus Time of Day (summer, minimum power swing day) shows the distribution of average magnitude of impulses (in Volts) according to different times in a day. Only the data of minimum power swing days (Saturdays on this site) are included, and amplitude represents the average magnitude of impulses occurring in the same time period (hourly basis) during the summer.

Figure T37 The plot of Average Duration of Impulses versus Time of Day (summer, minimum power swing day) shows the distribution of average duration of impulses (in microseconds) according to different times in a day. Only the data of minimum power swing days (Saturdays on this site) are included, and amplitude of the line represents the average duration of impulses occurring in the same time period (hourly basis) during the summer.

Figure T38 The plot of Number of Impulses versus Time of Day (summer, maximum power swing day) shows the distribution of number of impulses according to different times in a day. Only the data of maximum power swing days (Thursdays on this site) are included, and amplitude of each bar represents the total number of impulses occurring in the same time period (hourly basis) during the summer.

Figure T39 The plot of Average Magnitude of Impulses versus Time of Day (summer, maximum power swing day) shows the distribution of average magnitude of impulses (in Volts) according to different time in a day. Only the data of maximum power swing days (Thursdays on this site) are included, and amplitude of the line represents the average magnitude of impulses occurring in the same time period (hourly basis) during the summer.

Figure T40 The plot of Average Duration of Impulses versus Time of Day (summer, maximum power swing day) shows the distribution of average duration of impulses (in microseconds) according to different times in a day. Only the data of maximum power swing days (Thursdays on this site) are included, and amplitude of the line represents the average duration of impulses occurring in the same time period (hourly basis) during the summer.

3.2.2.2 Sag

Winter

Figure T41 The plot of Number of Sags versus Days of Week (winter) shows the distribution of number of sags according to different days of a week. Amplitude of each bar represents the total number of sags occurring in the same time period (hourly basis) during the winter.

Figure T42 The plot of Average Magnitude of Sags versus Days of Week (winter) shows the distribution of average magnitude of sags (in Volts) according to different days of a week. Amplitude represents the average magnitude of sags occurring in the same time period (hourly basis) during the winter.

Figure T43 The plot of Average Duration of Sags versus Days of Week (winter) shows the distribution of average duration of sags (in seconds) according to different days of a week. Amplitude of the line represents the average duration of sags occurring in the same time period (hourly basis) during the winter.

Figure T44 The plot of Number of Sags versus Magnitude (winter) shows the distribution of number of sags according to different magnitude. Amplitude of each bar represents the total number of sags whose magnitudes are in a specific range (the magnitude interval is 10V).

Figure T45 The plot of Number of Sags versus Duration (winter) shows the distribution of number of sags according to different duration. Amplitude of each bar represents the total number of sags whose durations are in a specific range (the duration interval is 0.05 seconds).

Figure T46 The plot of Number of Sags versus Time of Day (winter, minimum power swing day) shows the distribution of number of sags according to different times in a day. Only the data of minimum power swing days (Sundays on this site) are included, and amplitude of each bar represents the total number of sags occurring in the same time period (hourly basis) during the winter.

Figure T47 The plot of Average Magnitude of Sags versus Time of Day (winter, minimum power swing day) shows the distribution of average magnitude of sags (in Volts) according to different times in a day. Only the data of minimum power swing days (Sundays on this site) are included, and amplitude represents the average magnitude of sags occurring in the same time period (hourly basis) during the winter.

Figure T48 The plot of Average Duration of Sags versus Time of Day (winter minimum power swing day) shows the distribution of average duration of sags (in seconds) according to different times in a day. Only the data of minimum power swing days (Sundays on this site) are included, and amplitude of each bar represents the average duration of sags occurring in the same time period (hourly basis) during the winter.

Figure T49 The plot of Number of Sags versus Time of Day (winter, maximum power swing day) shows the distribution of number of sags according to different times in a day. Only the data of maximum power swing days (Tuesdays on this site) are included, and amplitude of each bar represents the total number of sags occurring in the same time period (hourly basis) during the winter.

Figure T50 The plot of Average Magnitude of Sags versus Time of Day (winter, maximum power swing day) shows the distribution of average magnitude of sags (in Volts) according to different times in a day. Only the data of maximum power swing days (Tuesdays on this site) are included, and amplitude represents the average magnitude of sags occurring in the same time period (hourly basis) during the winter.

Figure T51 The plot of Average Duration of Sags versus Time of Day (winter, maximum power swing day) shows the distribution of average duration of sags (in seconds) according to different times in a day. Only the data of maximum power swing days (Tuesdays on site) are included, and amplitude of each bar represents the average duration of sags occurring in the same time period (hourly basis) during the winter.

Summer

Figure T52 The plot of Number of Sags versus Days of Week (summer) shows the distribution of number of sags according to different days in a week. Amplitude of each bar represents the total number of sags occurring in the same time period (hourly basis) during the summer.

Figure T53 The plot of Average Magnitude of Sags versus Days of Week (summer) shows the distribution of average magnitude of sags (in Volts) according to different days of a week. Amplitude represents the average magnitude of sags occurring in the same time period (hourly basis) during the summer.

Figure T54 The plot of Average Duration of Sags versus Day of Week (summer) shows the distribution of average duration of sags (in seconds) according to different days of a week. Amplitude represents the average duration of sags occurring in the same time period (hourly basis) during the summer.

Figure T55 The plot of Number of Sags versus Magnitude (summer) shows the distribution of number of sags according to different magnitude. Amplitude of each bar represents the total number of sags whose magnitudes are in a specific range (the magnitude interval is 10V).

Figure T56 The plot of Number of Sags versus Duration (summer) shows the distribution of number of sags according to different duration. Amplitude of each bar represents the total number of sags whose durations are in a specific range (the duration interval is 0.05 seconds).

Figure T57 The plot Number of Sags versus Time of Day (summer), maximum power swing day) shows the distribution of number of sags according to different times in a day. Only the data of minimum power swing days (Saturdays on this site) are included, and amplitude of each bar represents the total number of sags occurring in the same time period (hourly basis) during the summer.

Figure T58 The plot of Average Magnitude of Sags versus Time of Day (summer, minimum power swing day) shows the distribution of average magnitude of sags (in Volts) according to different times in a day. Only the data of minimum power swing days (Saturdays on this site) are included, and amplitude of each bar represents the average magnitude of sags occurring in the same time period (hourly basis) during the summer.

Figure T59 The plot of Average Duration of Sags versus Time of Day (summer, minimum power swing day) shows the distribution of average duration of sags (in seconds) according to different times in a day. Only the data of minimum power swing days (Saturdays on this site) are included, and amplitude of each bar represents the average duration of sags occurring in the same time period (hourly basis) during the summer.

Figure T60 The plot of Number of Sags versus Time of Day (summer, maximum power swing day) shows the distribution of number of sags according to different times in a day. Only the data of maximum power swing days (Thursdays on this site) are included, and amplitude of each bar represents the total number of sags occurring in the same time period (hourly basis) during the summer.

Figure T61 The plot of Average Magnitude of Sags versus Time of Day (summer, maximum power swing day) shows the distribution of average magnitude of sags (in Volts) according to different times in a day. Only the data of maximum power swing days (Thursdays on this site) are included, and amplitude of each bar represents the average magnitude of sags occurring in the same time period (hourly basis) during the summer.

Figure T62 The plot of Average Duration of Sags versus Time of Day (summer, maximum power swing day) shows the distribution of average duration of sags (in seconds) according to different times in a day. Only the data of maximum power swing days (Thursdays on this site) are included, and amplitude of each bar represents the average duration of sags occurring in the same time period (hourly basis) during the summer.

3.2.2.3 Surge

Winter

Figure T63 The plot of Number of Surges versus Day of Week (winter) shows the distribution of number of surges according to different days of a week. Amplitude of each bar represents the total number of surges occurred in the same time period (hourly basis) during the winter.

Figure T64 The plot of Average Magnitude of Surges versus Day of Week (winter) shows the distribution of average magnitude of surges (in Volts) according to different days of a week. Amplitude represents the average magnitude of surges occurred in the same time period (hourly basis) during the winter.

Figure T65 The plot of Average Duration of Surges versus Day of Week (winter) shows the distribution of average duration of surges (in seconds) according to different days of a week. Amplitude of each bar represents the average duration of surges occurring in the same time period (hourly basis) during the winter.

Figure T66 The plot of Number of Surges versus Magnitude (winter) shows the distribution of number of surges according to different magnitude. Amplitude of each bar represents the total number of surges whose magnitudes are in a specific range (the magnitude interval is 0.5 V).

Figure T67 The plot of Number of Surges versus Duration (winter) shows the distribution of number of surges according to different duration. Amplitude of each bar represents the total number of surges whose durations are in a specific range (the duration interval is 0.1 seconds).

Figure T68 The plot of Number of Surges versus Time of Day (winter, minimum power swing day) shows the distribution of number of surges according to different times in a day. Only the data of minimum power swing days (Sundays on this site) are included, and amplitude of each bar represents the total number of surges occurring in the same time period (hourly basis) during the winter.

Figure T69 The plot of Average Magnitude of Surges versus Time of Day (winter, minimum power swing day) shows the distribution of average magnitude of surges (in Volts) according to different times in a day. Only the data of minimum power swing days (Sundays on this site) are included, and amplitude represents the average magnitude of surges occurring in the same time period (hourly basis) during the winter.

Figure T70 The plot of Average Duration of Surges versus Time of Day (winter, minimum power swing day) shows the distribution of average duration of surges (in seconds) according to different times in a day. Only the data of minimum power swing days (Sundays on this site) are included, and amplitude of each bar represents the average durajtion of surges occurring in the same time period (hourly basis) during the winter.

Figure T71 The plot of Number of Surges versus Time of Day (winter, maximum power swing day) shows the distribution of number of surges according to different times in a day. Only the data of maximum power swing days (Tuesdays on this site) are included, and amplitude of each bar represents the total number of surges occurring in the same time period (hourly basis) during the winter.

Figure T72 The plot of Average Magnitude of Surges versus Time of Day (winter, maximum power swing day) shows the distribution of average magnitude of surges (in Volts) according to different times in a day. Only the data of maximum power swing days (Tuesdays on this site) are included, and amplitude represents the average magnitude of surges occurring in the same time period (hourly basis) during the winter.

Figure T73 The plot of Average Duration of Surges versus Time of Day (winter, maximum power swing day) shows the distribution of average duration of surges (in seconds) according to different times in a day. Only the data of maximum power swing days (Tuesdays on this site) are included, and amplitude represents the average duration of surges occurring in the same time period (hourly basis) during the winter.

Figure T74 The plot of Number of Surges versus Day of Week (summer) shows the distribution of number of surges according to different days of a week. Amplitude of each bar represents the total number of surges occurring in the same time period (hourly basis) during the summer.

Figure T75 The plot of Average Magnitude of Surges versus Day of Week (summer) shows the distribution of average magnitude of surges (in Volts) according to different days of a week. Amplitude represents the average magnitude of surges occurring in the same time period (hourly basis) during the summer.

Figure T76 The plot of Average Duration of Surges versus Day of Week (summer) shows the distribution of average duration of surges (in seconds) according to different days of a week. Amplitude represents the average duration of surges occurring in the same time period (hourly basis) during the summer.

Figure T77 The plot of Number of Surges versus Magnitude (summer) shows the distribution of number of surges according to different magnitude. Amplitude of each bar represents the total number of surges whose magnitudes are in a specific range (the magnitude interval is 0.5 V).

Figure T78 The plot of Number of Surges versus Duration (summer) shows the distribution of number of surges according to different duration. Amplitude of each bar represents the total number of surges whose durations are in a specific range (the duration interval is 0.1 seconds).

Figure T79 The plot of Number of Surges versus Time of Day (summer, minimum power swing day) shows the distribution of number of surges according to different times in a day. Only the data of minimum power swing days (Saturdays on this site) are included, and amplitude of each bar represents the total number of surges occurring in the same time period (hourly basis) during the summer.

Figure T80 The plot of Average Magnitude of Surges versus Time of Day (summer, minimum power swing day) shows the distribution of average magnitude of surges (in Volts) according to different times in a day. Only the data of minimum power swing days (Saturdays on this site) are included, and amplitude represents the average magnitude of surges occurring in the same time period (hourly basis) during the summer.

Figure T81 The plot of Average Duration of Surges versus Time of Day (summer, minimum power swing day) shows the distribution of average duration of surges (in seconds) according to different times in a day. Only the data of minimum power swing days (Saturdays on this site) are included, and amplitude of each bar represents the average duration of surges occurring in the same time period (hourly basis) during the summer.

Figure T82 The plot of Number of Surges versus Time of Day (summer, maximum power swing day) shows the distribution of number of surges according to different time in a day. Only the data of maximum power swing days (Thursdays on this site) are included, and amplitude of each bar represents the total number of surges occurring in the same time period (hourly basis) during the summer.

Figure T83 The plot of Average Magnitude of Surges versus Time of Day (summer, maximum power swing day) shows the distribution of average magnitude of surges (in Volts) according to different times in a day. Only the data of maximum power swing days (Thursdays on this site) are included, and amplitude of the line represents the average magnitude of surges occurring in the same time period (hourly basis) during the summer.

Figure T84 The plot of Average Duration of Surges versus Time of Day (summer, maximum power swing day) shows the distribution of average duration of surges (in seconds) according to different times in a day. Only the data of maximum power swing days (Thursdays on this site) are included, and amplitude of each bar represents the average duration of surges occurring in the same time period (hourly basis) during the summer.

3.2.2.4 Frequency Disturbances

Winter

Figure T85 The plot of Number of Frequency Disturbances versus Day of Week (winter) shows the distribution of number of frequency disturbances according to different days of a week. Amplitude of each bar represents the total number of frequency disturbances occurring in the same time period (hourly basis) during the winter.

Figure T86 The plot of Average Magnitude of Frequency Disturbances versus Day of Week (winter) shows the distribution of average magnitude of frequency disturbances (in Hz) according to different days of a week. Amplitude represents the average magnitude of frequency disturbances occurring in the same time period (hourly basis) during the winter.

Figure T87 The plot of Number of Frequency Disturbances versus Frequency (winter) shows the distribution of number of frequency disturbances according to different frequency. Amplitude of each bar represents the total number of frequency disturbances whose frequencies are in a specific range (the frequency interval is 0.5 Hz).

Figure T88 The plot of Number of Frequency Disturbances versus Time of Day (winter, maximum power swing day) shows the distribution of number of frequency disturbances according to different times in a day. Only the data of maximum power swing days (Sundays on this site) are included, and amplitude of each bar represents the total number of frequency disturbances occurring in the same time period (hourly basis) during the winter.

Figure T89 The plot of Average Maximum of Frequency Disturbances versus Time of Day (winter, maximum power swing day) shows the distribution of average magnitude of frequency disturbances (in Hz) according to different times in a day. Only the data of minimum power swing days (Sundays on this site) are included and amplitude represents the average magnitude of frequency disturbances occurring in the same time period (hourly basis) during the winter.

Figure T90 The plot of Number of Frequency Disturbances versus Time of Day (winter, maximum power swing day) shows the distribution of number of frequency disturbances according to different times in a day. Only the data of maximum power swing days (Tuesdays on this site) are included, and amplitude of each bar represents the total number of frequency disturbances occurring in the same time period (hourly basis) during the winter.

Figure T91 The plot of Average Magnitude of Frequency Disturbances versus Time of Day (winter, maximum power swing day) shows the distribution of average magnitude of frequency disturbances (in Hz) according to different times in a day. Only the data of maximum power swing days (Tuesdays on this site) are included, and amplitude represents the average magnitude of frequency disturbances occurring in the same time period (hourly basis) during the winter.

Summer

Figure T92 The plot of Number of Frequency Disturbances versus Day of Week (summer) shows the distribution of number of frequency disturbances according to different days of a week. Amplitude of each bar represents the total number of frequency disturbances occurring in the same time period (hourly basis) during the summer.

Figure T93 The plot of Average Magnitude of Frequency Disturbances versus Day of Week (summer) shows the distribution of average magnitude of frequency disturbances (in Hz) according to different days of a week. Amplitude represents the average magnitude of frequency disturbances occurring in the same time period (hourly basis) during the summer.

Figure T94 The plot of Number of Frequency Disturbances versus Frequency (summer) shows the distribution of number of frequency disturbances according to different magnitude. Amplitude of each bar represents the total number of frequency disturbances whose frequencies are in a specific range (the frequency interval is 0.5 Hz).

Figure T95 The plot of Number of Frequency Disturbances versus Time of Day (summer, minimum power swing day) shows the distribution of number of frequency disturbances according to different times in a day. Only the data of minimum power swing days (Saturdays on this site) are included, and amplitude of each bar represents the total number of frequency disturbances occurring in the same time period (hourly basis) during the summer.

Figure T96 The plot of Average Magnitude of Frequency Disturbances versus Time of Day (summer, minimum power swing day) shows the distribution of average magnitude of frequency disturbances (in Hz) according to different times in a day. Only the data of minimum power swing days (Saturdays on this site) are included, and amplitude represents the average magnitude of frequency disturbances occurring in the same time period (hourly basis) during the summer.

Figure 97 The plot of Number of Frequency Disturbances versus Time of Day (summer, maximum power swing day) shows the distribution of number of frequency disturbances according to different times in a day. Only the data of maximum power swing days (Thursdays on this site) are included, and amplitude of each bar represents the total number of frequency disturbances occurring in the same time period (hourly basis) during the summer.

Figure T98 The plot of Average Magnitude of Frequency Disturbances versus Time of Day (summer, maximum power swing day) shows the distribution of average magnitude of frequency disturbances (in Hz) according to different times in a day. Only the data of maximum power swing days (Thursdays on this site) are included, and amplitude represents the average magnitude of frequency disturbances occurring in the same time period (hourly basis) during the summer.

3.2.2.5 Voltages

Winter

Figure T99 The plot of Number of Over Voltage Events versus Voltage (winter) shows the distribution of number of over-voltage disturbances according to different voltage. Amplitude of each bar represents the total number of voltage disturbances whose magnitudes are in a specific range (the voltage interval is 0.2v).

Figure T100 The plot of Number of Under Voltage Events versus Voltage (winter) shows the distribution of number of under-voltage disturbances according to different voltage. Amplitude of each bar represents the total number of voltage disturbances whose magnitudes are in a specific range (the voltage interval is 10v).

Summer

Figure T101 The plot of Number of Over Voltage Events versus Voltage (summer) shows the distribution of number of over-voltage disturbances according to different voltage. Amplitude of each bar represents the total number of voltage disturbances whose magnitudes are in a specific range (the voltage interval is 0.2v).

Figure T102 The plot of Number of Under Voltage Events versus Voltage (summer) shows the distribution of number of under-voltage disturbances according to different voltage. Amplitude of each bar represents the total number of voltage disturbances whose magnitudes are in a specific range (the voltage interval is 10v).

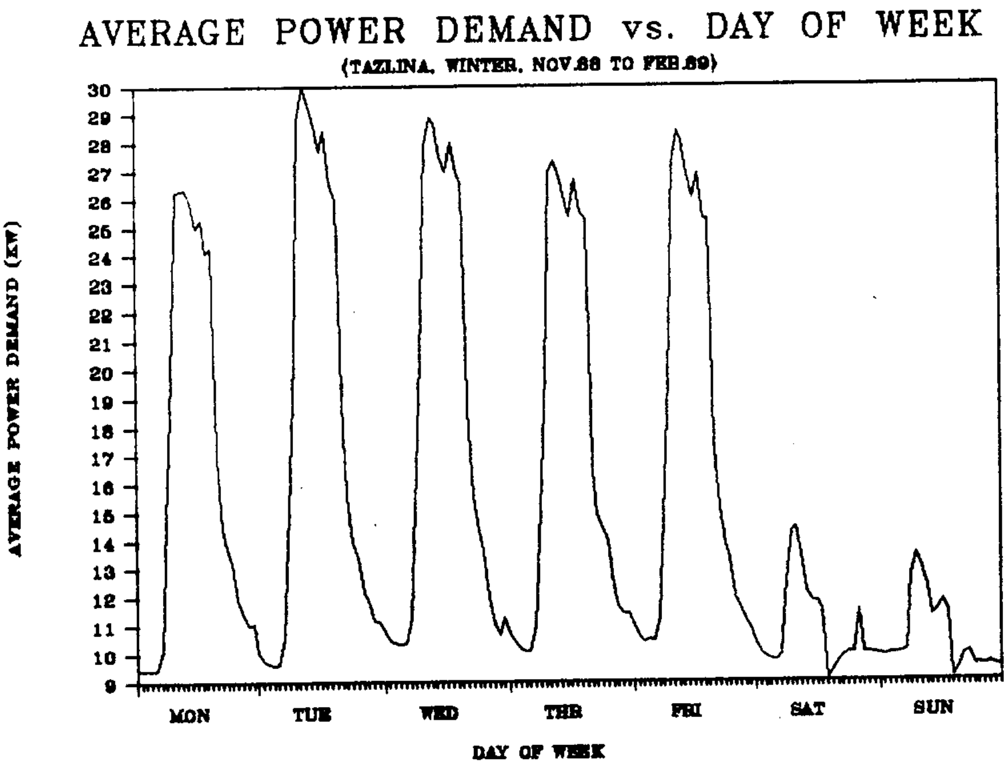


Figure T1

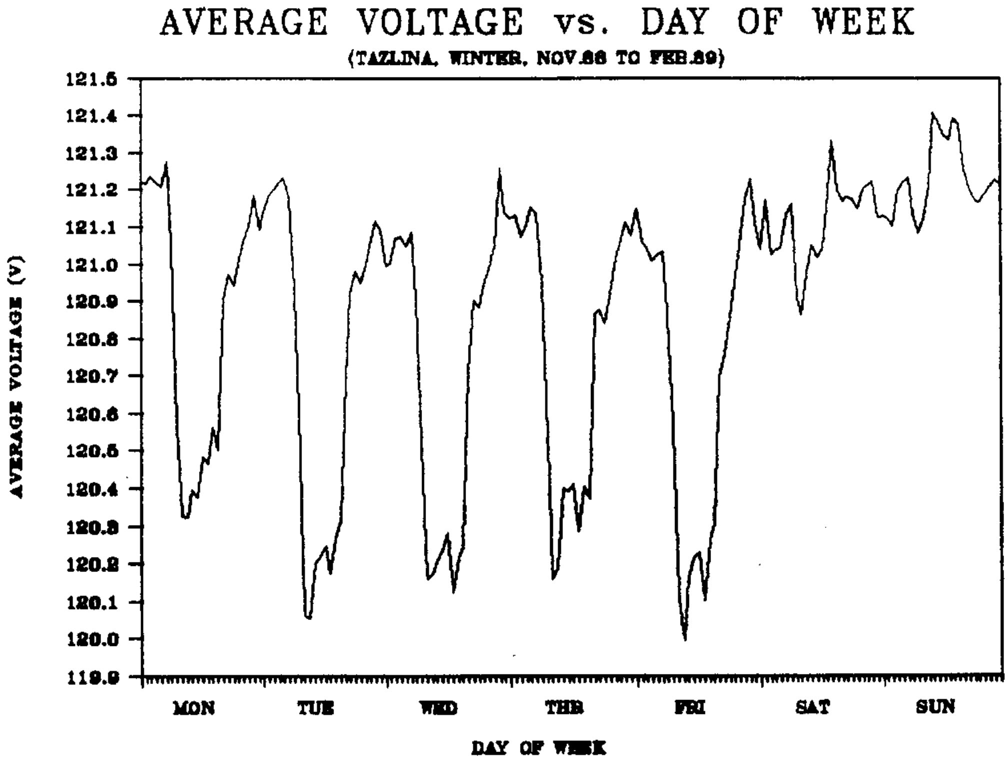


Figure T2

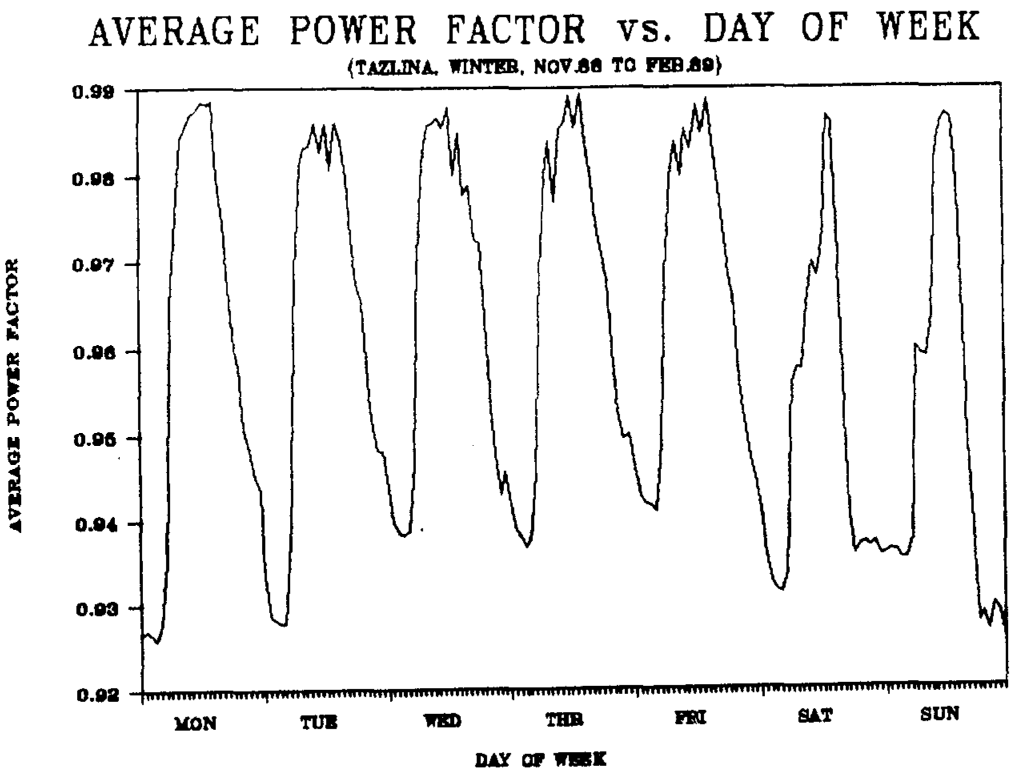


Figure T3

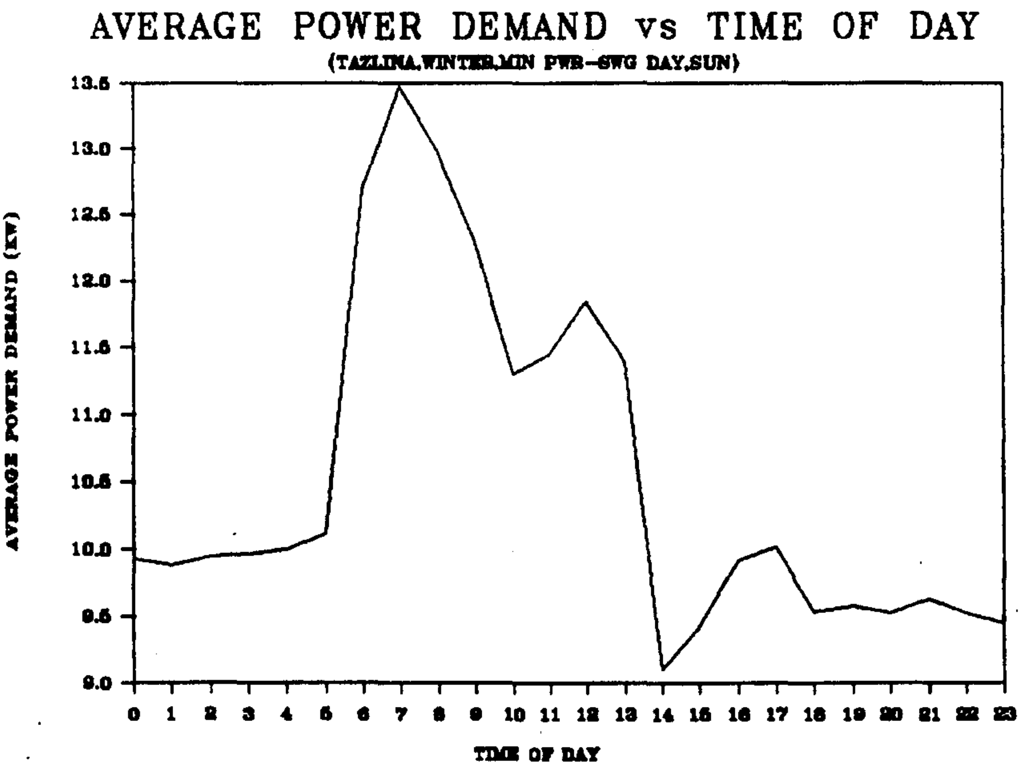


Figure T4

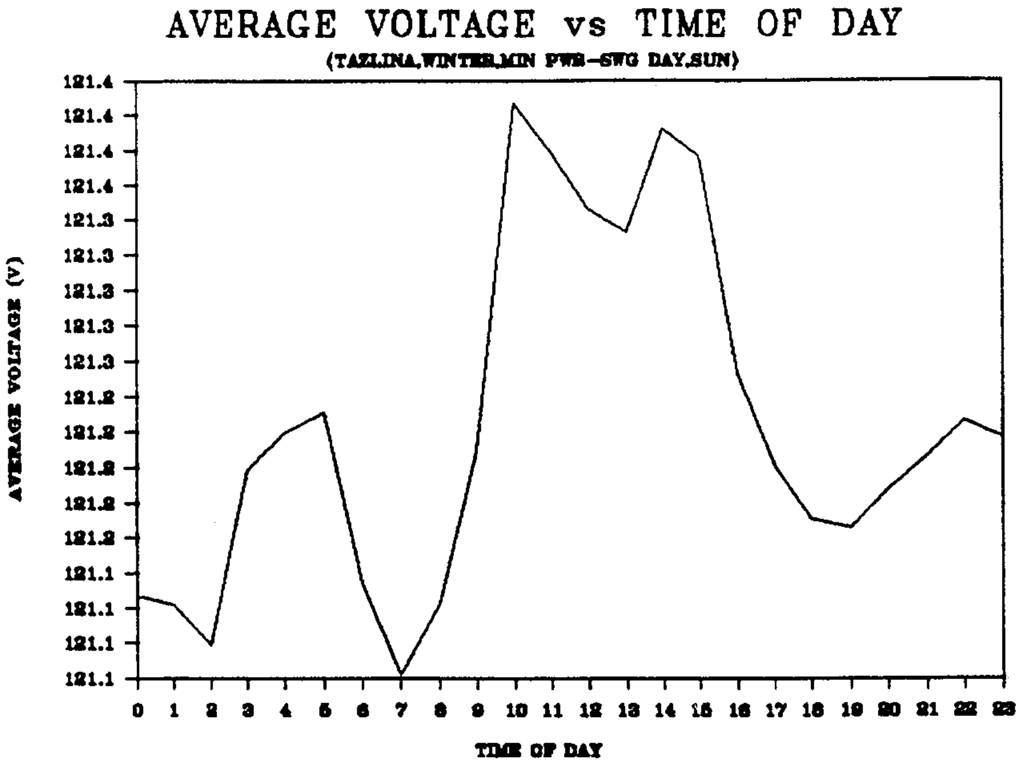


Figure T5

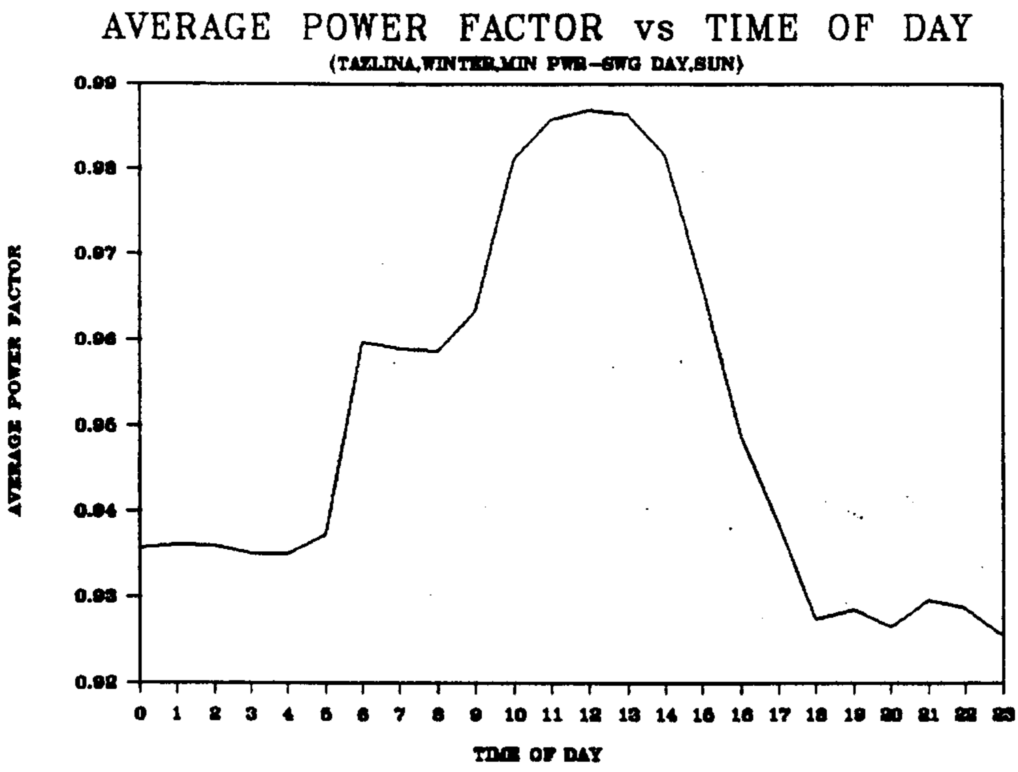


Figure T6

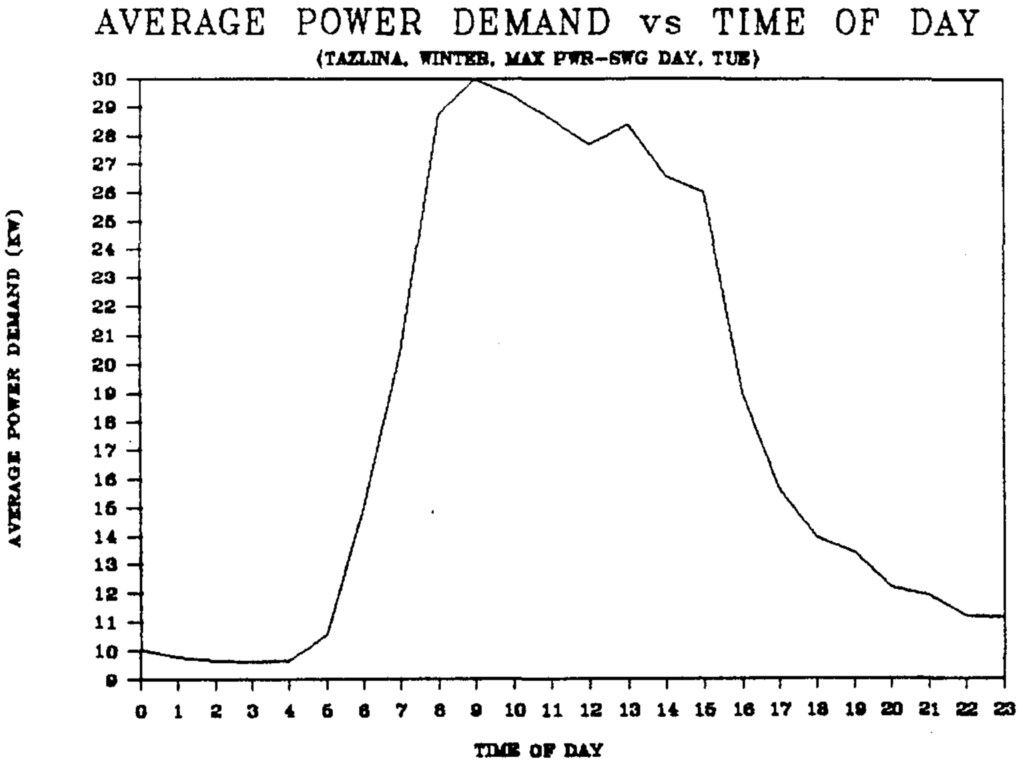


Figure T7

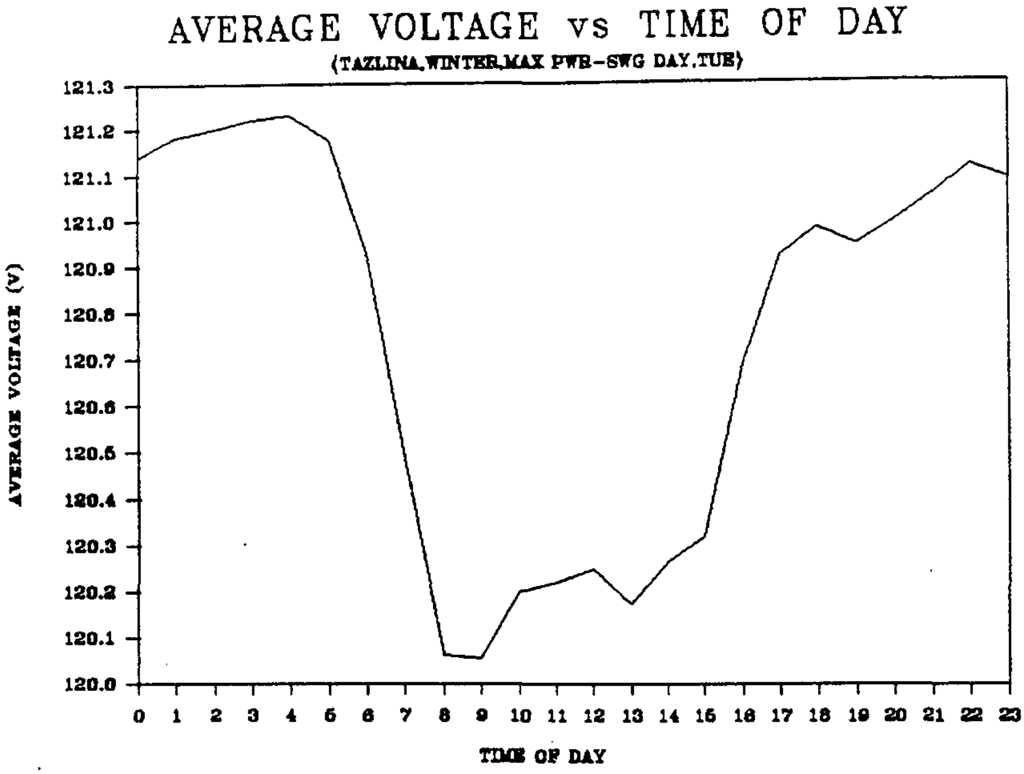


Figure T8

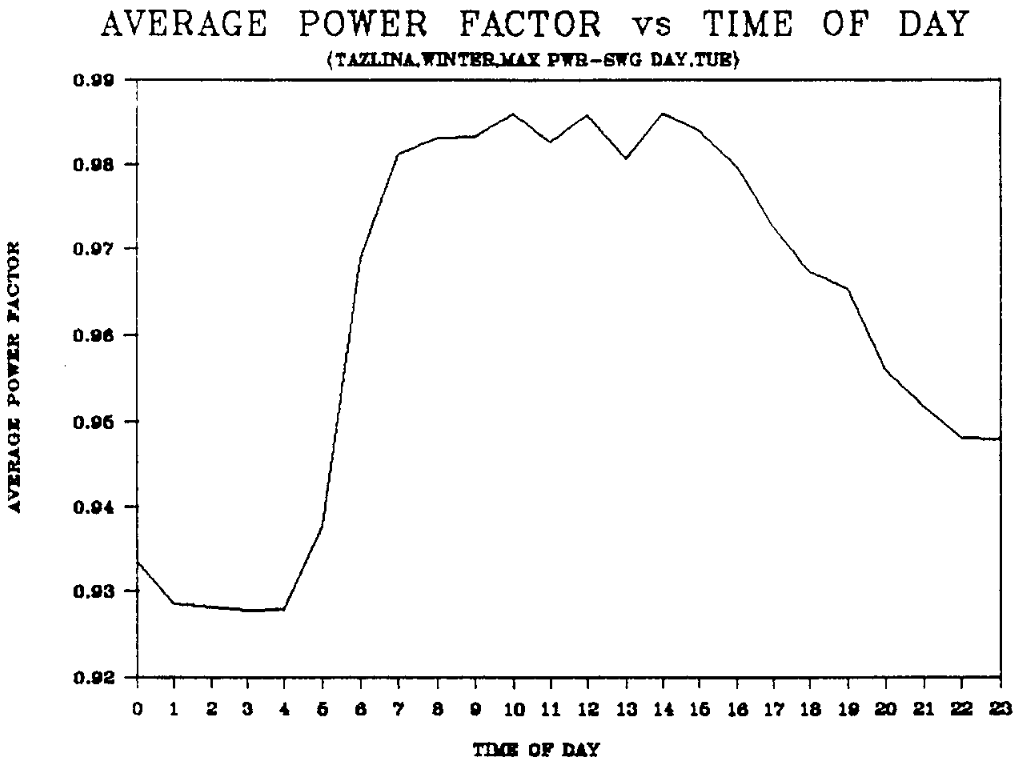


Figure T9

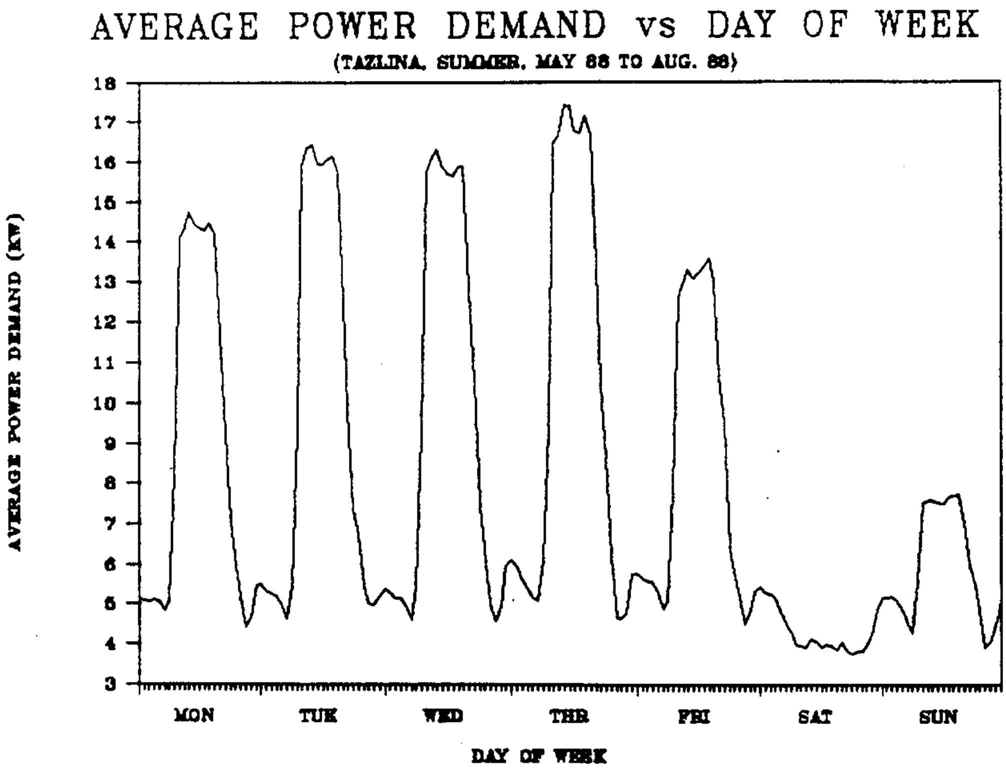


Figure T10

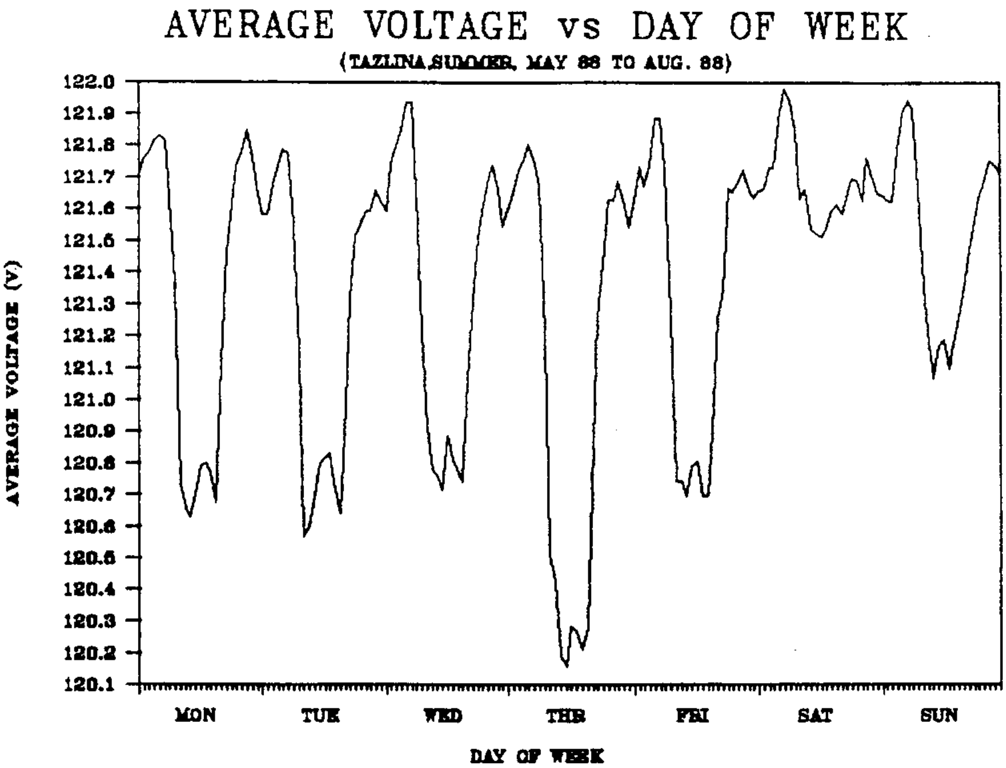


Figure T11

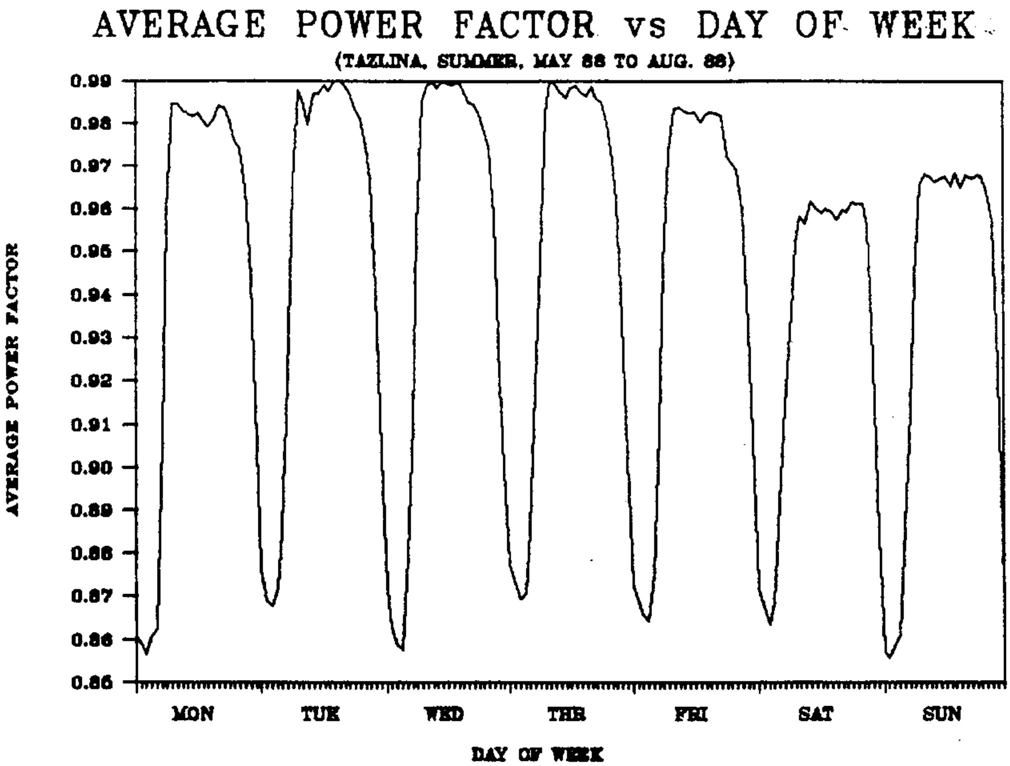


Figure T12

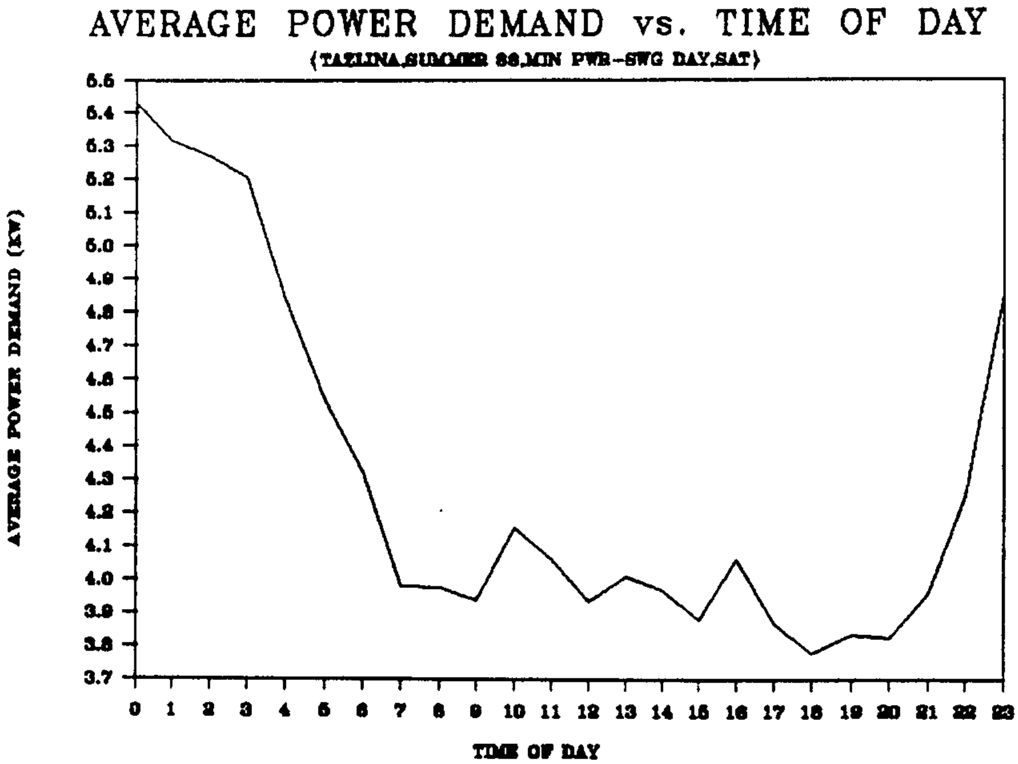


Figure T13

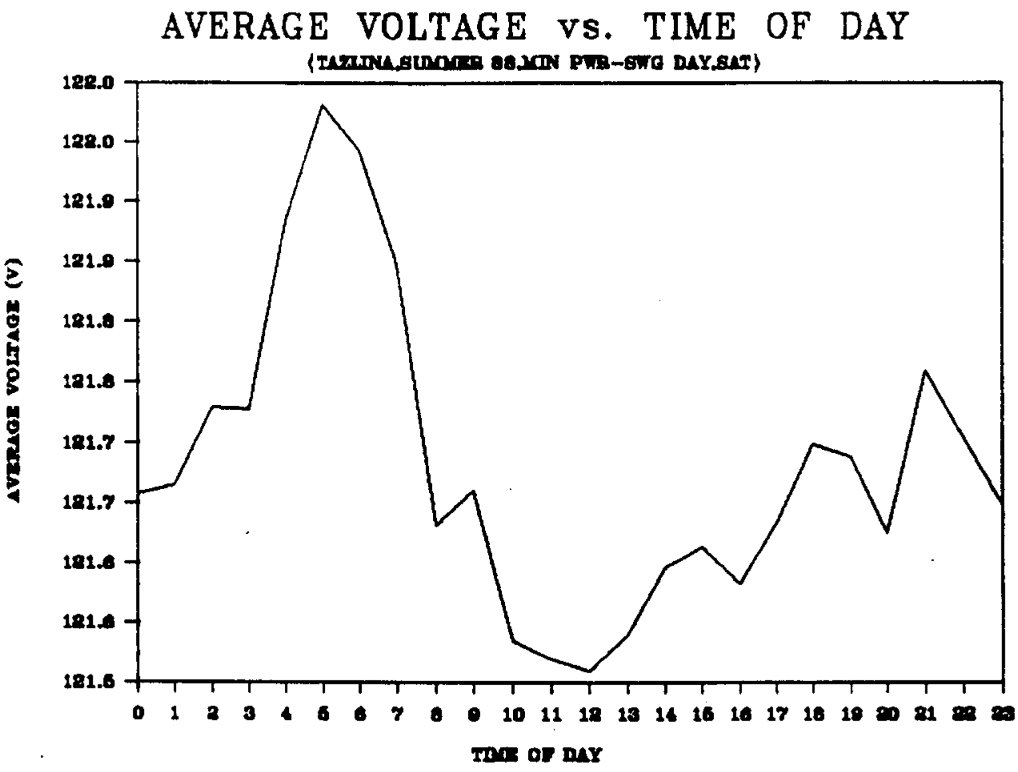


Figure T14

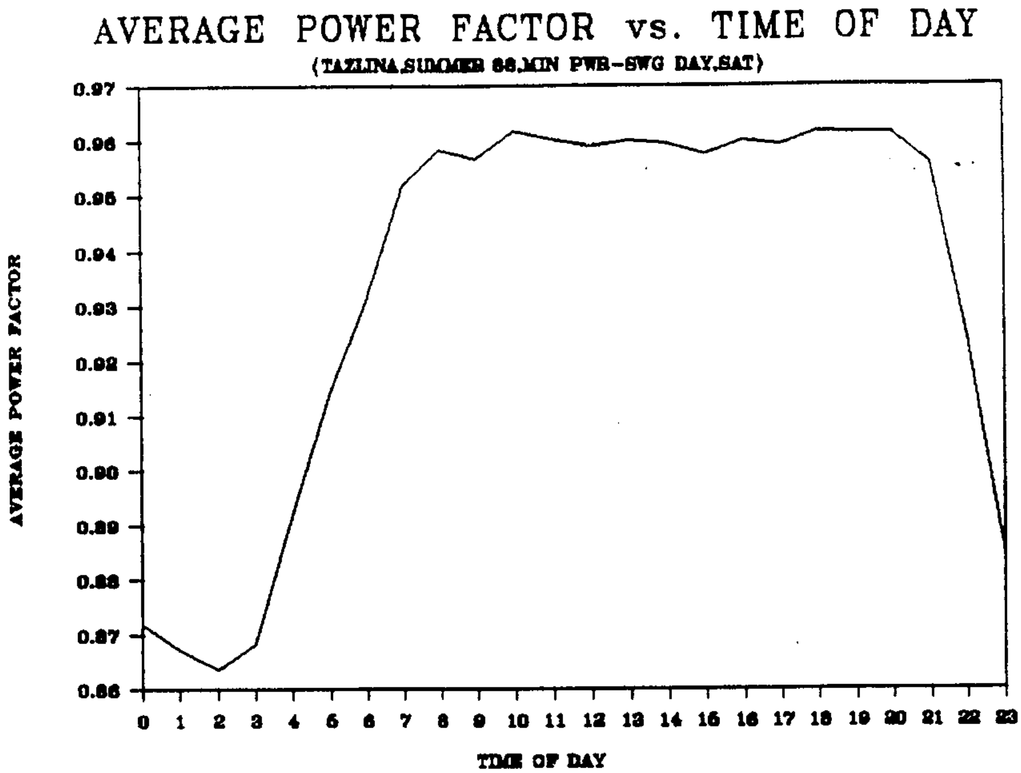


Figure T15

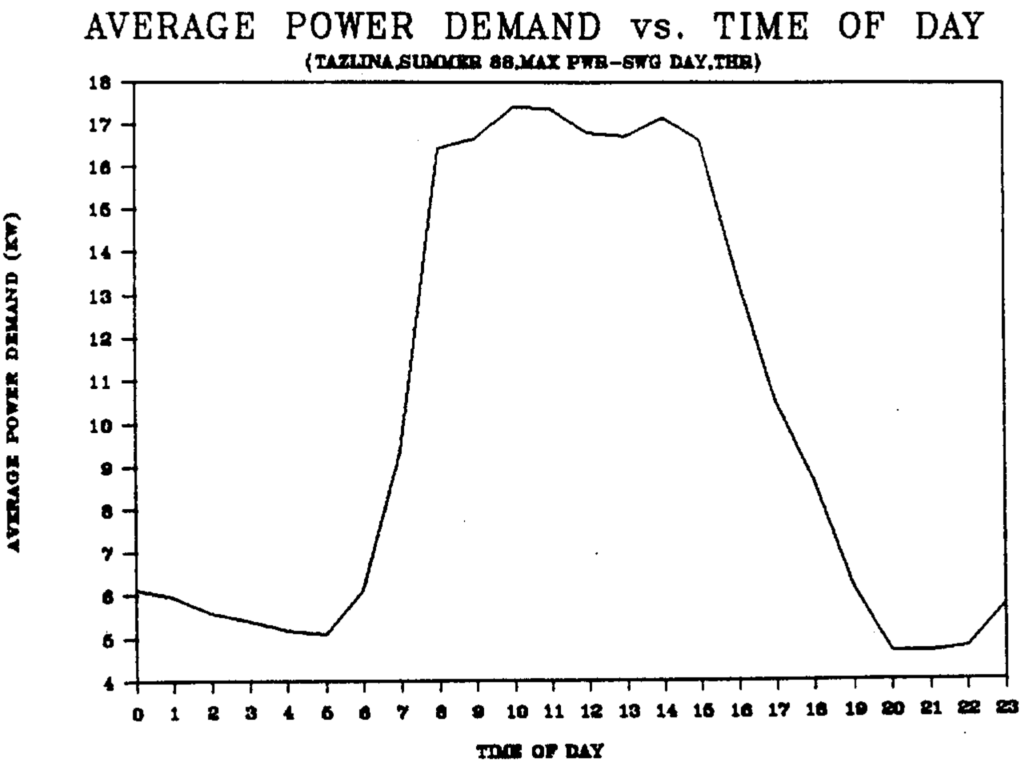


Figure T16

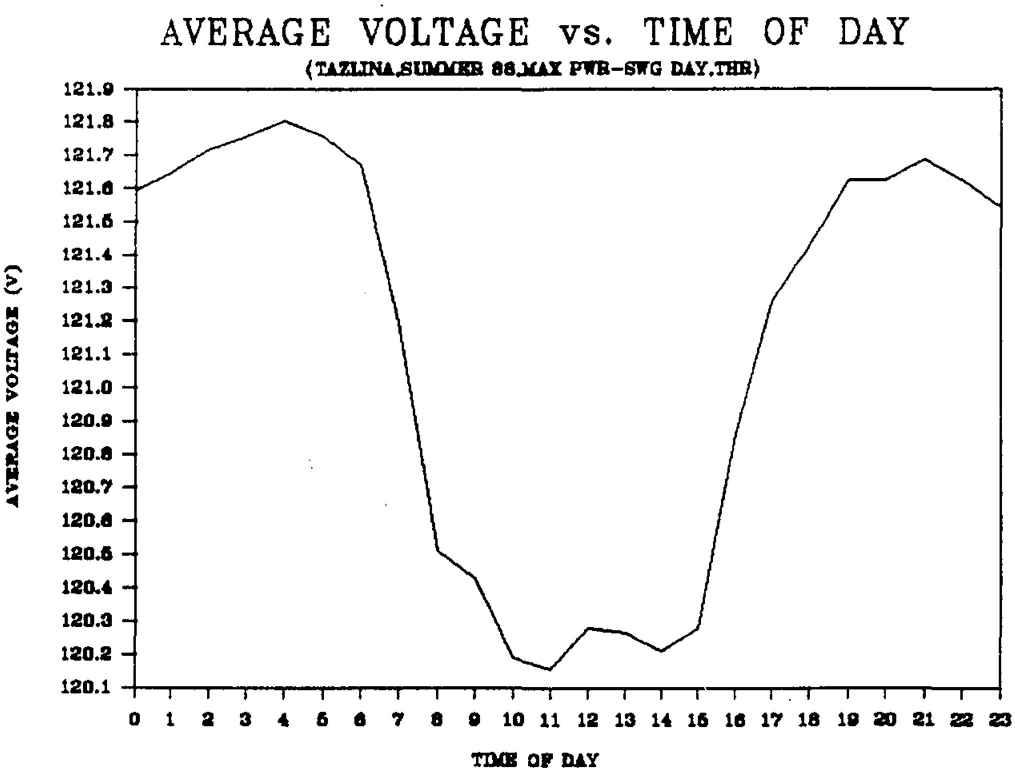


Figure T17

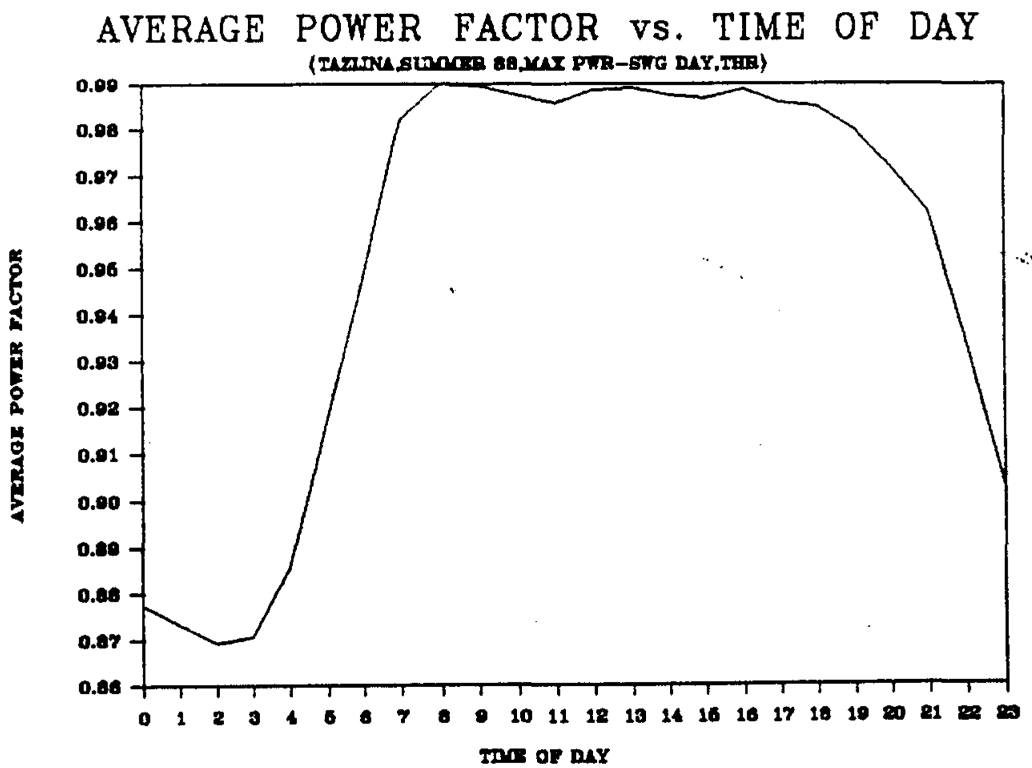


Figure T18

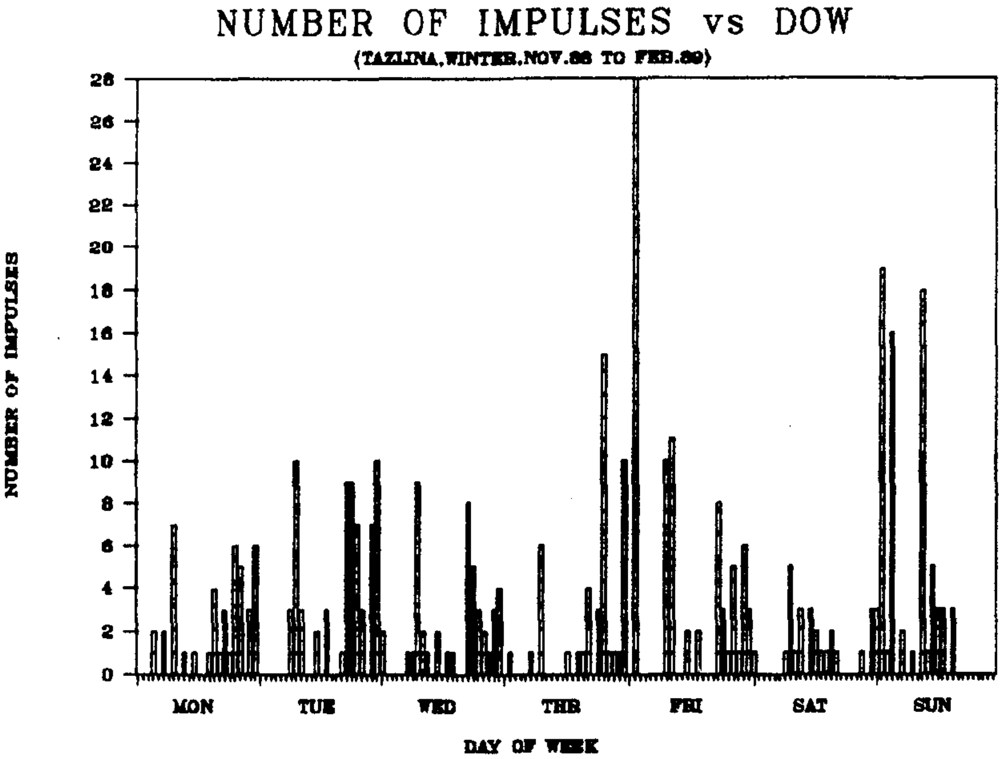


Figure T19

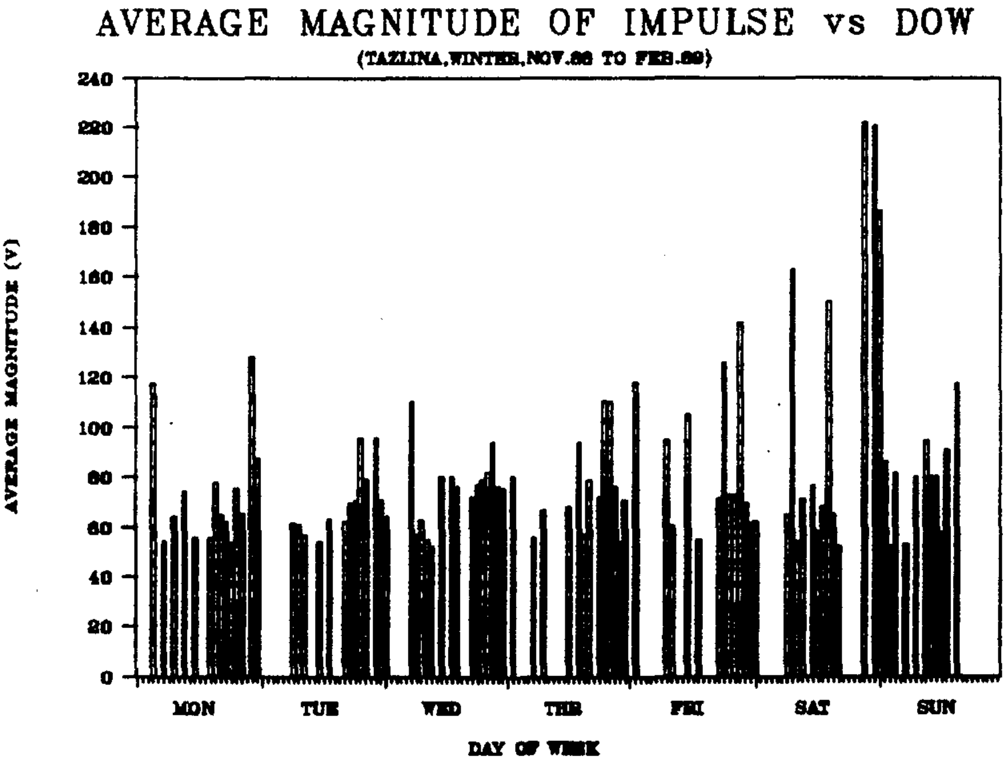


Figure T20

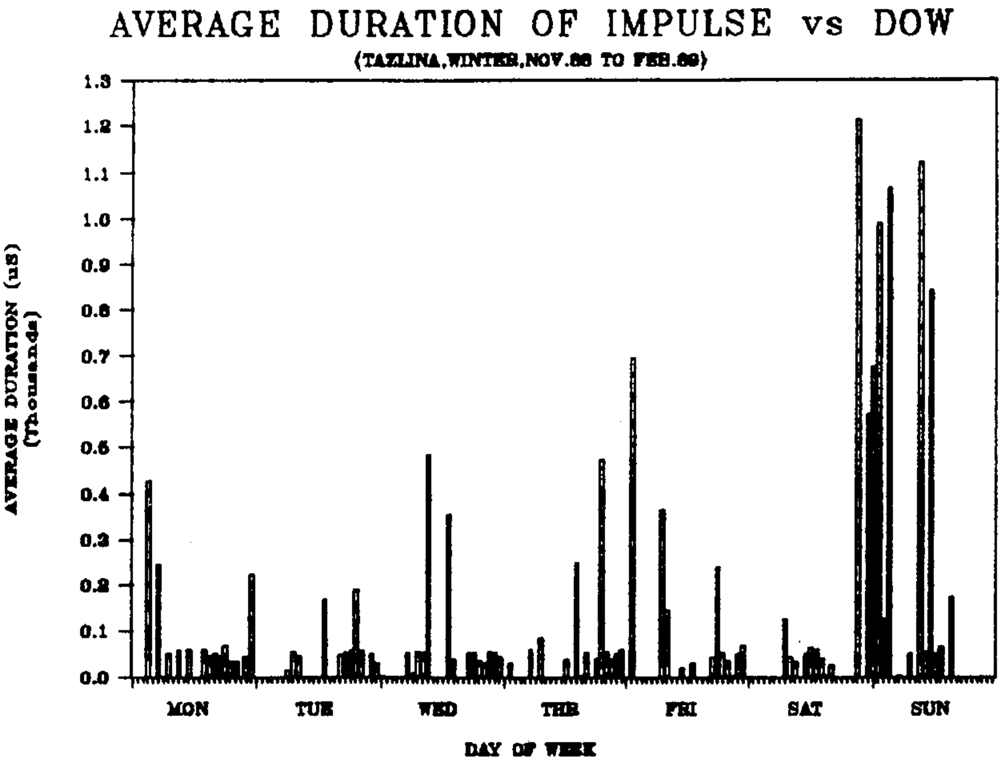


Figure T21

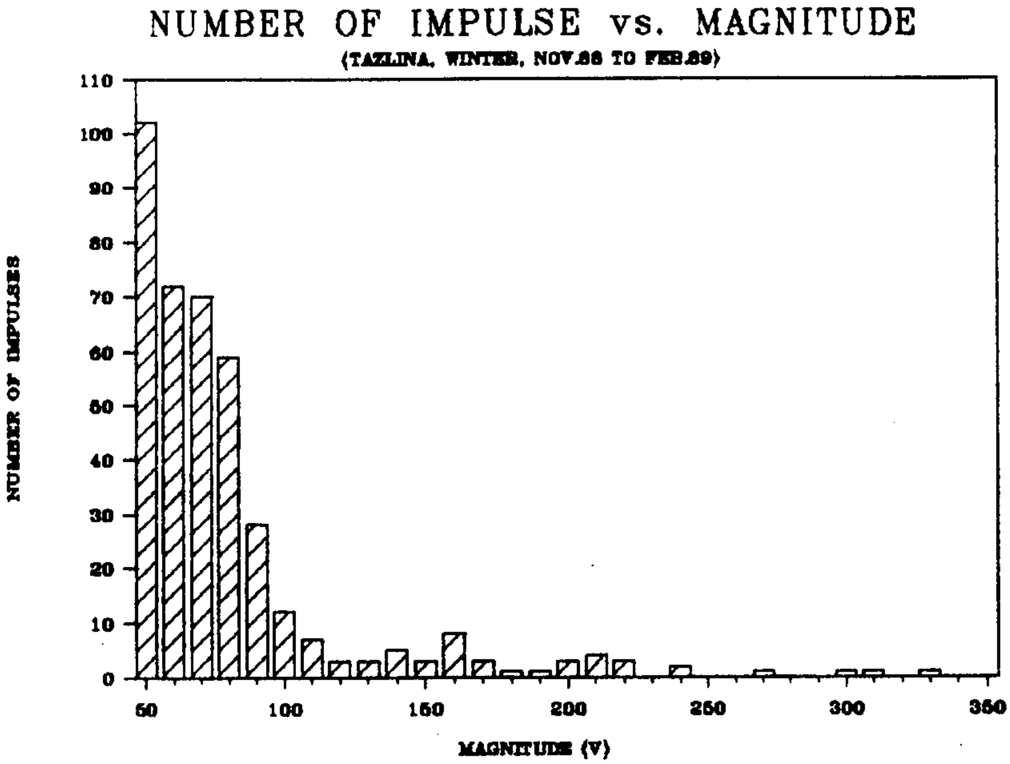


Figure T22

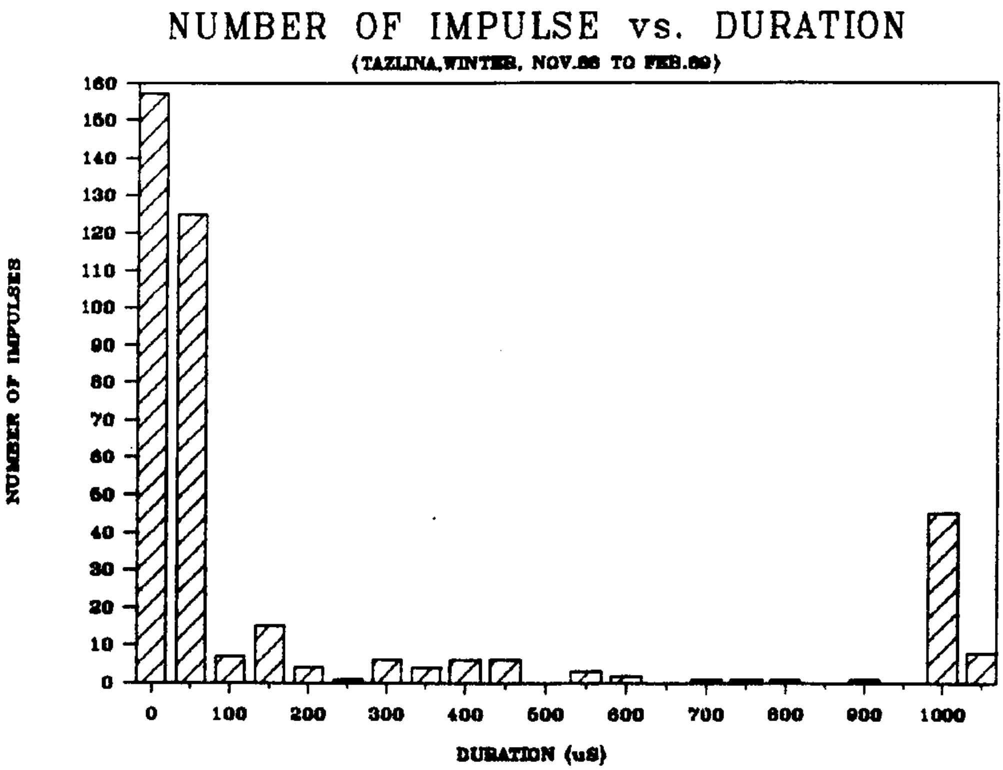


Figure T23

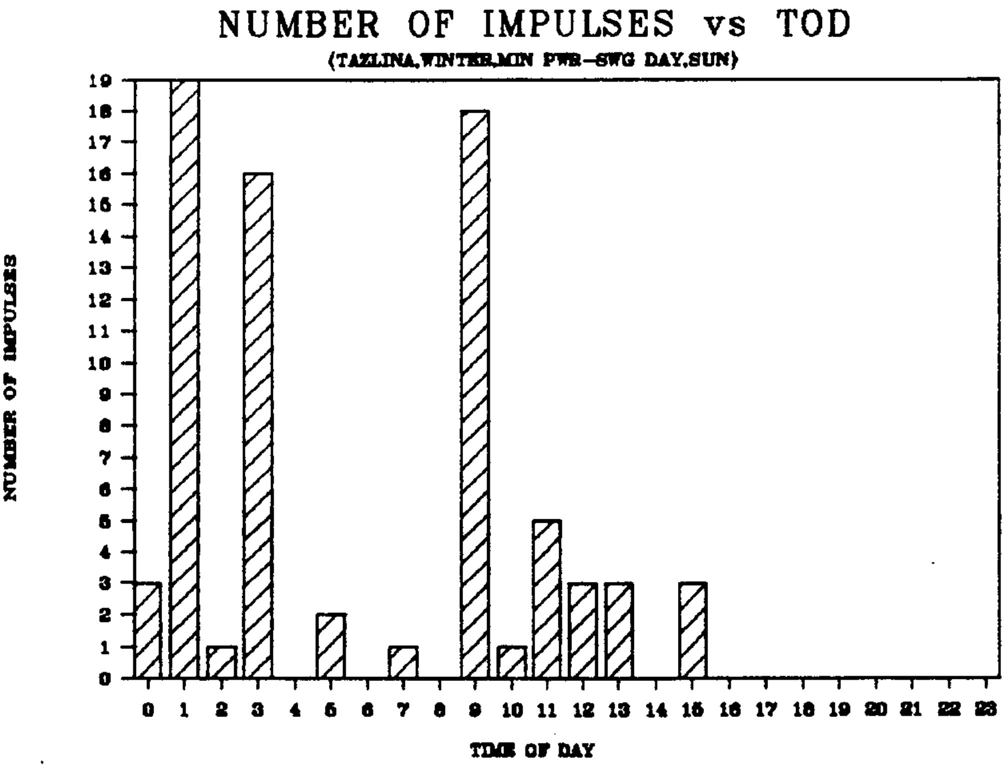


Figure T24

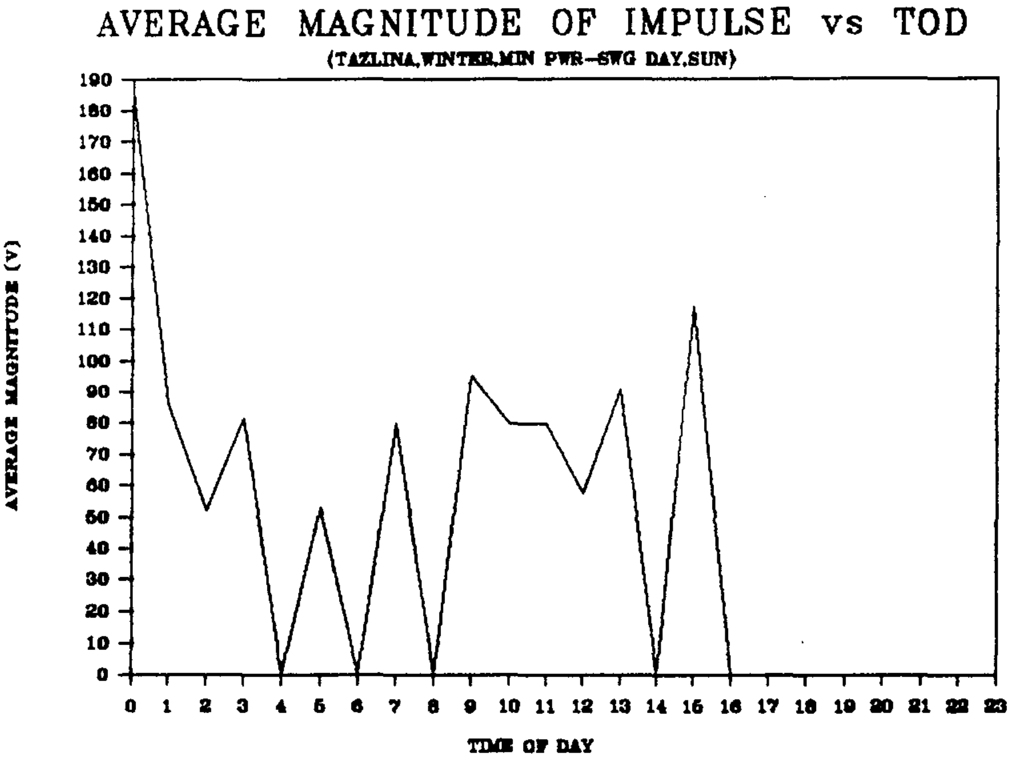


Figure T25

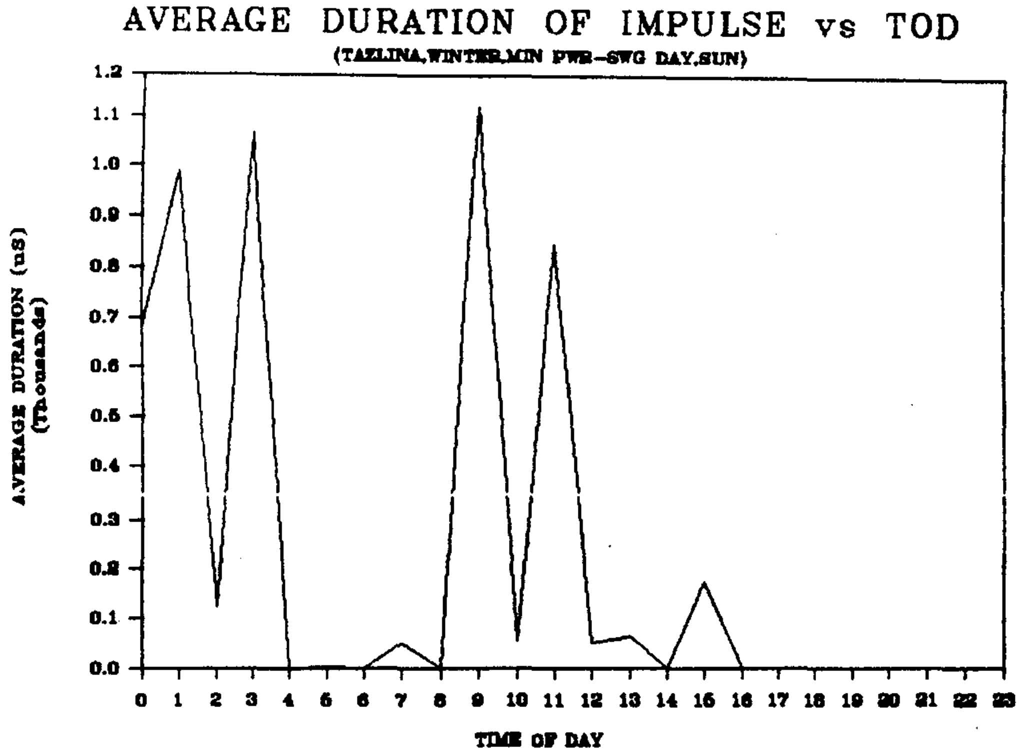


Figure T26

NUMBER OF IMPULSES vs TOD

(TAZLINA, WINTER, MAX PWR-SWG DAY, TUE)

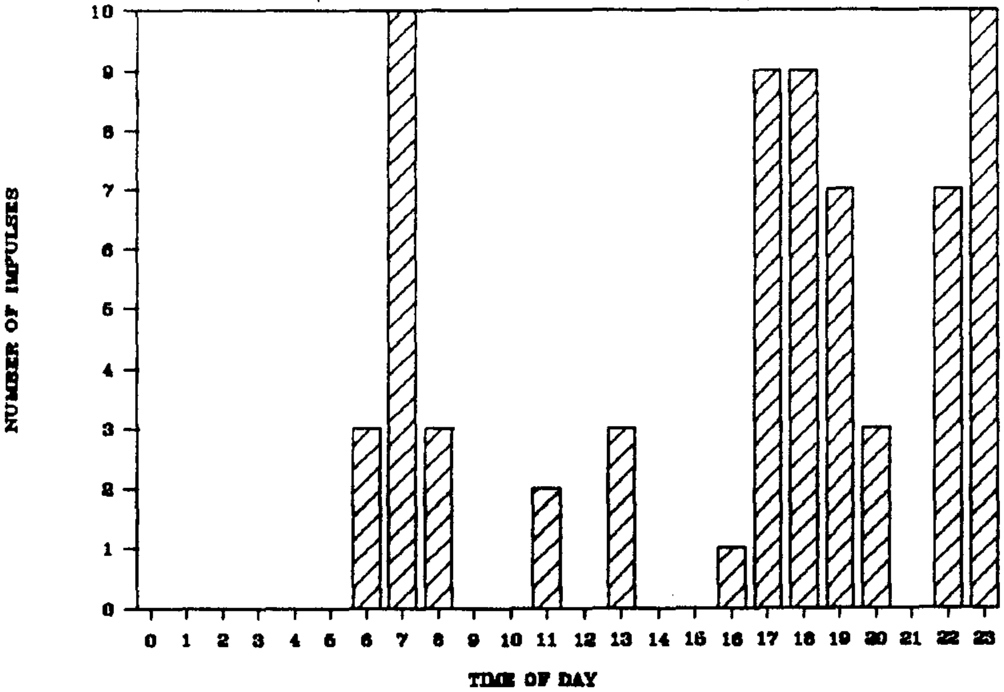


Figure T27

AVERAGE MAGNITUDE OF IMPULSE vs TOD

(TAZLINA, WINTER, MAX PWR-SWG DAY, TUE)

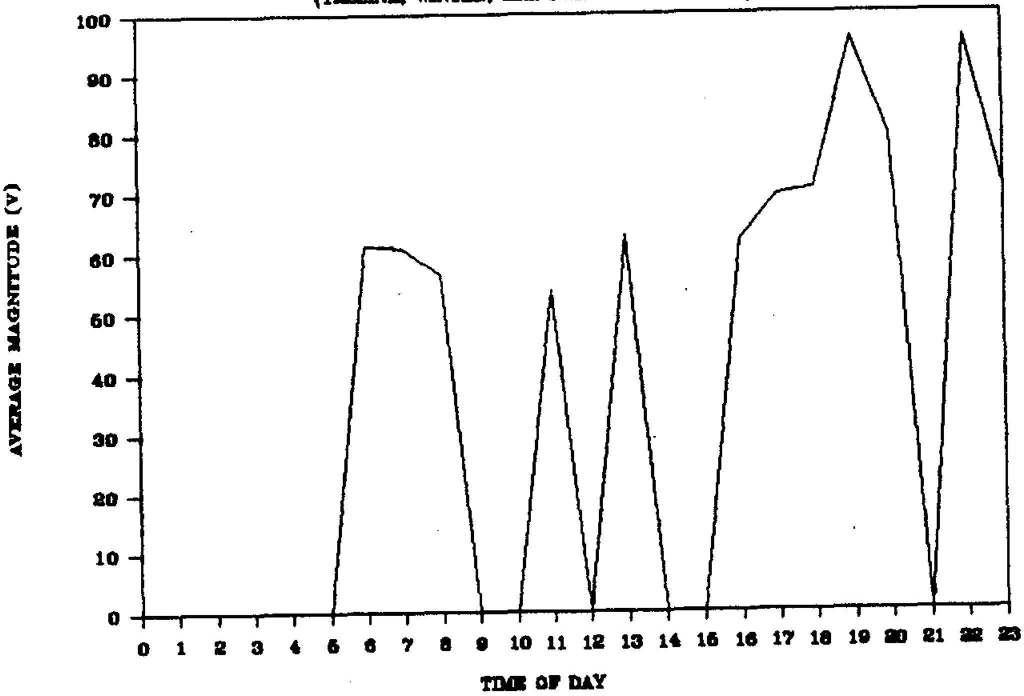


Figure T28

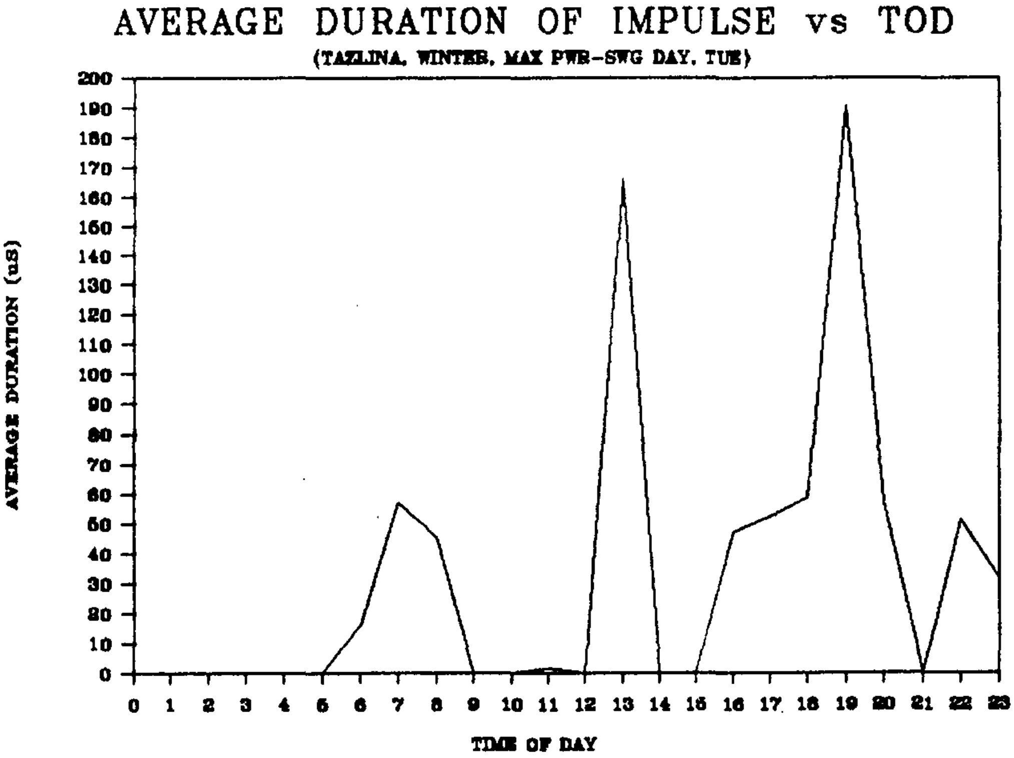


Figure T29

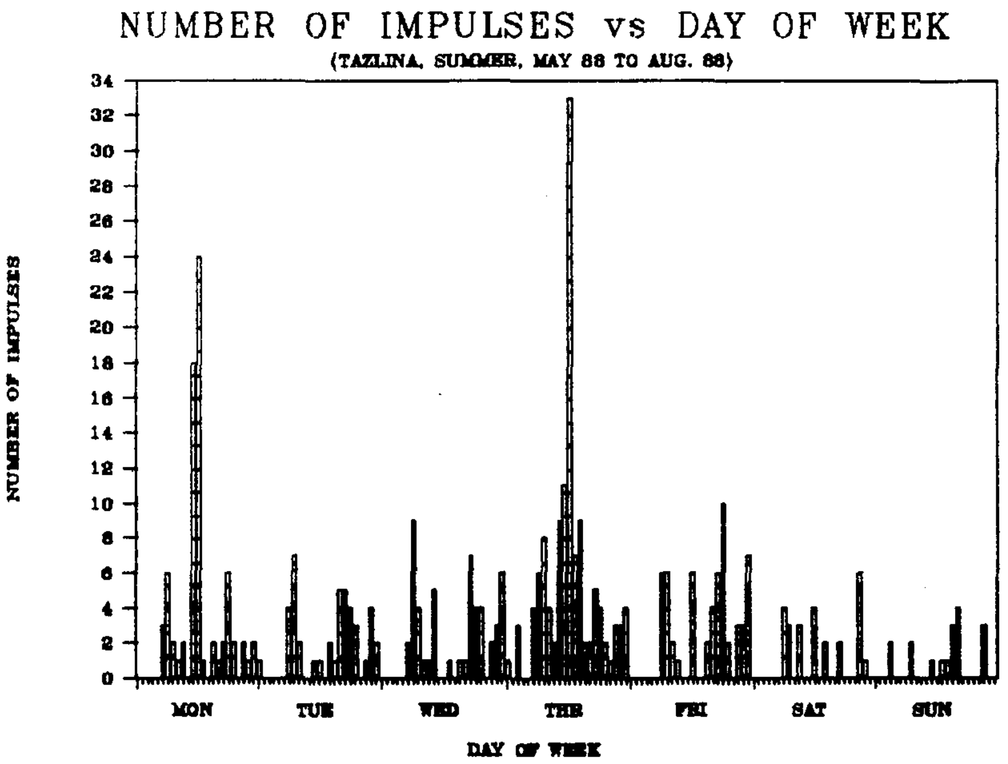


Figure T30

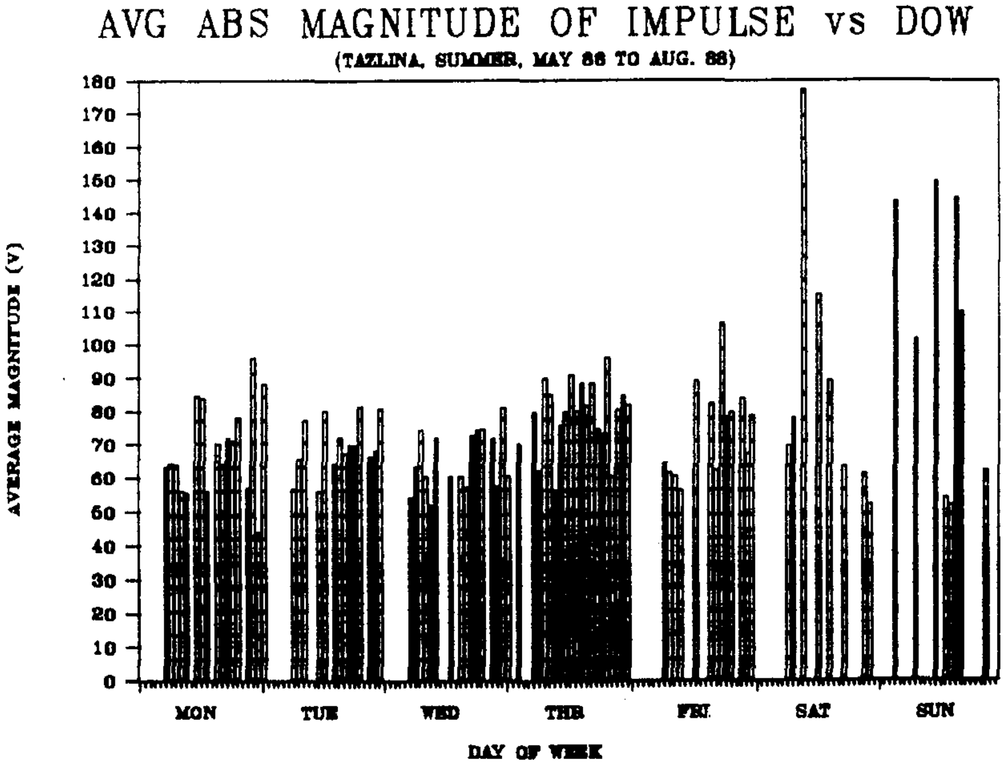


Figure T31

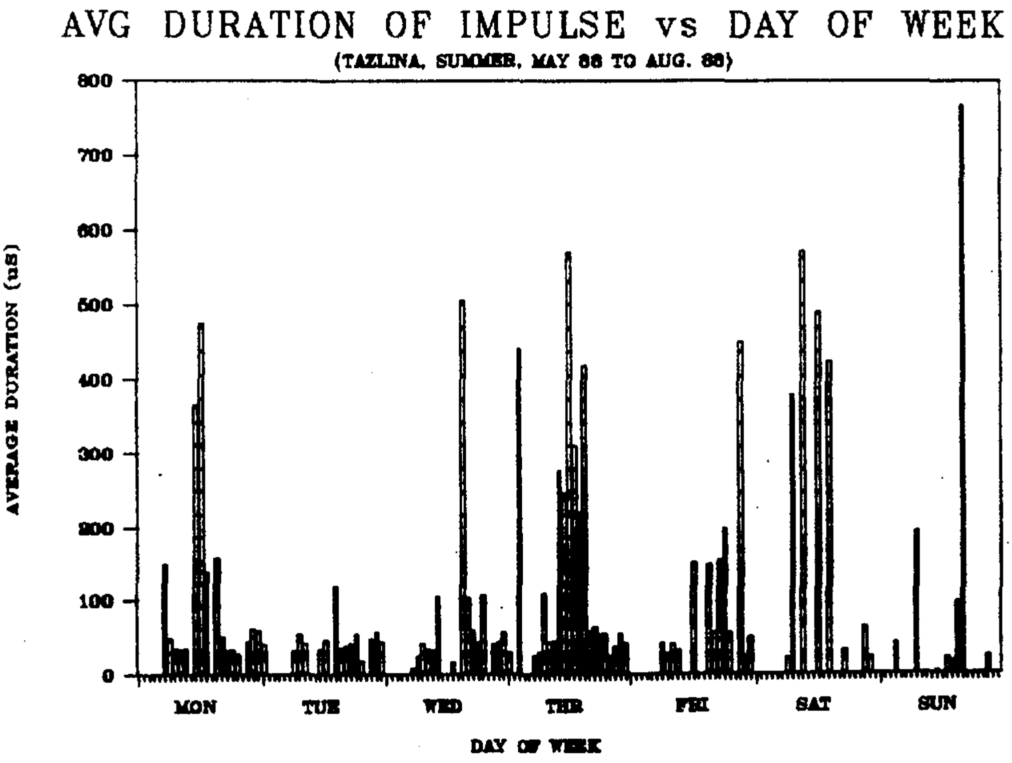


Figure T32

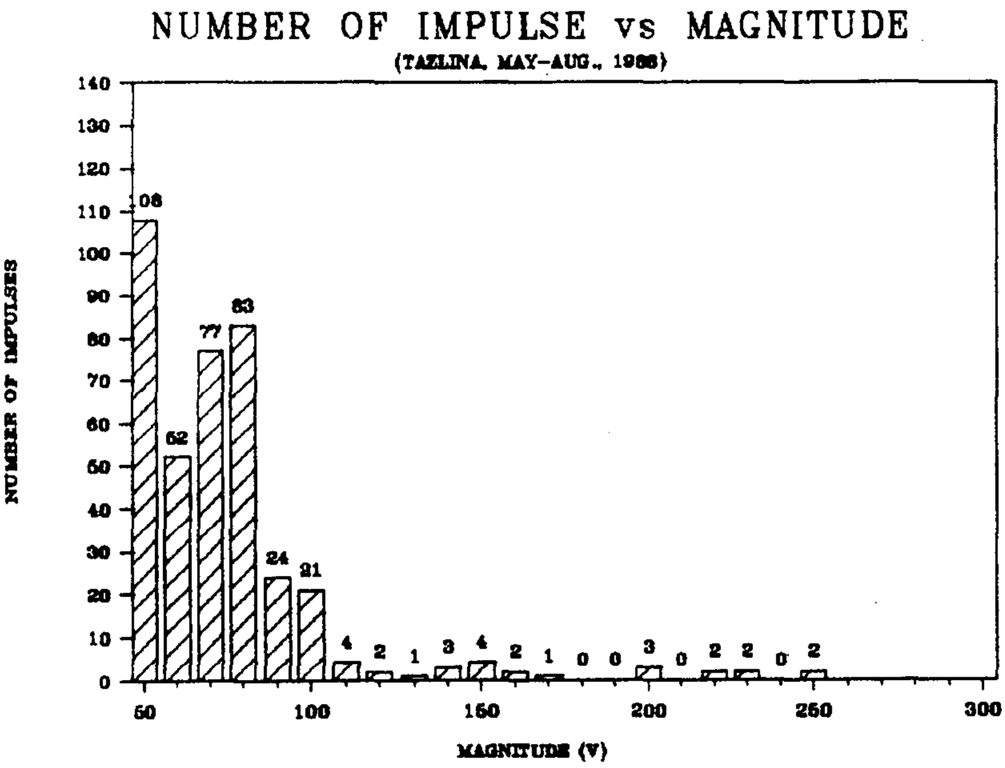


Figure T33

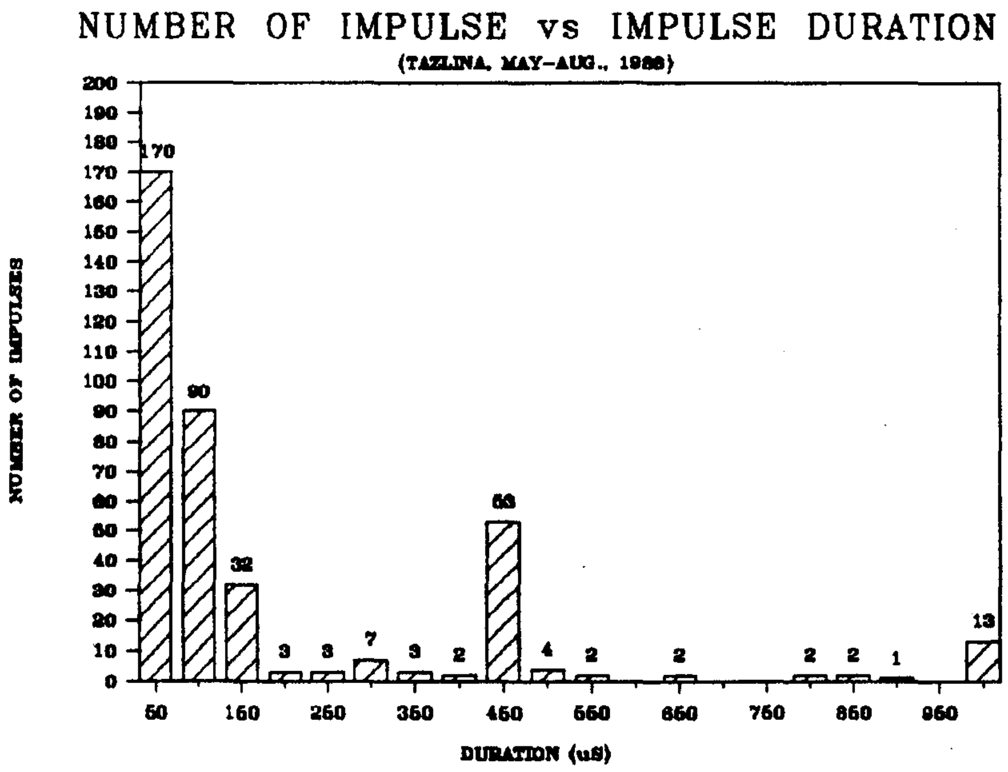


Figure T34

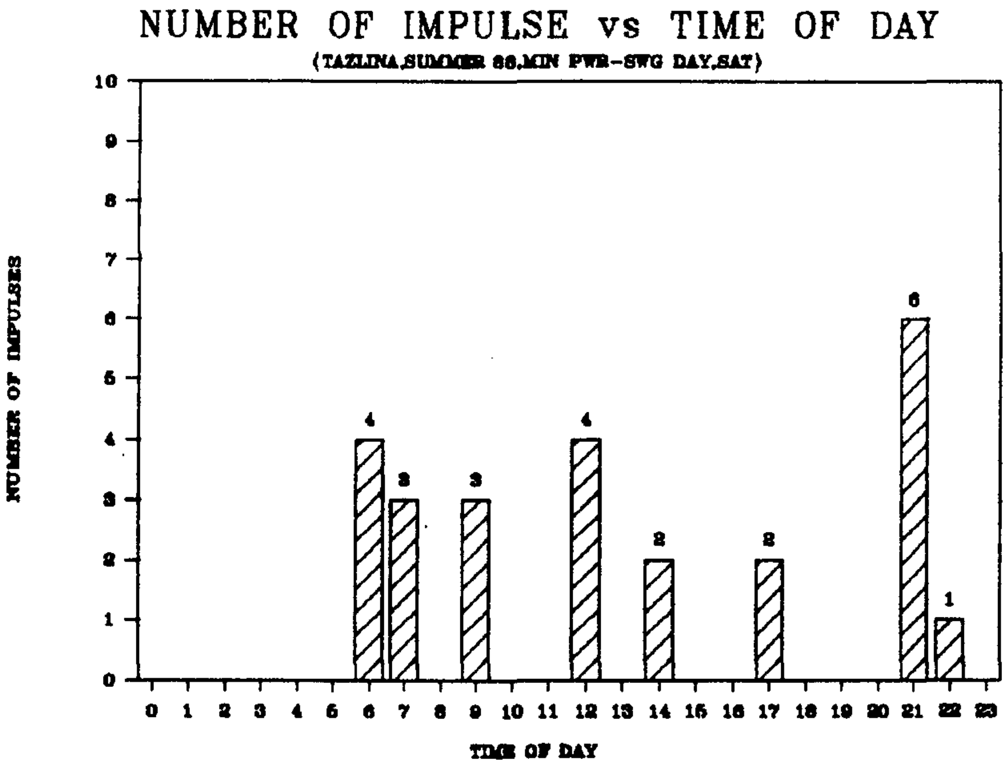


Figure T35

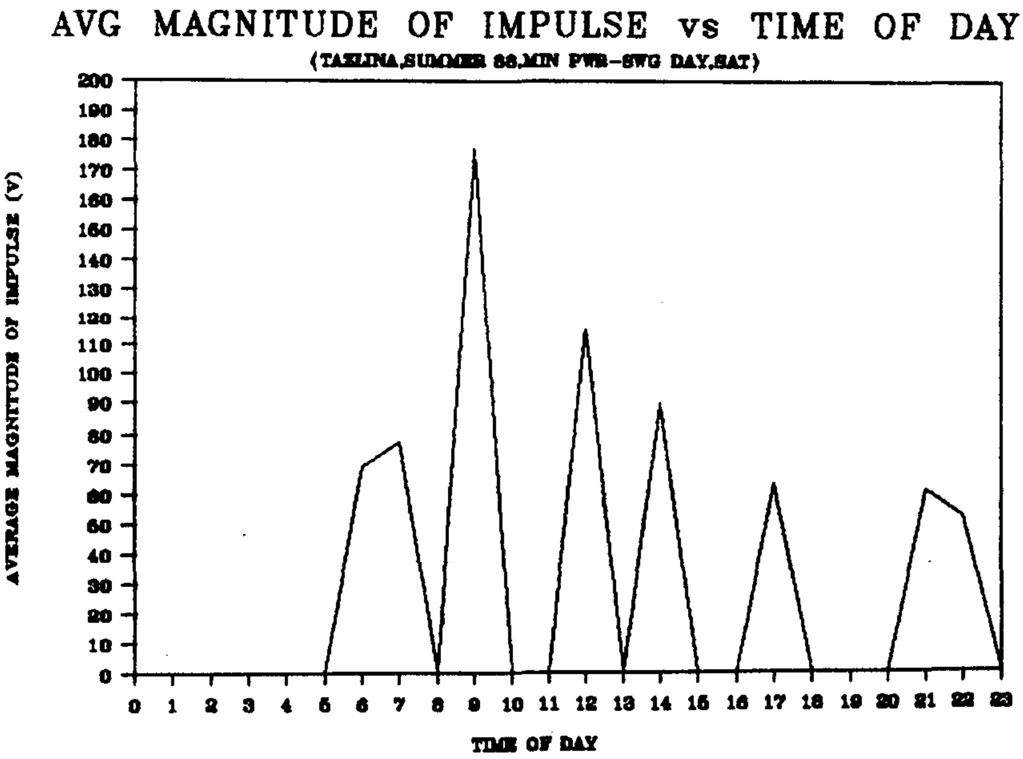


Figure T36

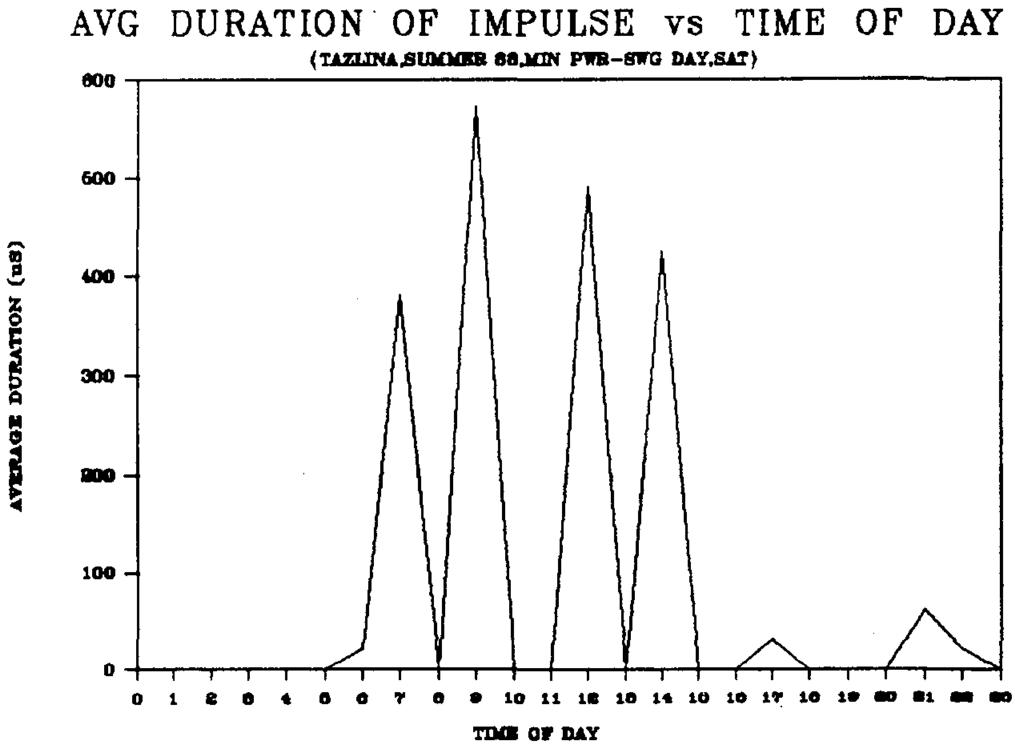


Figure T37

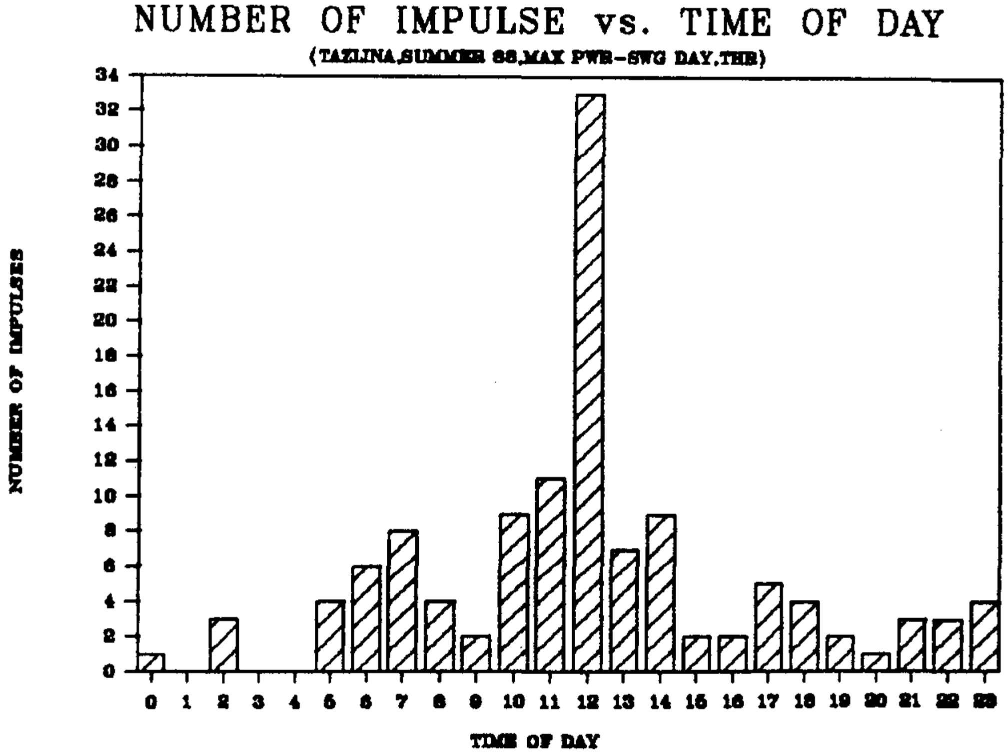


Figure T38

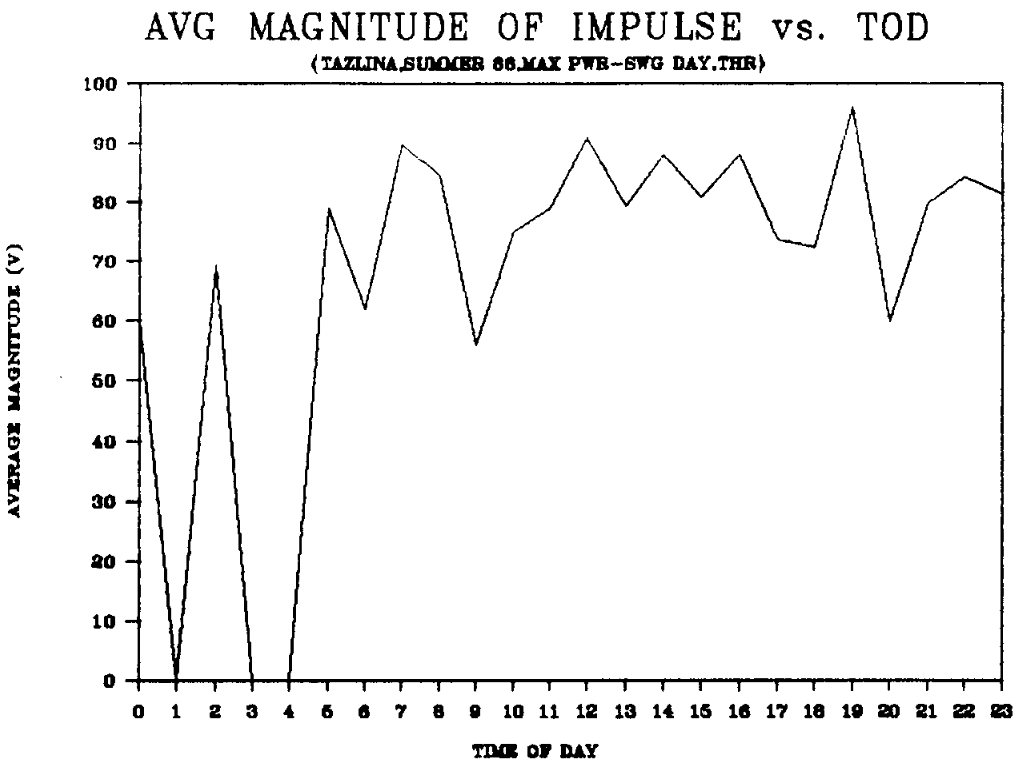


Figure T39

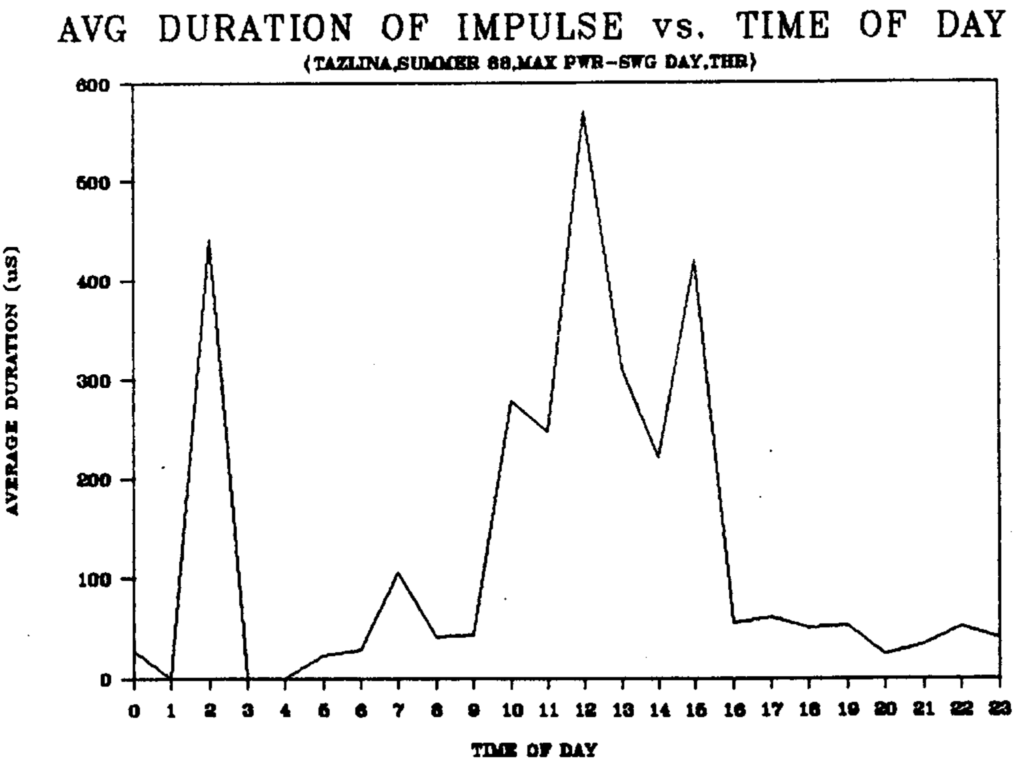


Figure T40

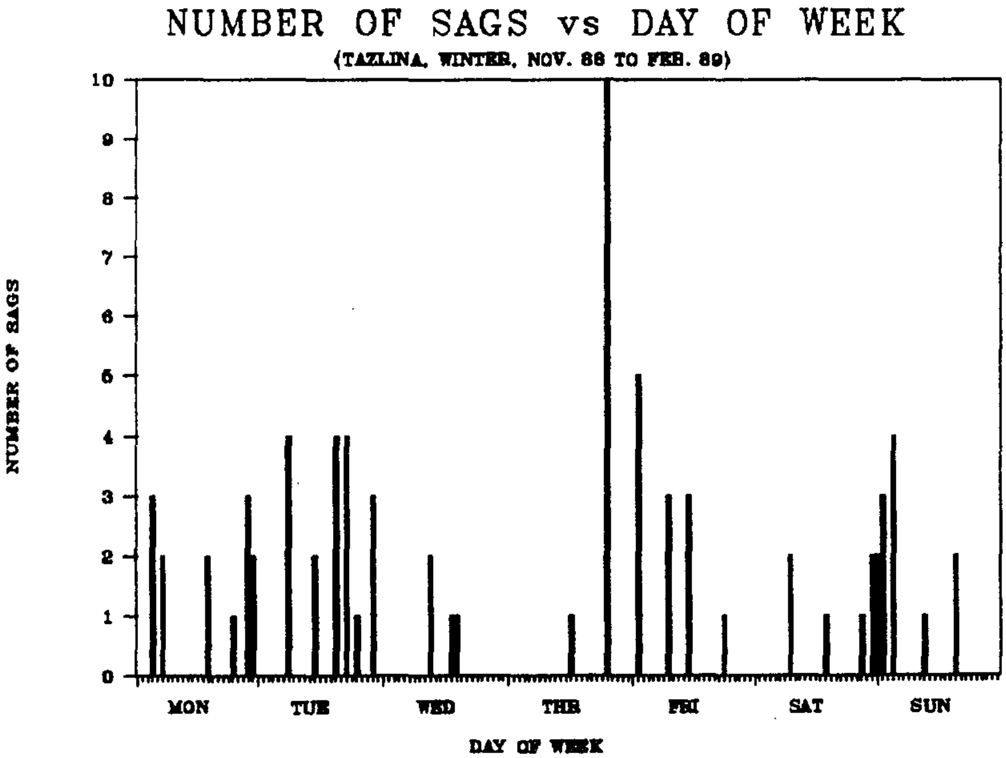


Figure T41

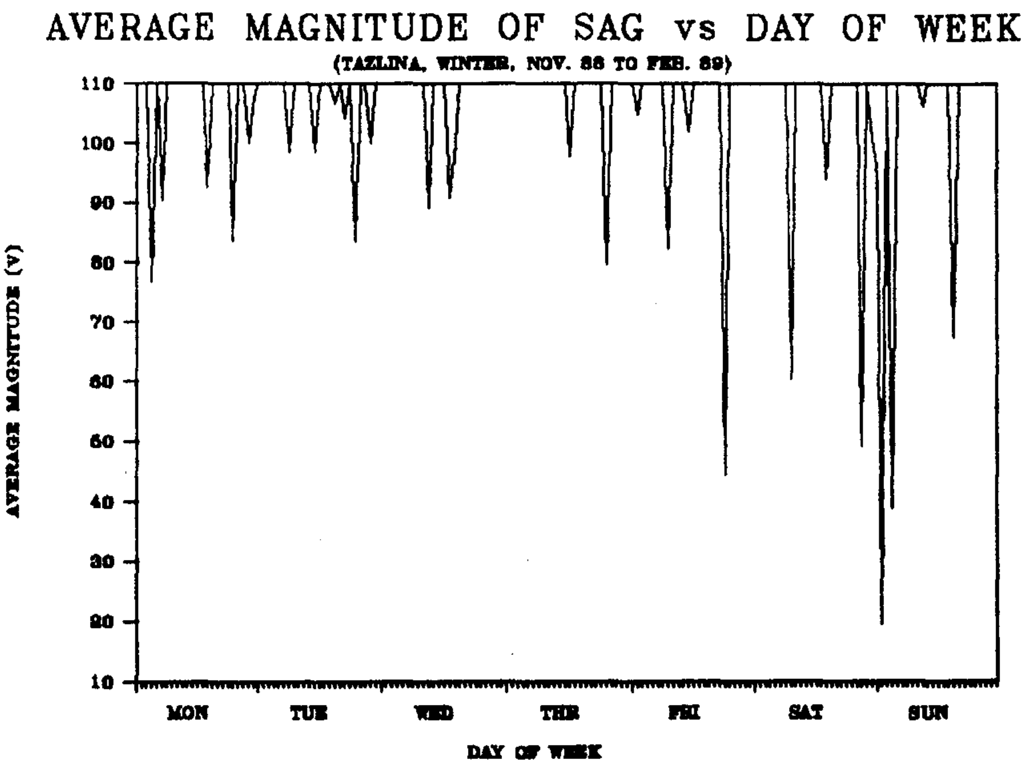


Figure T42

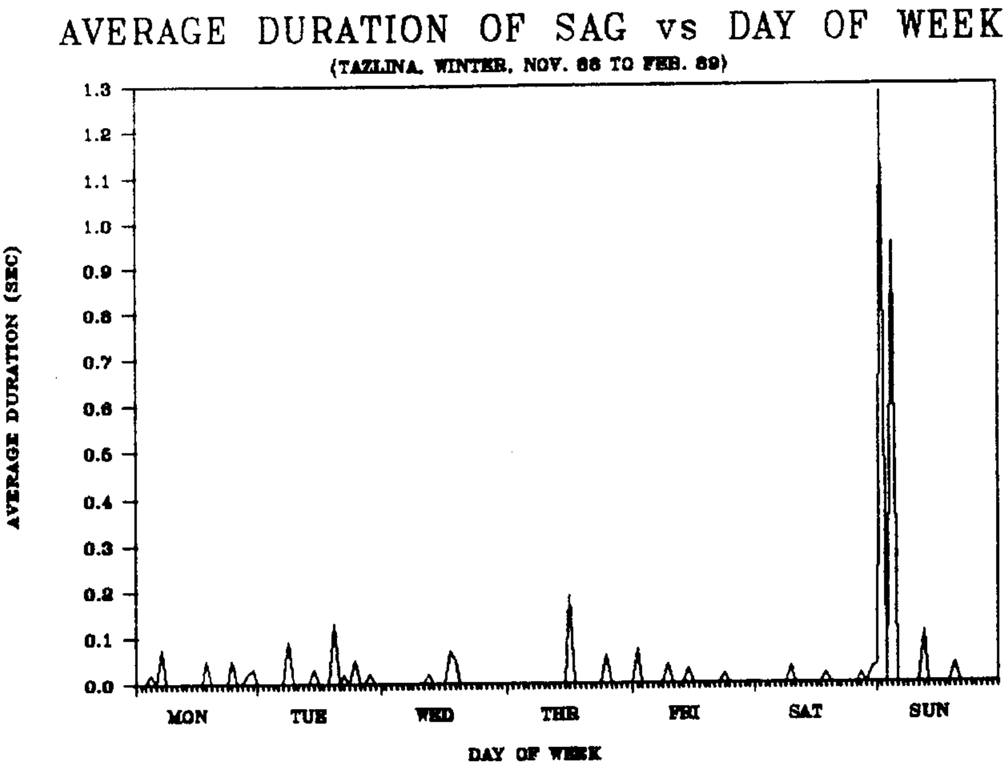


Figure T43

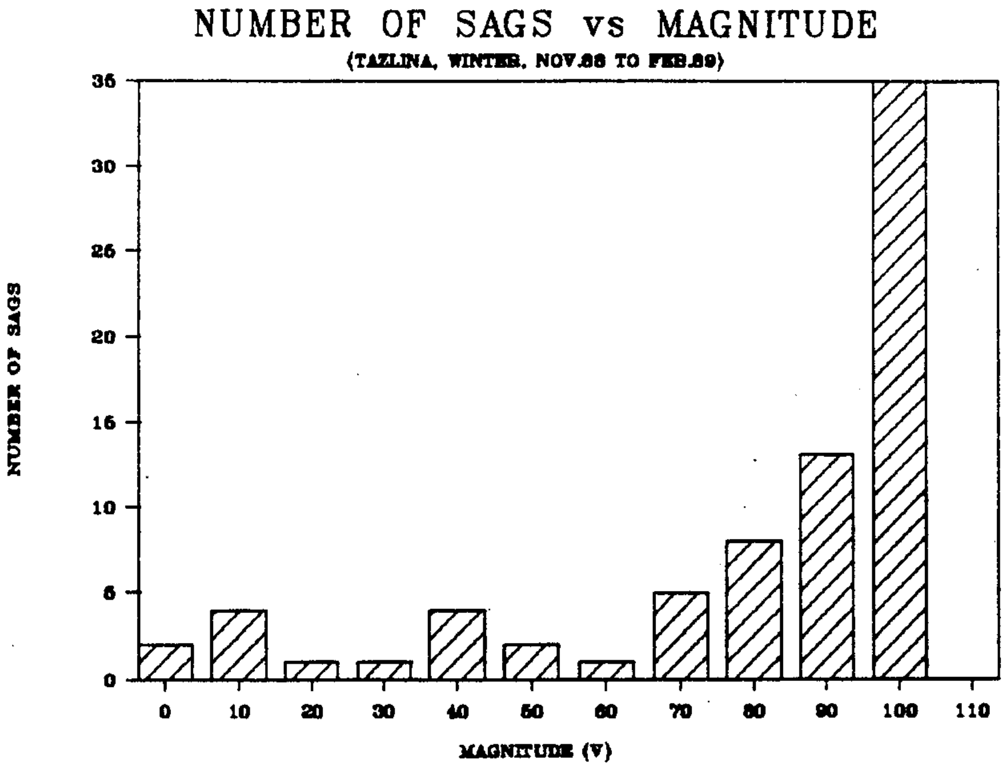


Figure T44

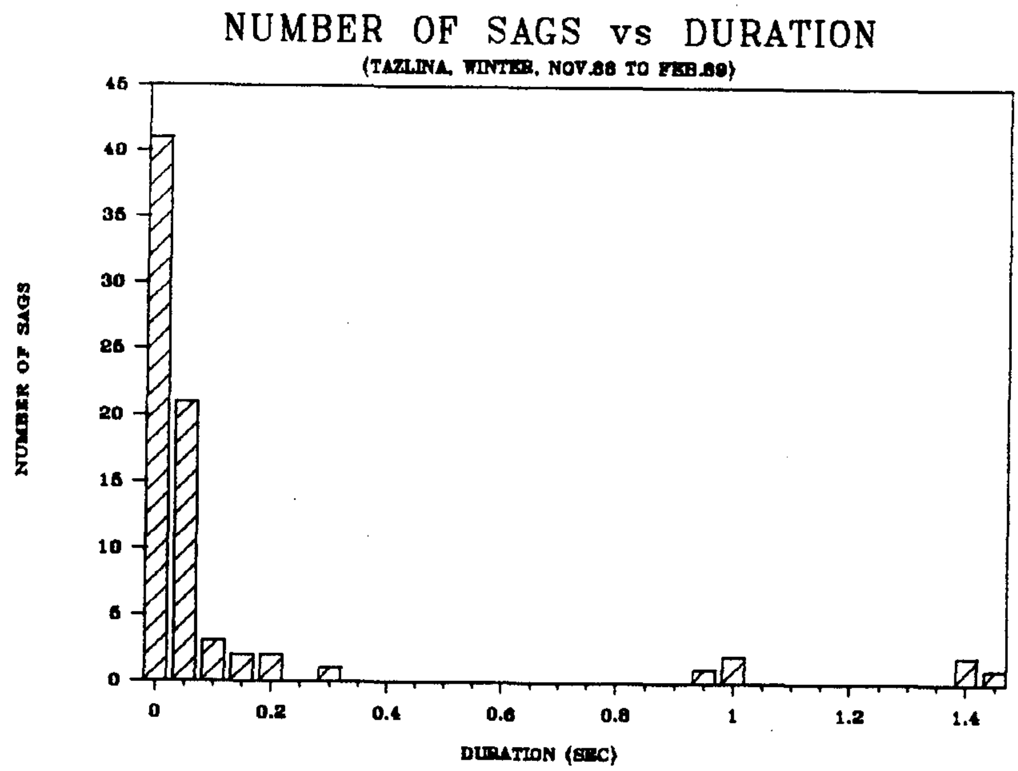


Figure T45

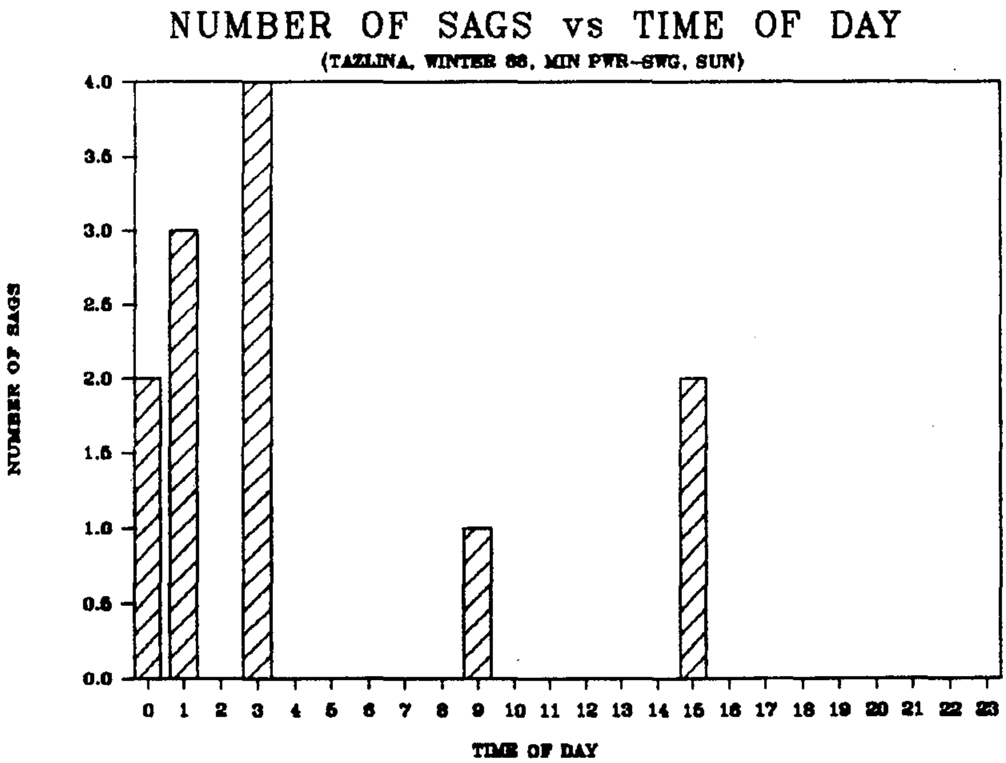


Figure T46

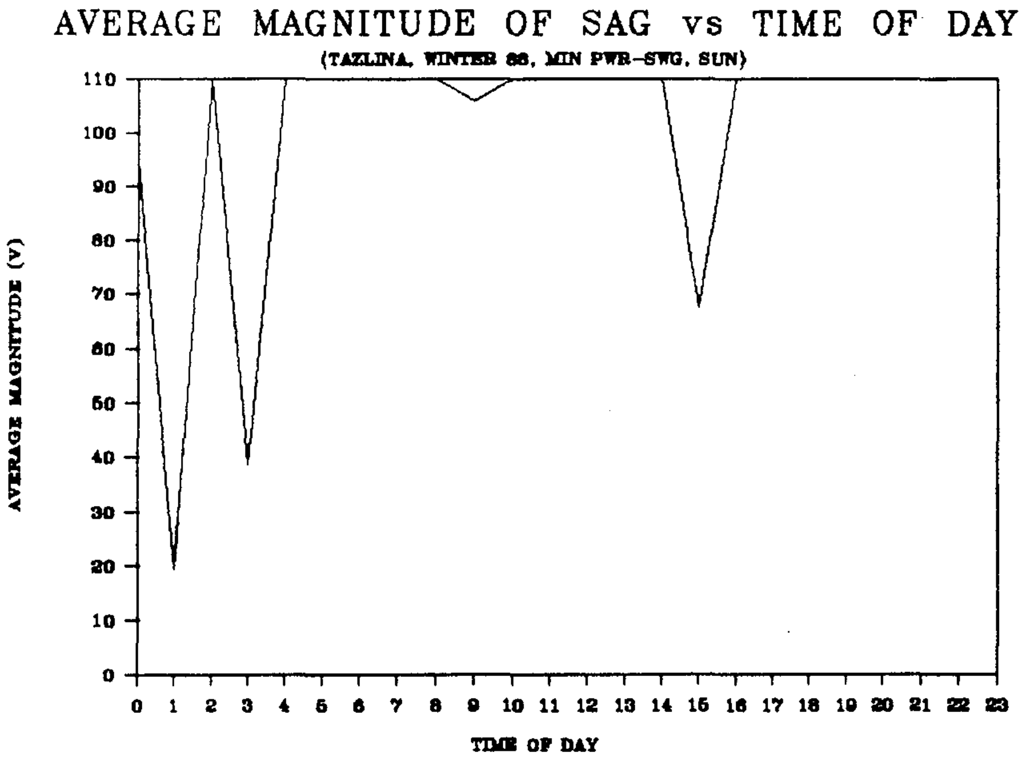


Figure T47

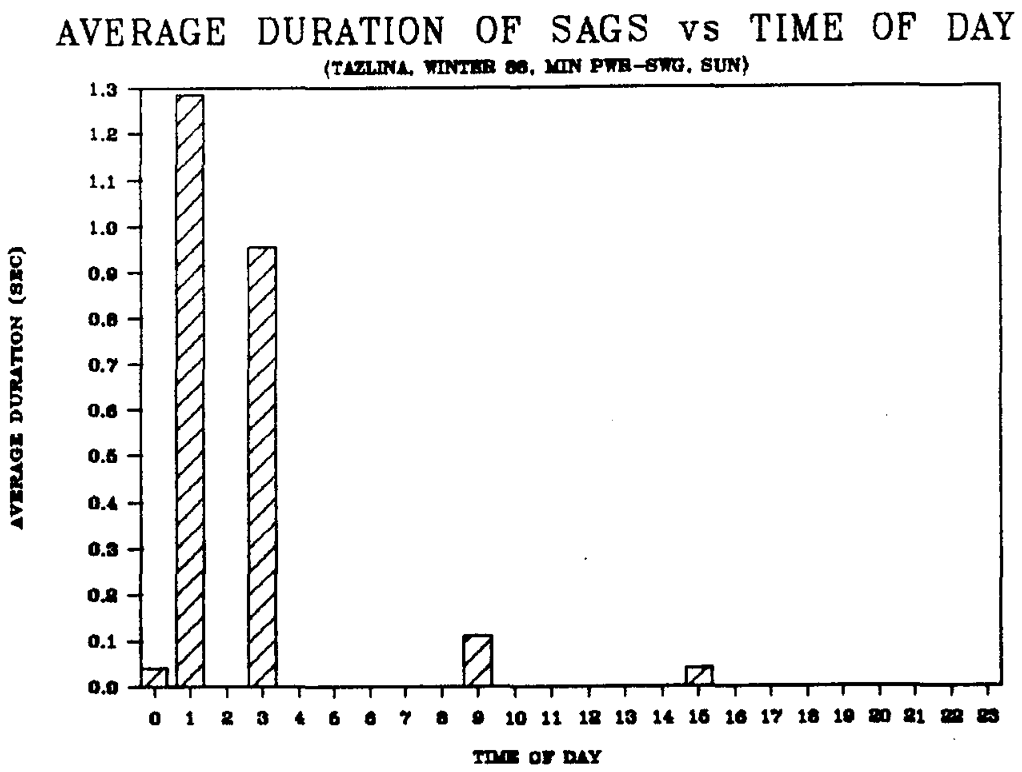


Figure T48

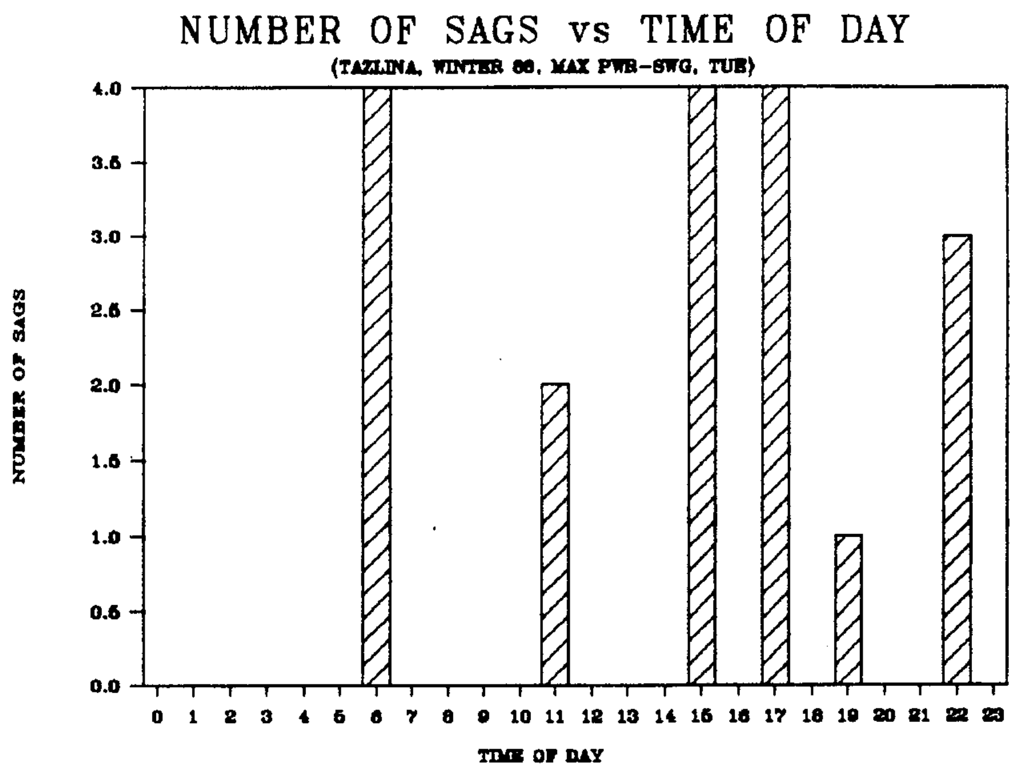


Figure T49

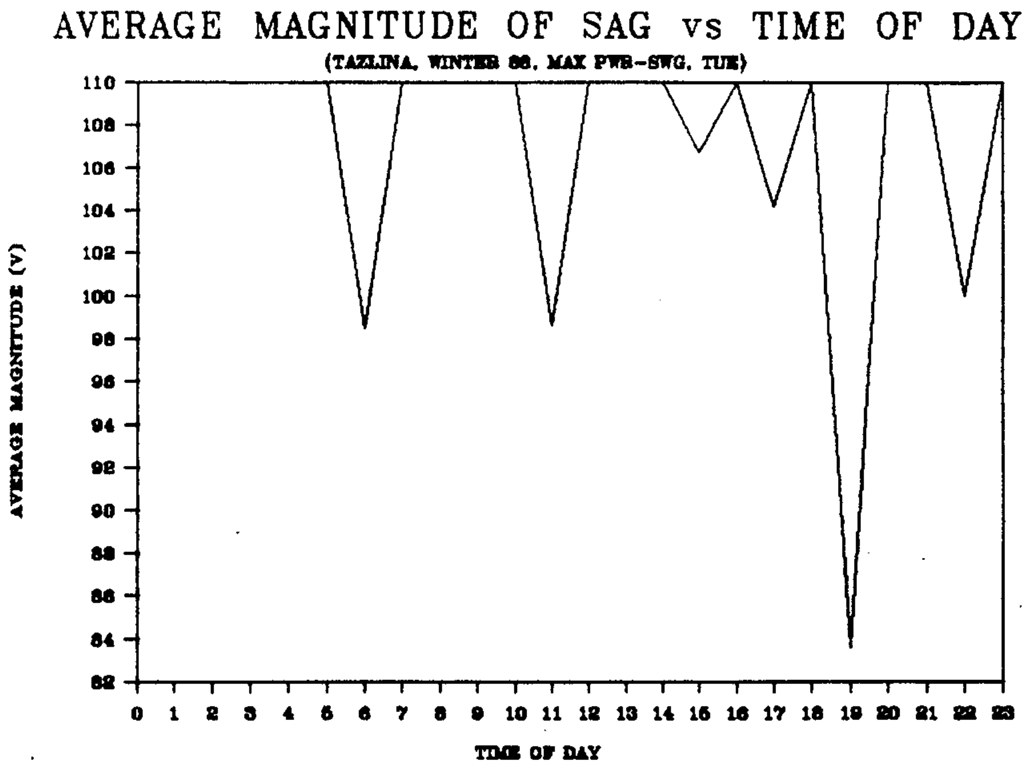


Figure T50

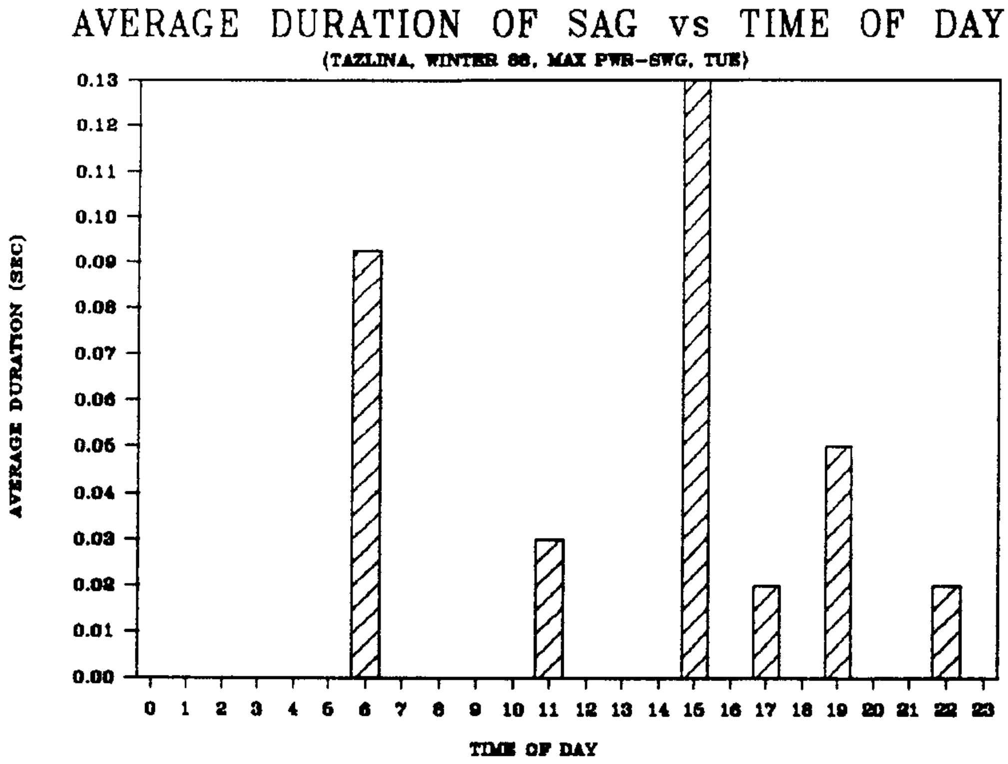


Figure T51

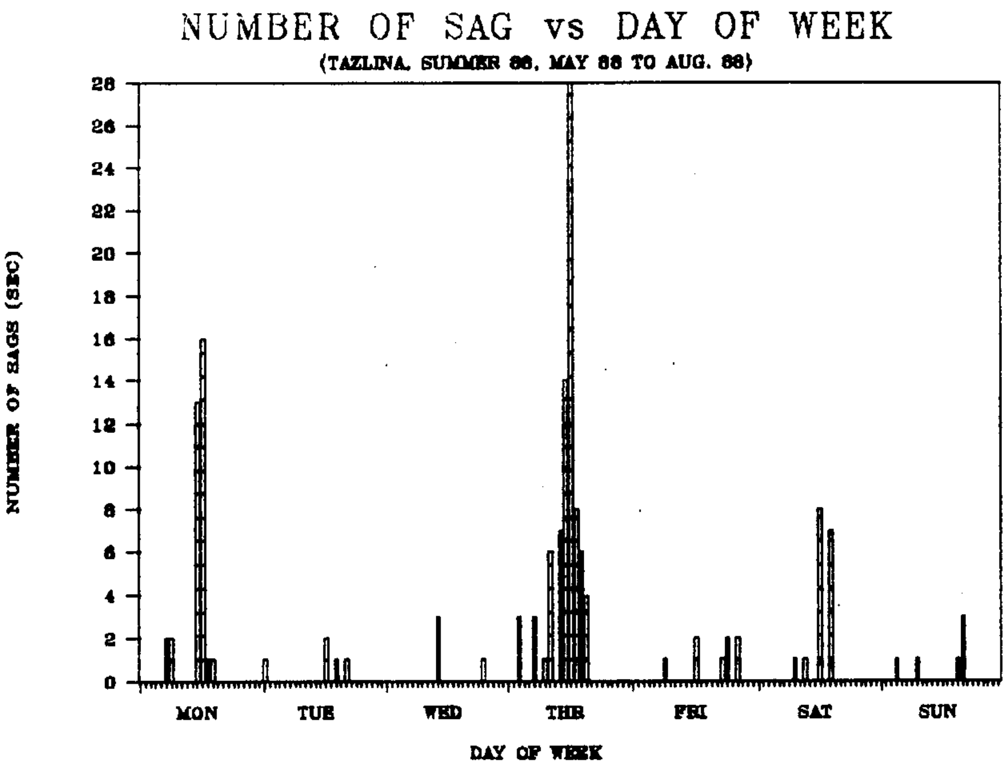


Figure T52

AVERAGE MAGNITUDE OF SAG vs DAY OF WEEK

(TAZLINA, SUMMER 88, MAY 88 TO AUG. 88)

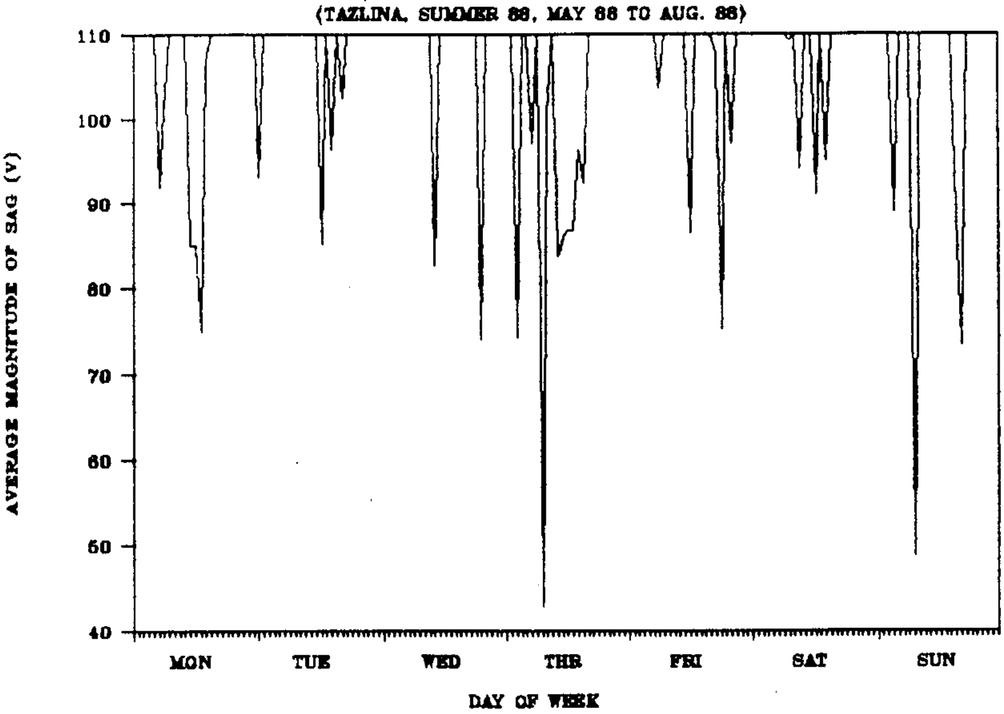


Figure T53

AVERAGE DURATION OF SAG vs DAY OF WEEK

(TAZLINA, SUMMER 88, MAY 88 TO AUG. 88)

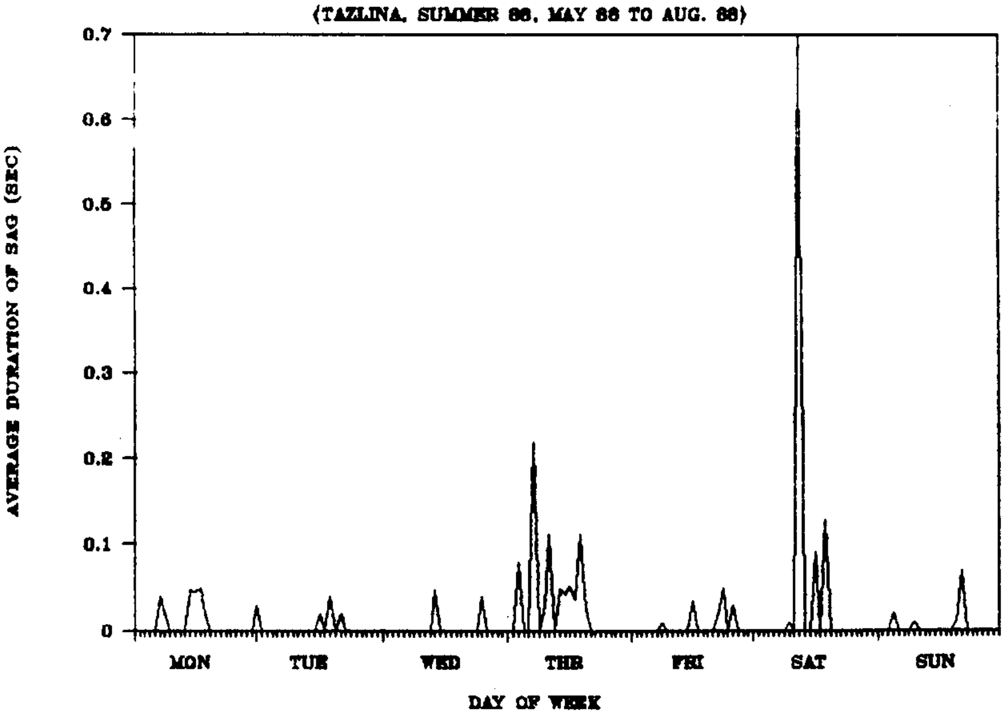


Figure T54

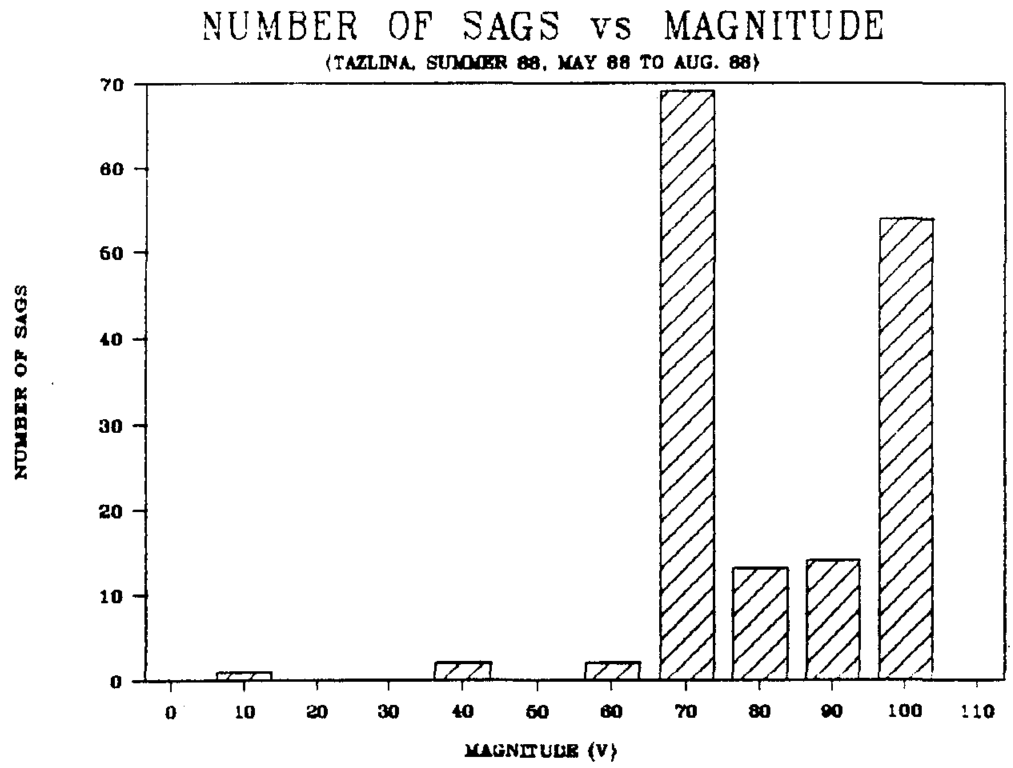


Figure T55

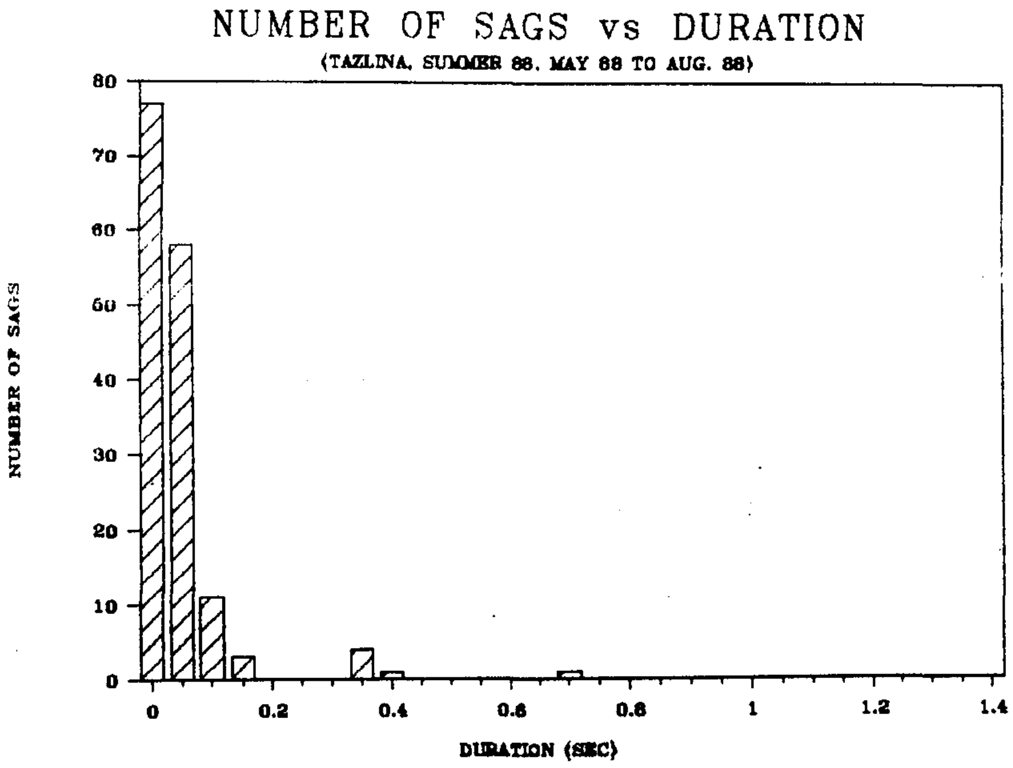


Figure T56

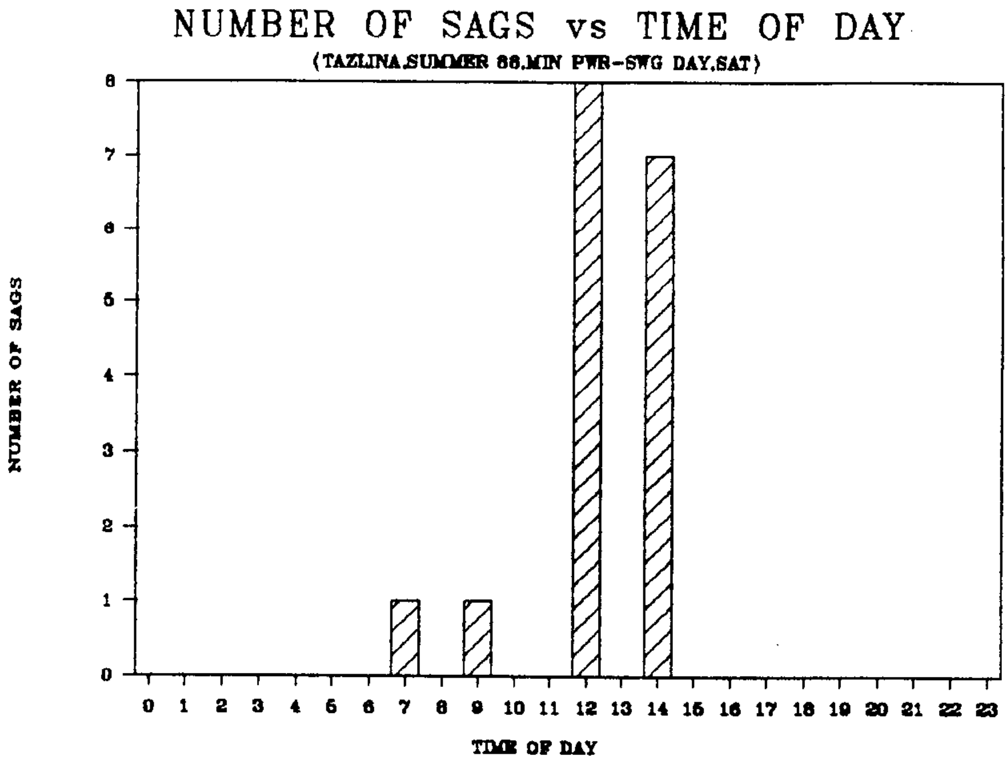


Figure 57

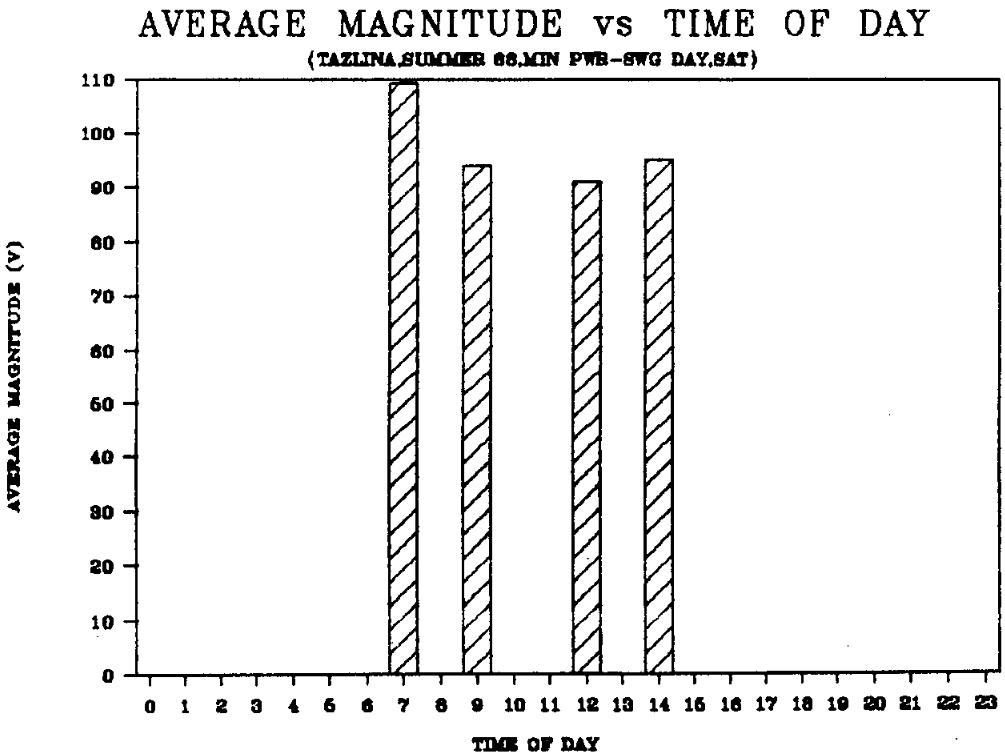


Figure T58

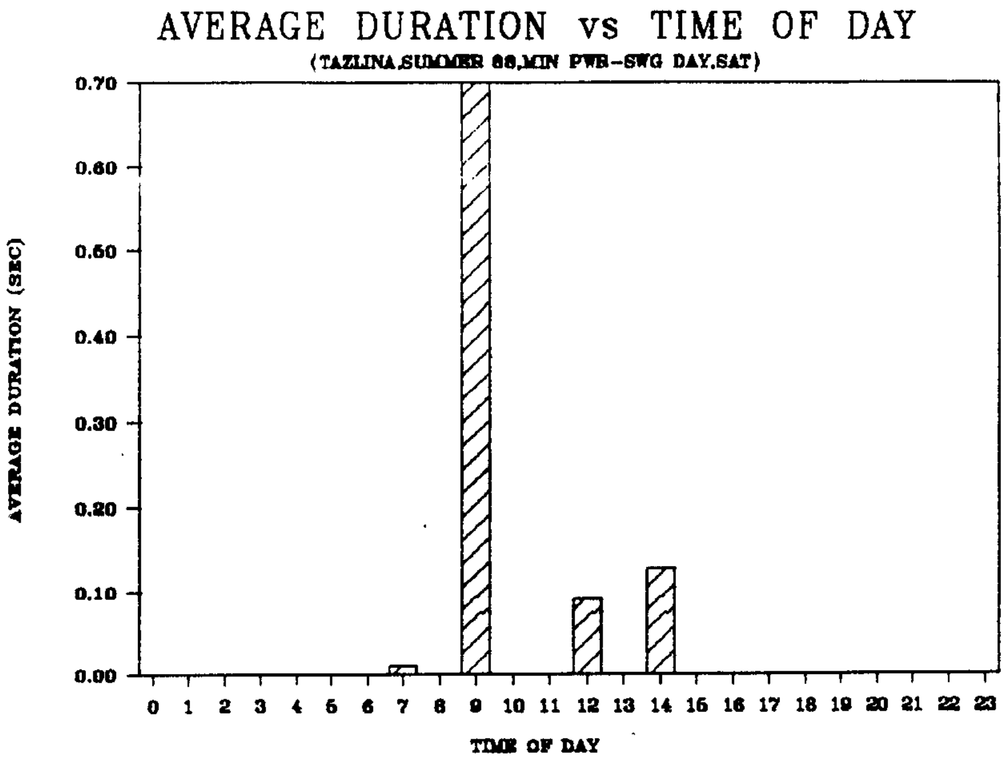


Figure T59

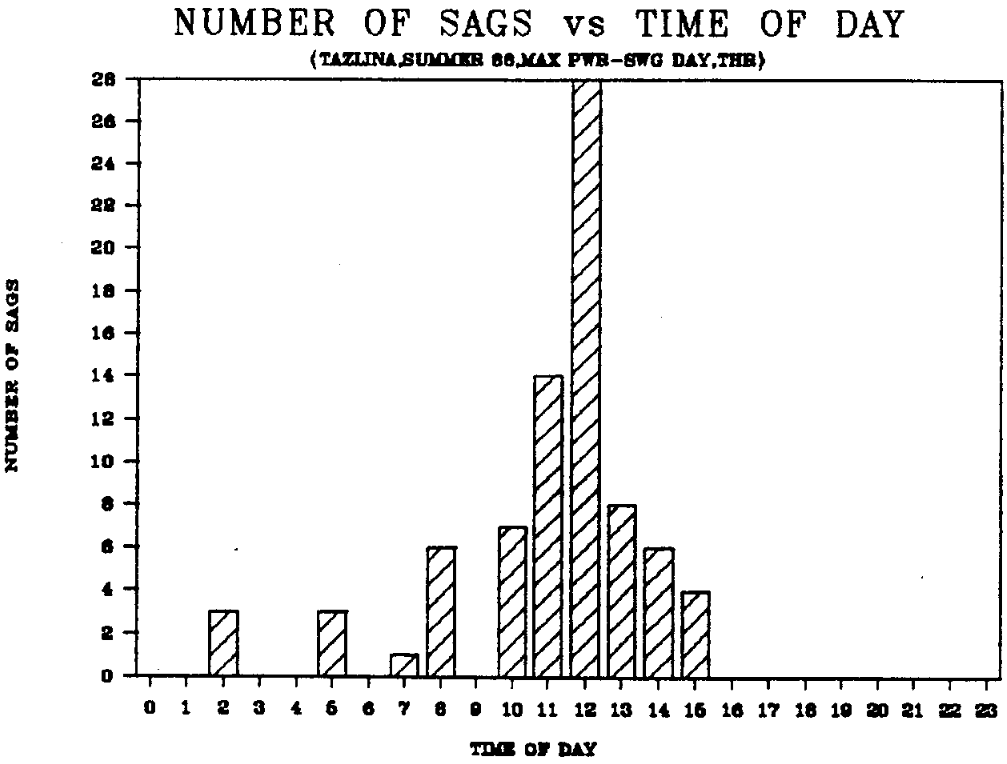


Figure T60

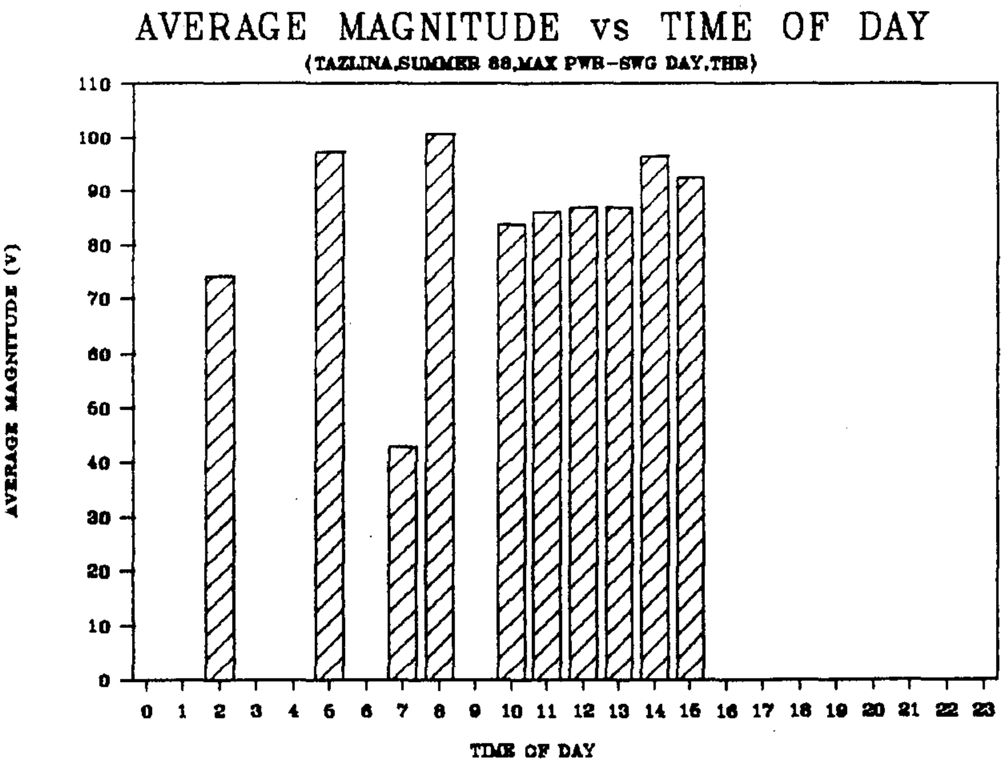


Figure T61

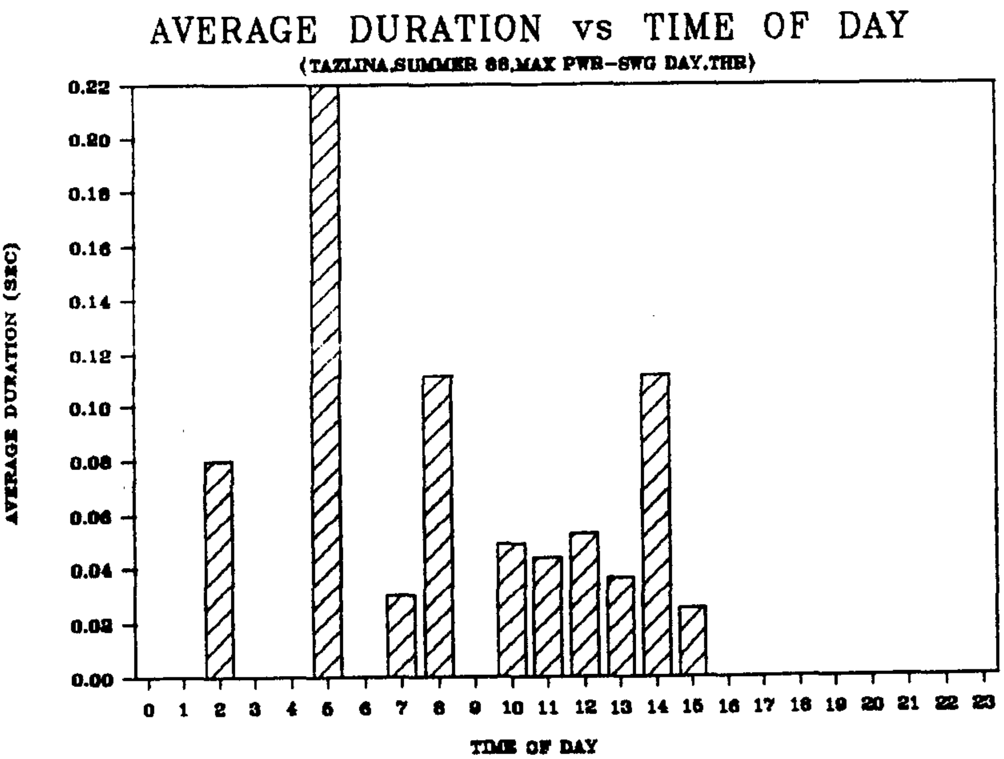


Figure T62

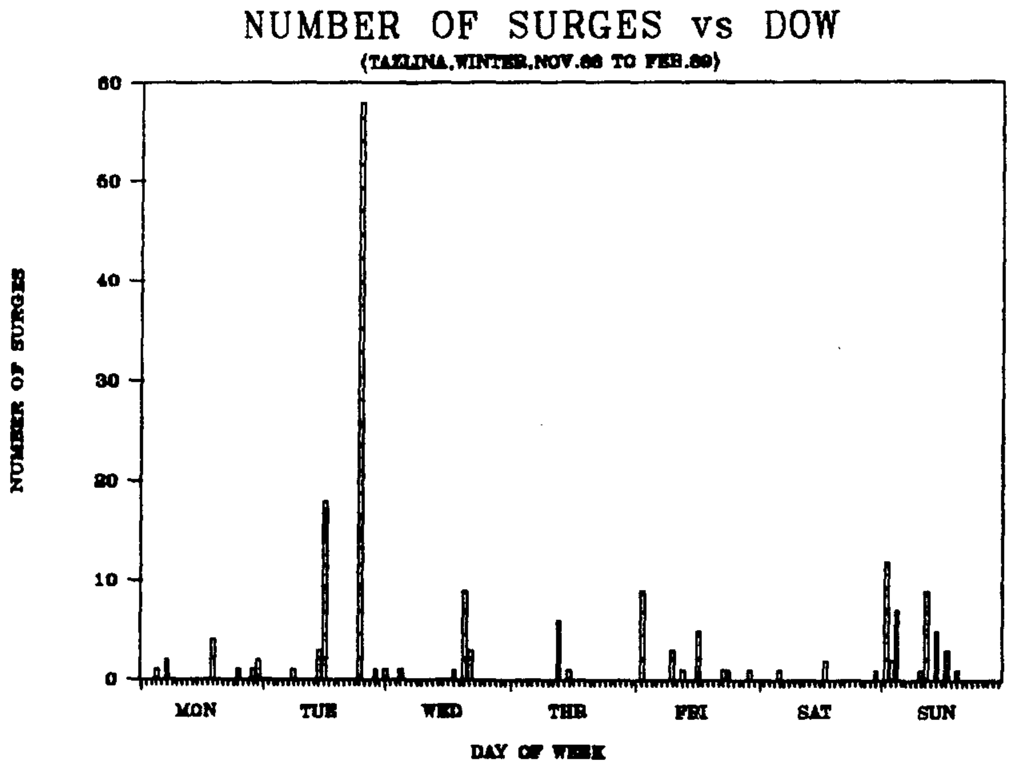


Figure T63

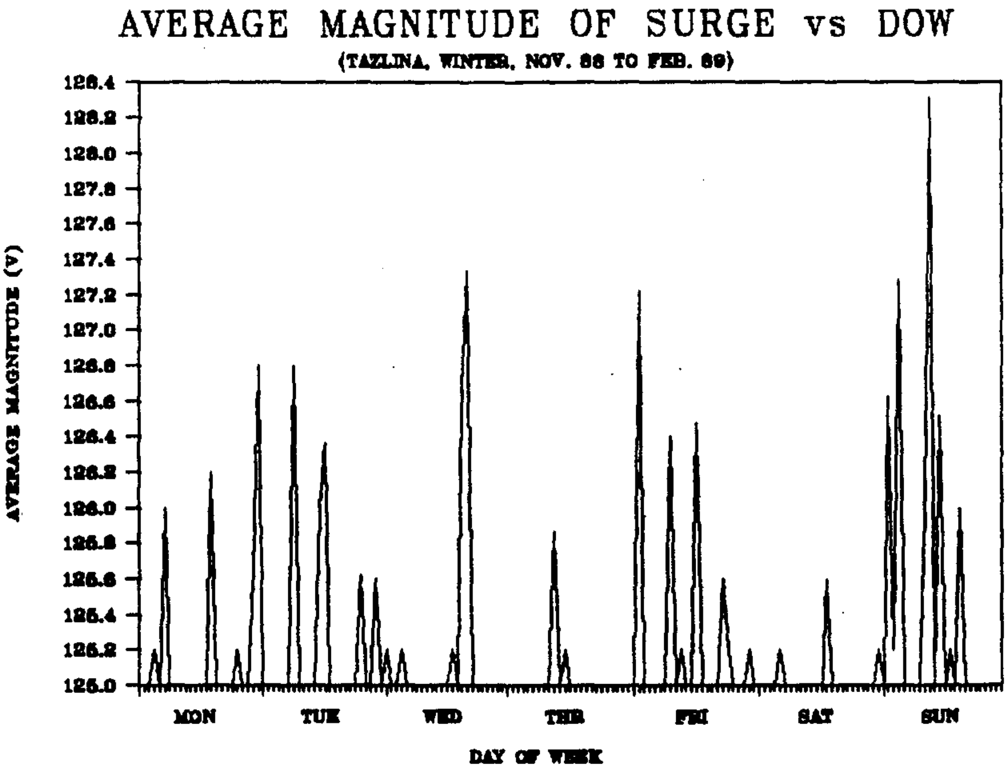


Figure T64

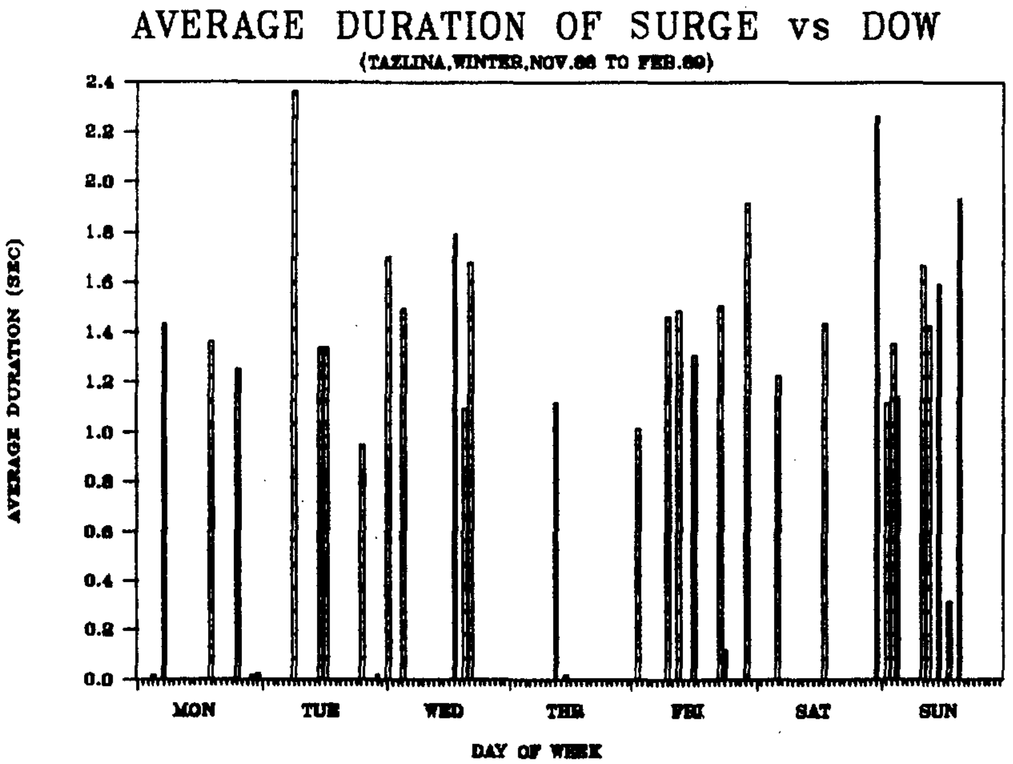


Figure T65

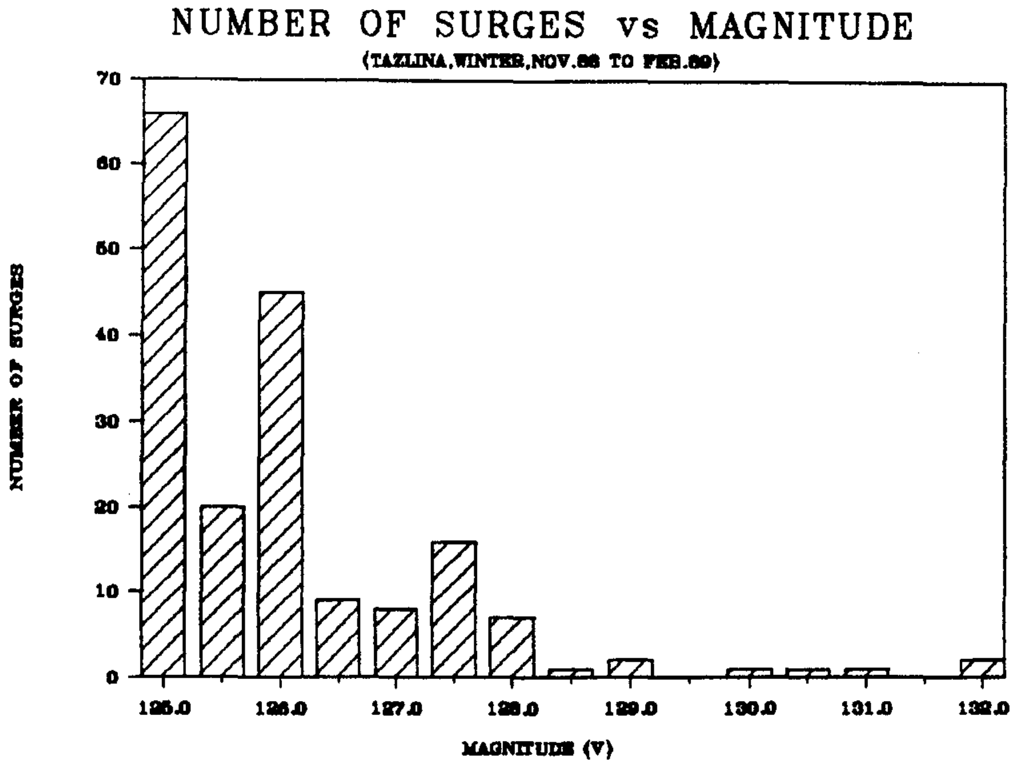


Figure T66

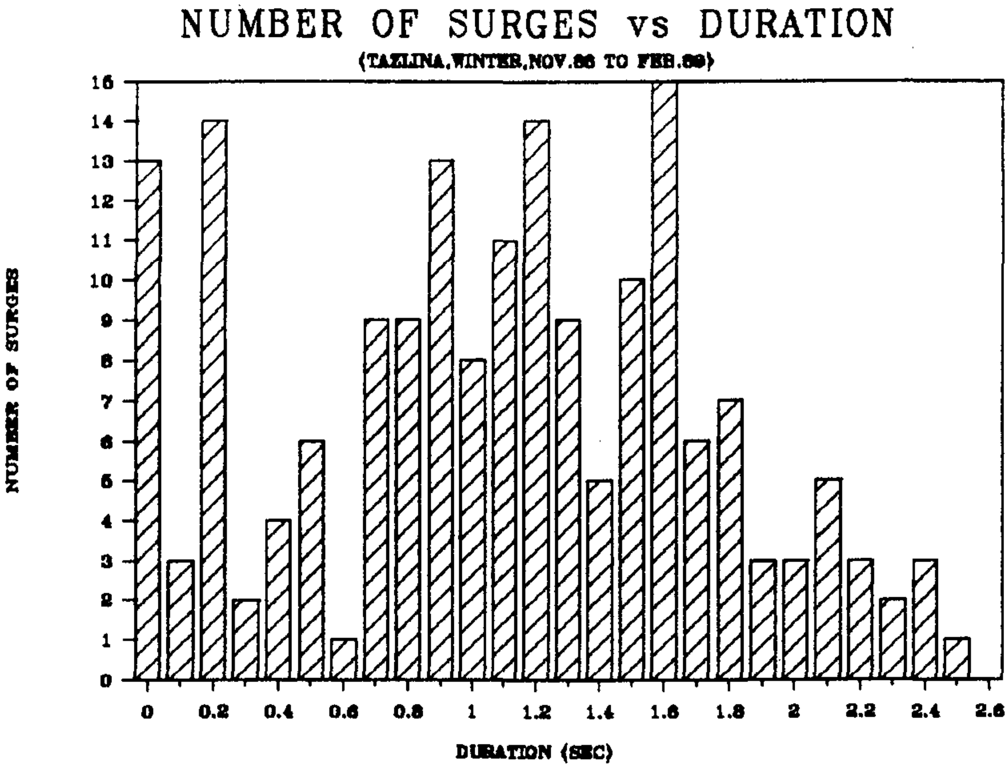


Figure T67

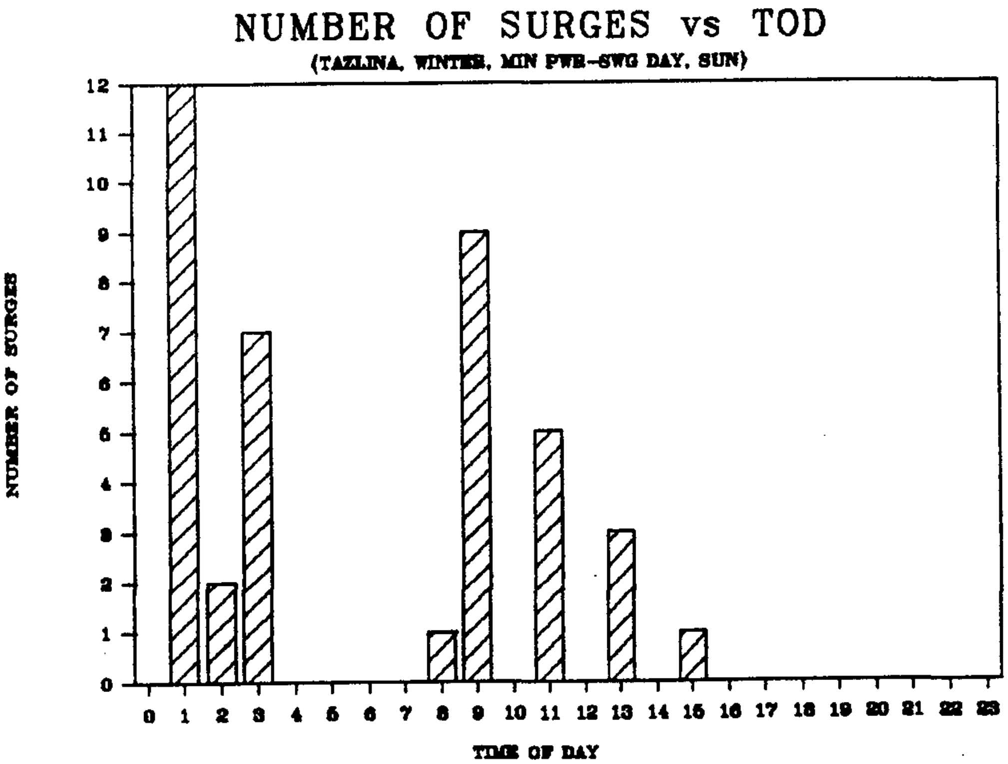


Figure T68

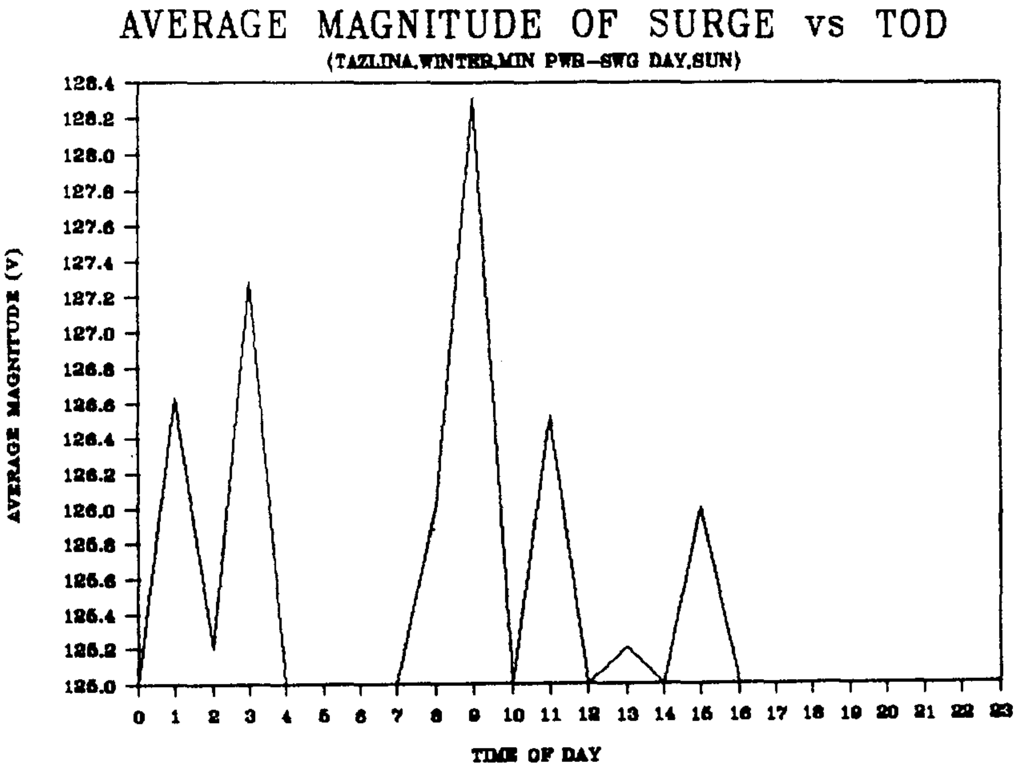


Figure T69

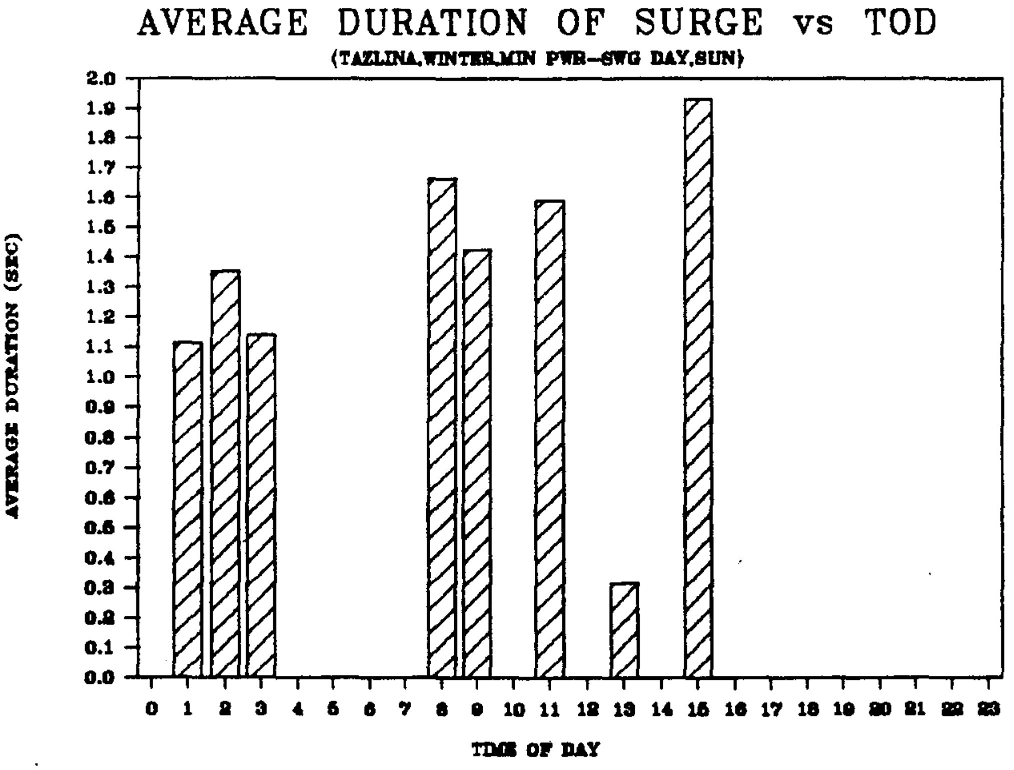


Figure T70

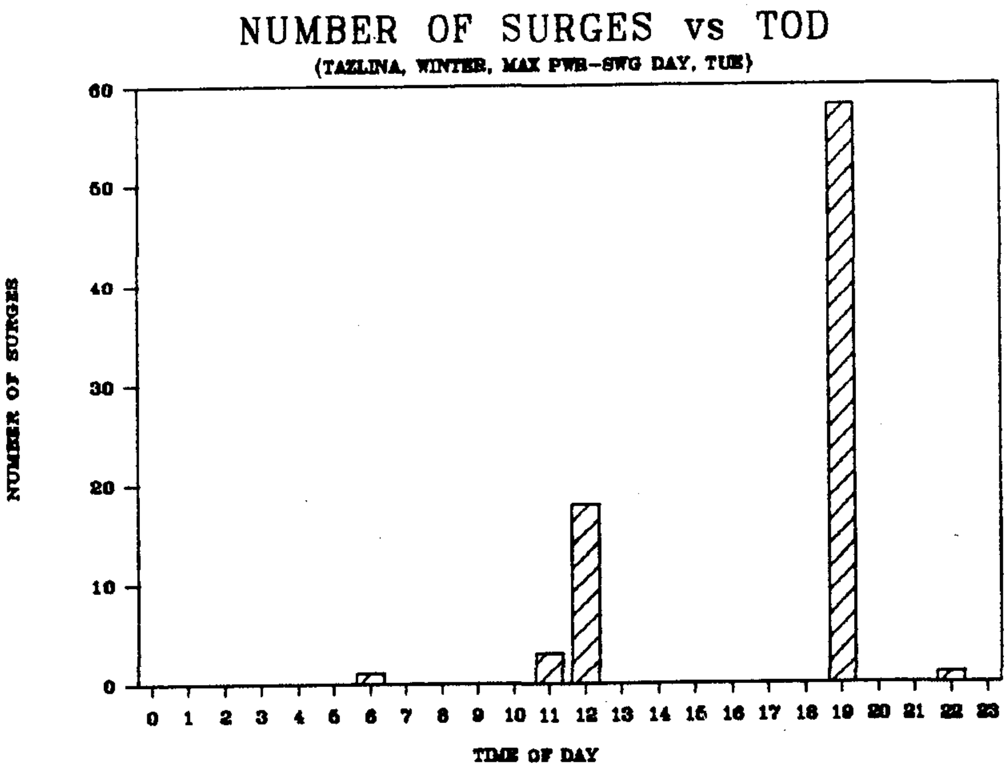


Figure T71

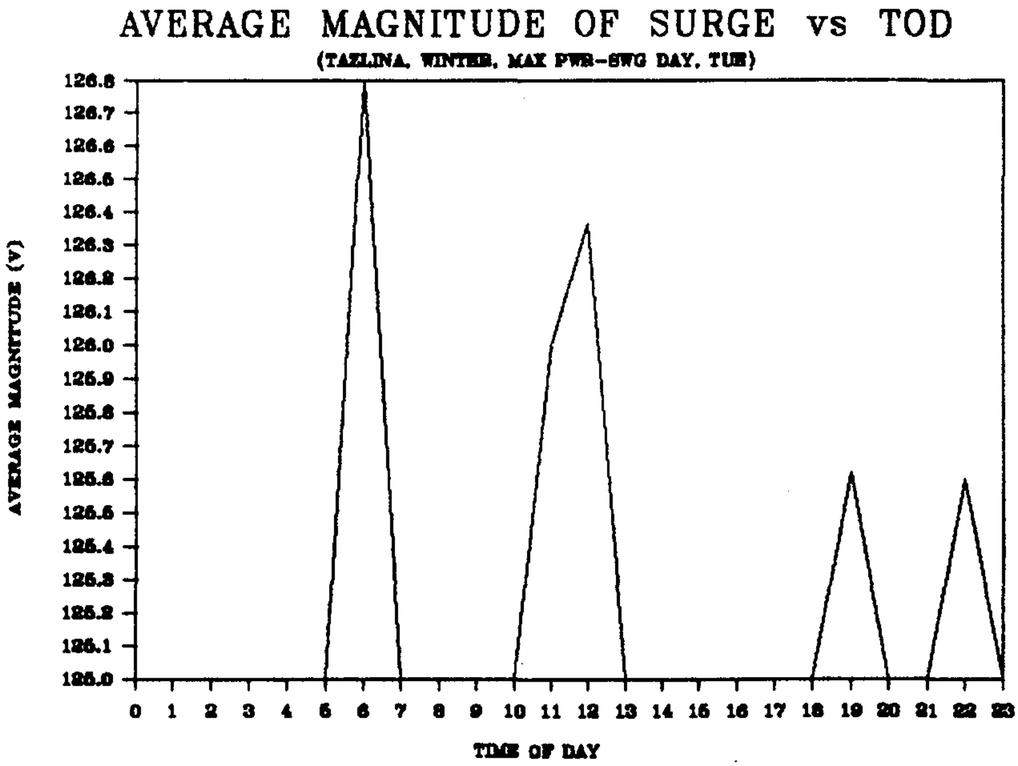


Figure T72

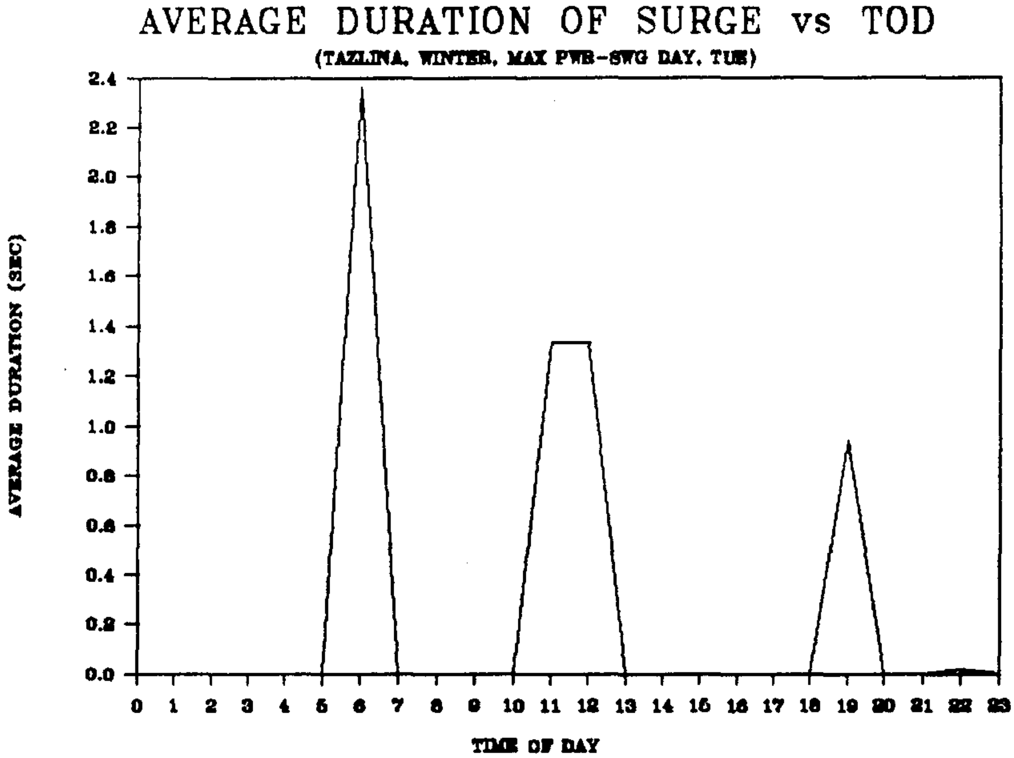


Figure T73

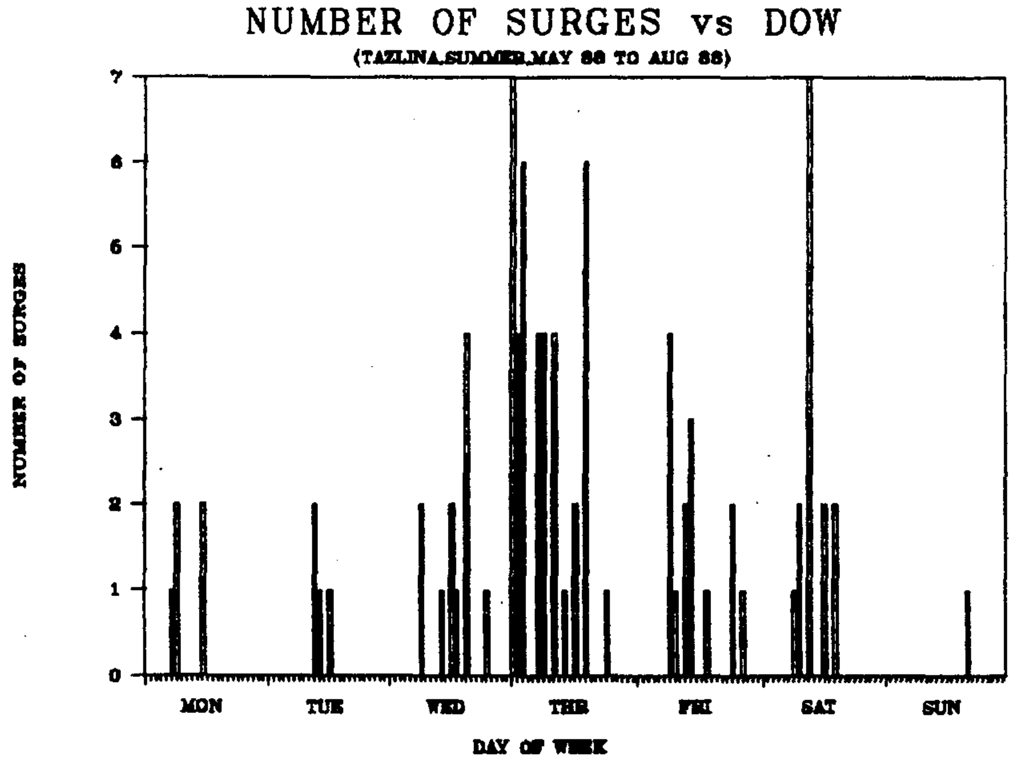


Figure T74

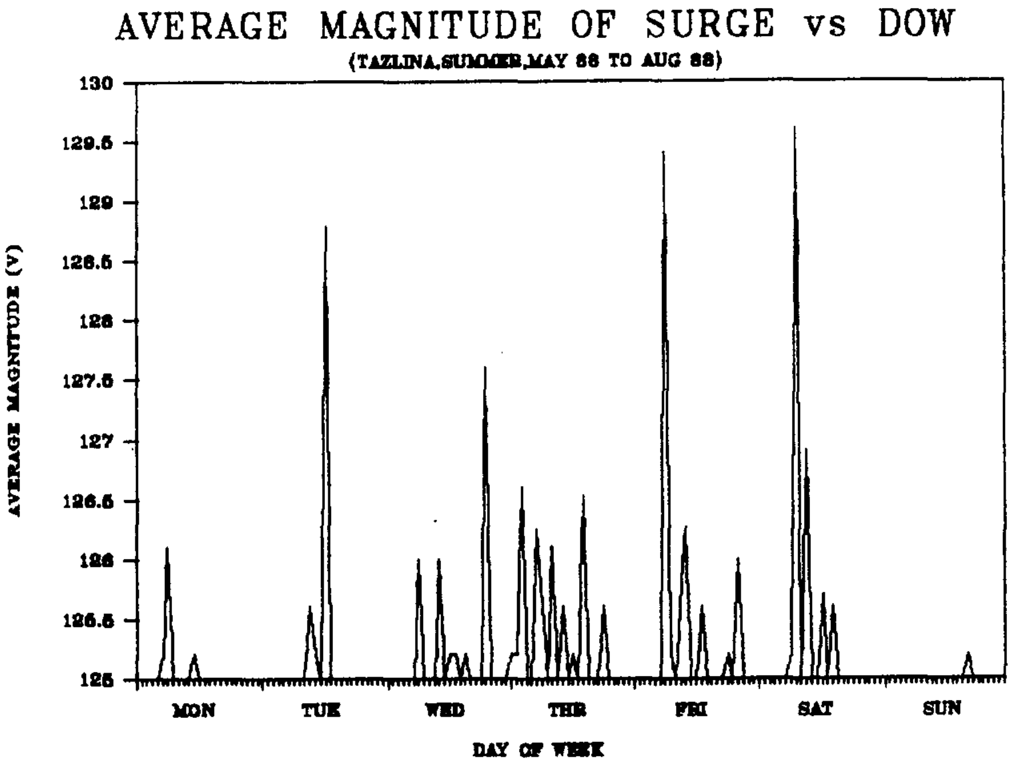


Figure T75

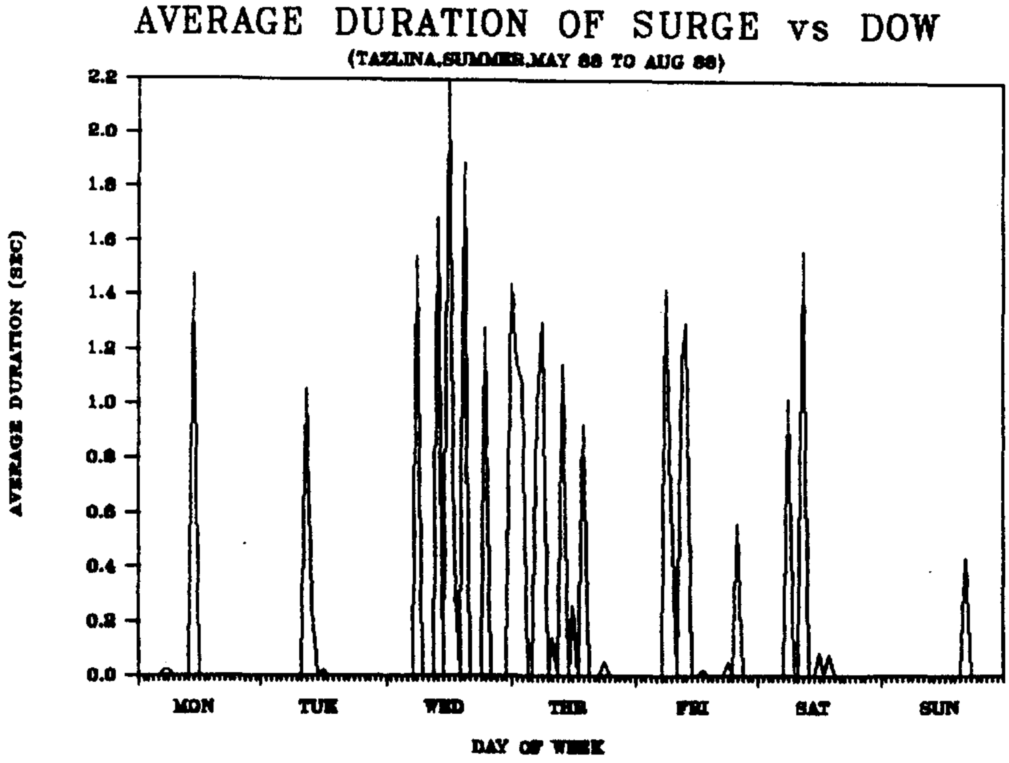


Figure T76

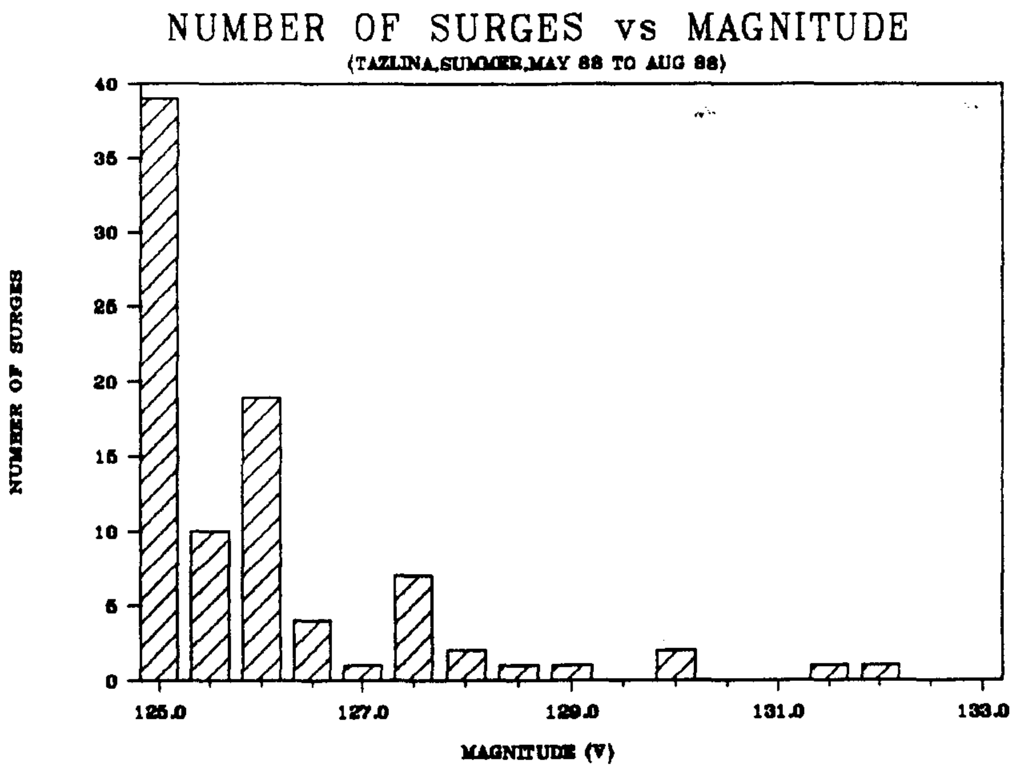


Figure T77

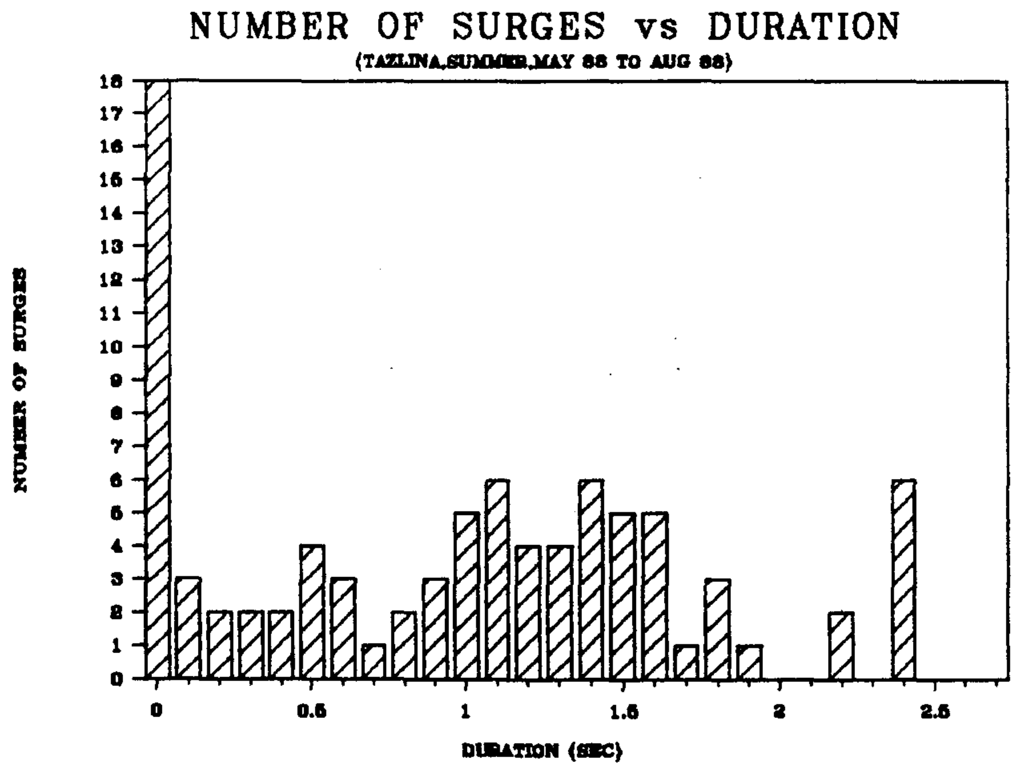


Figure T78

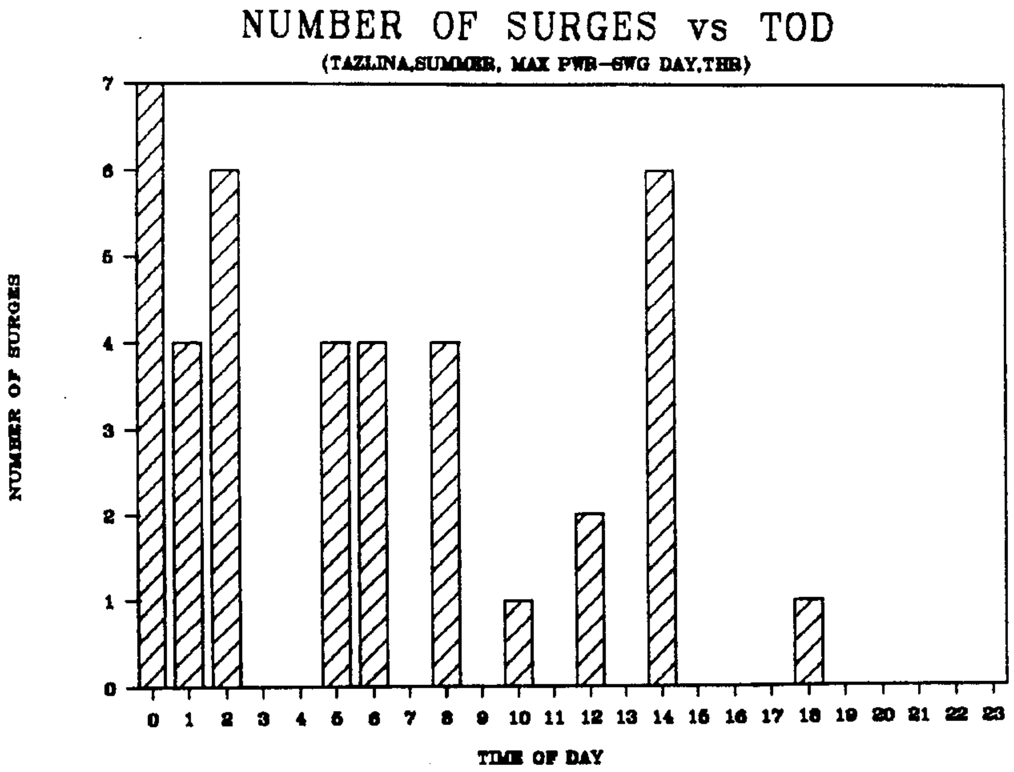


Figure T79

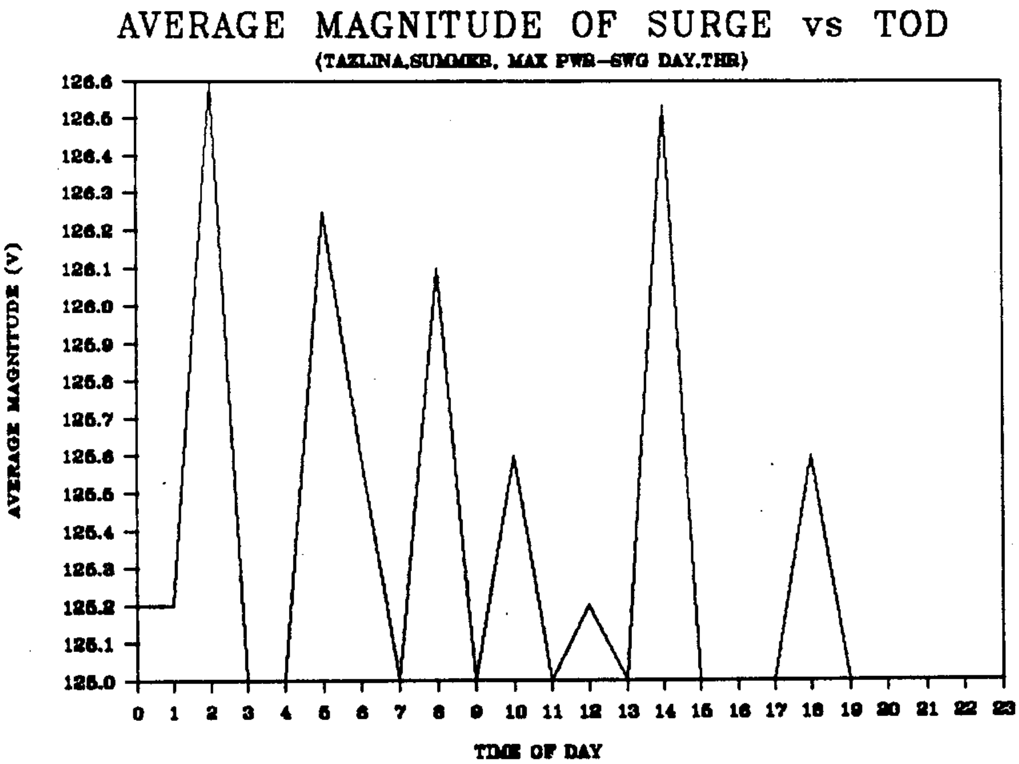


Figure T80

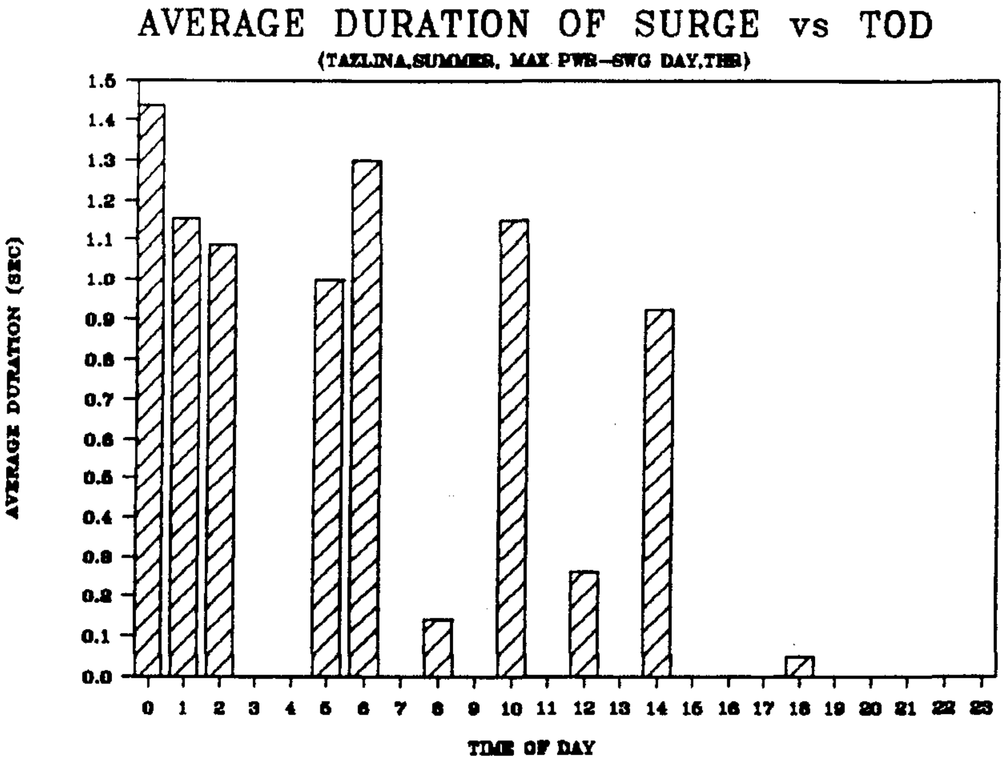


Figure T81

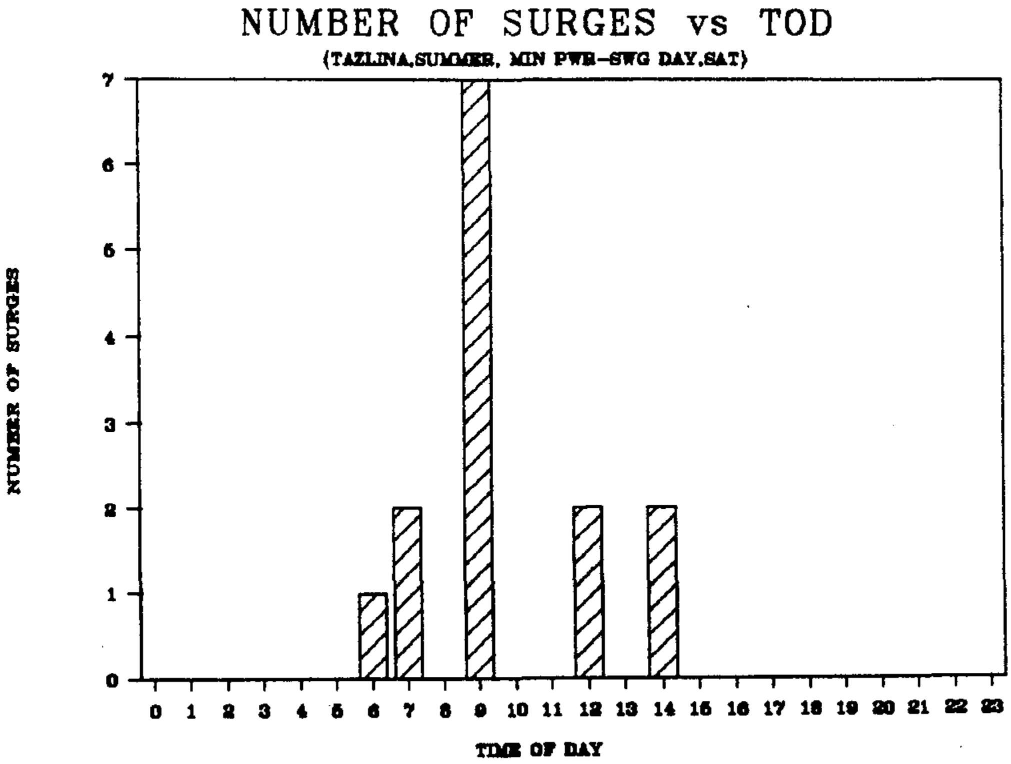


Figure T82

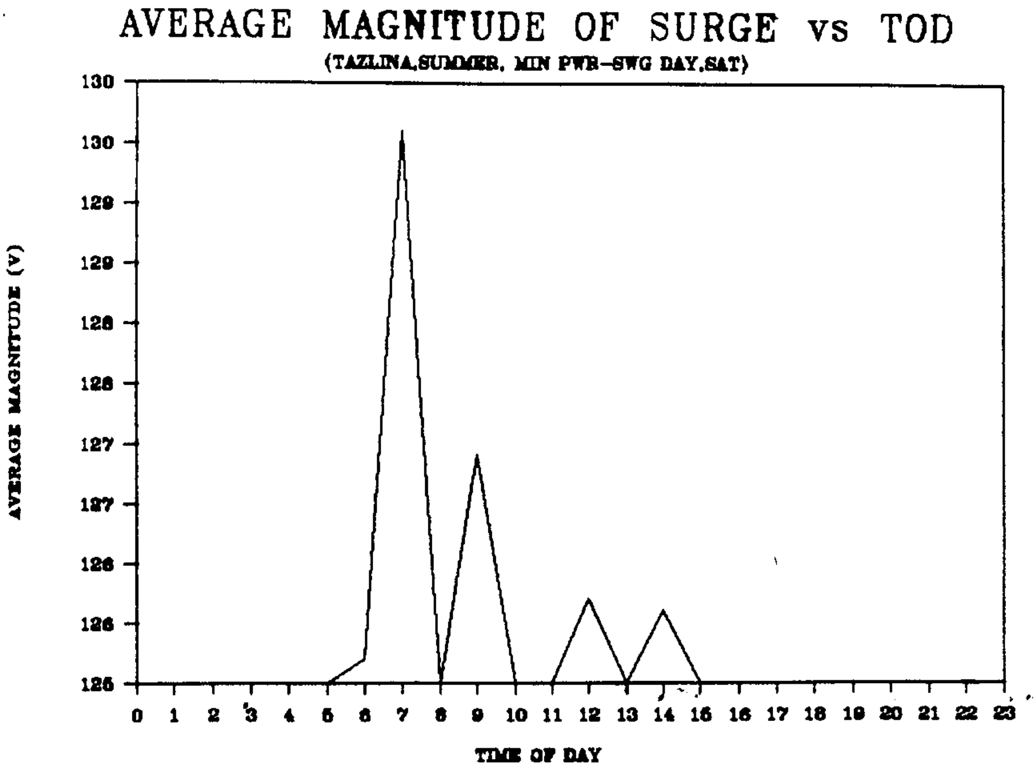


Figure T83

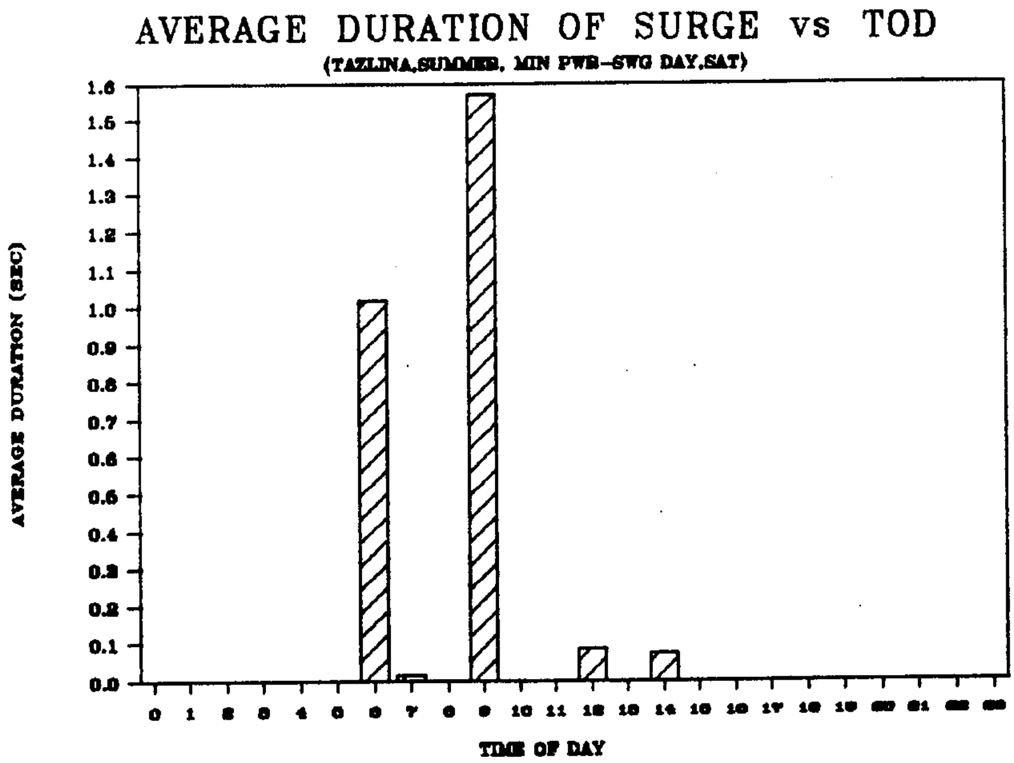


Figure T84

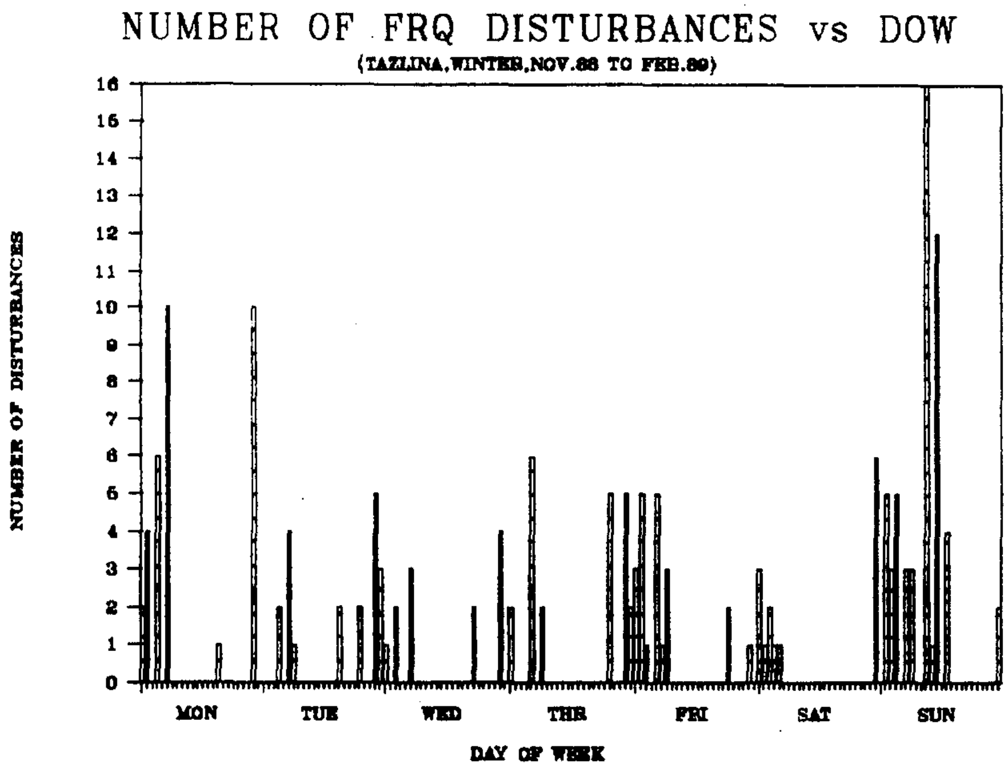


Figure T85

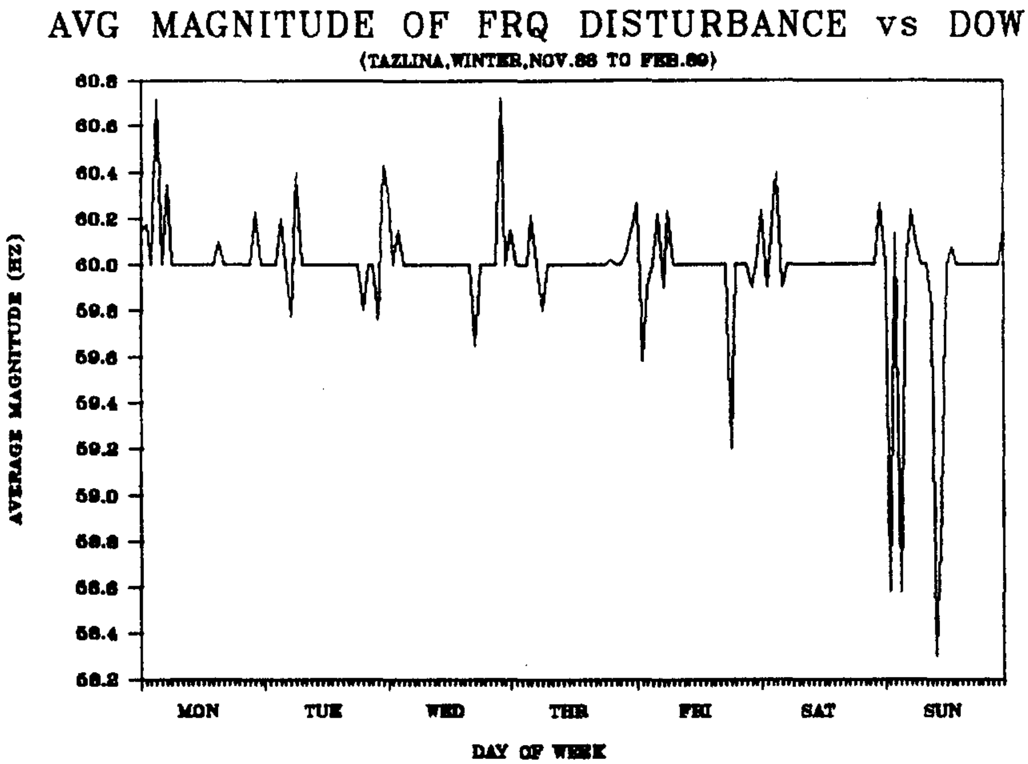


Figure T86

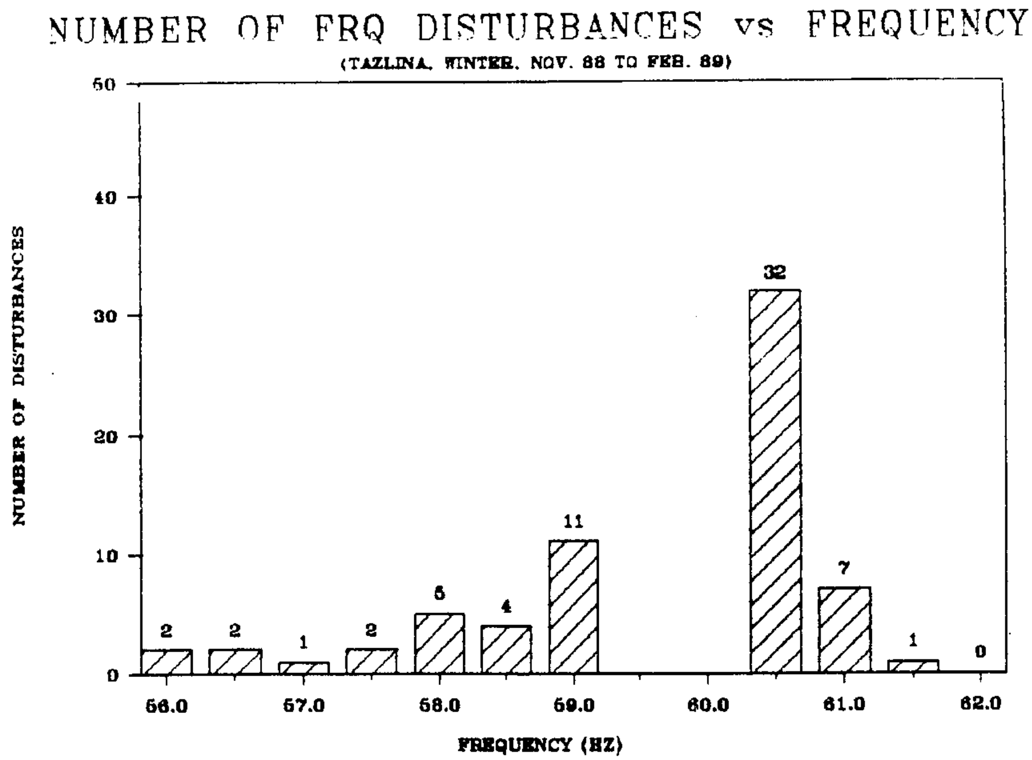


Figure T87

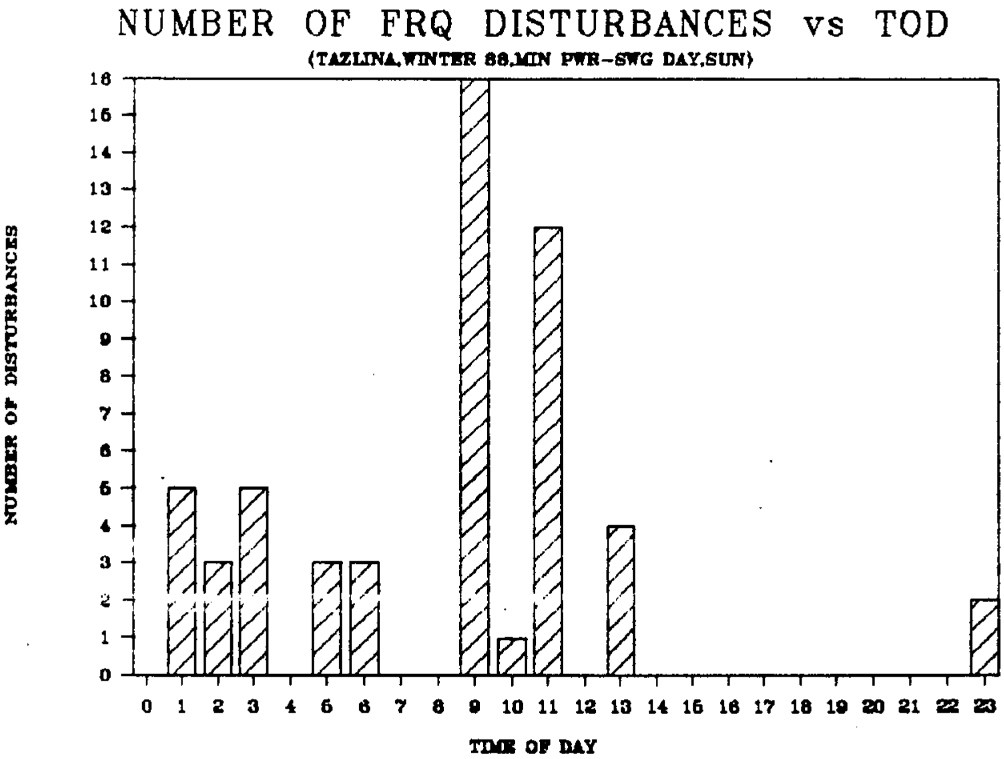


Figure T88

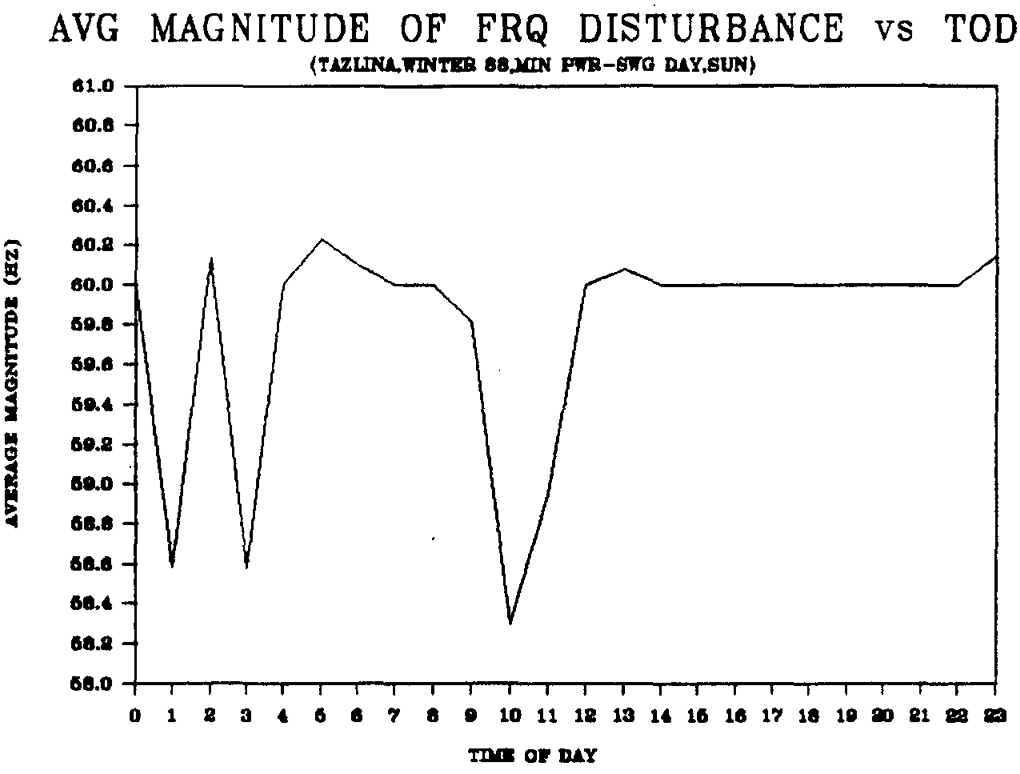


Figure T89

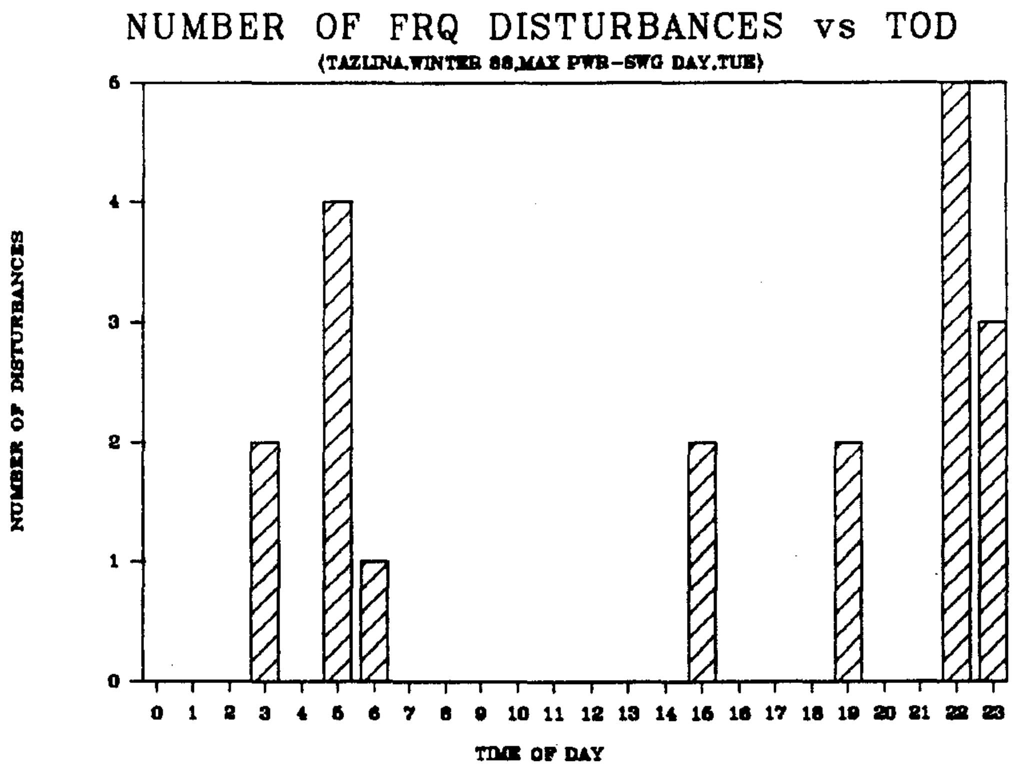


Figure T90

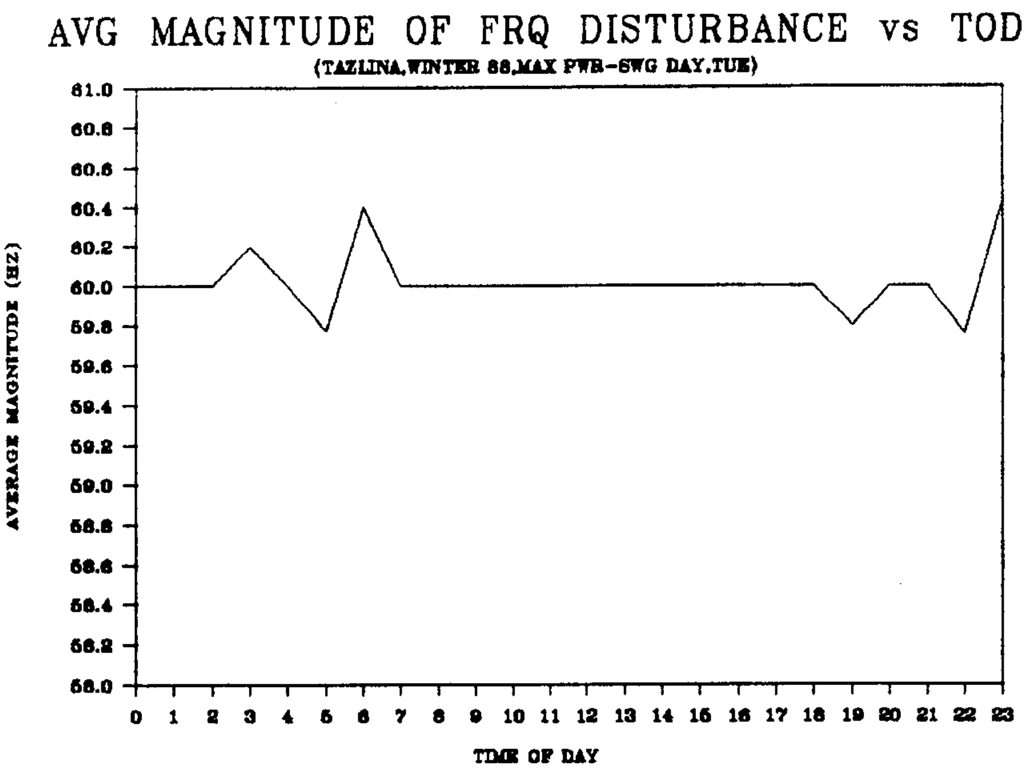


Figure T91

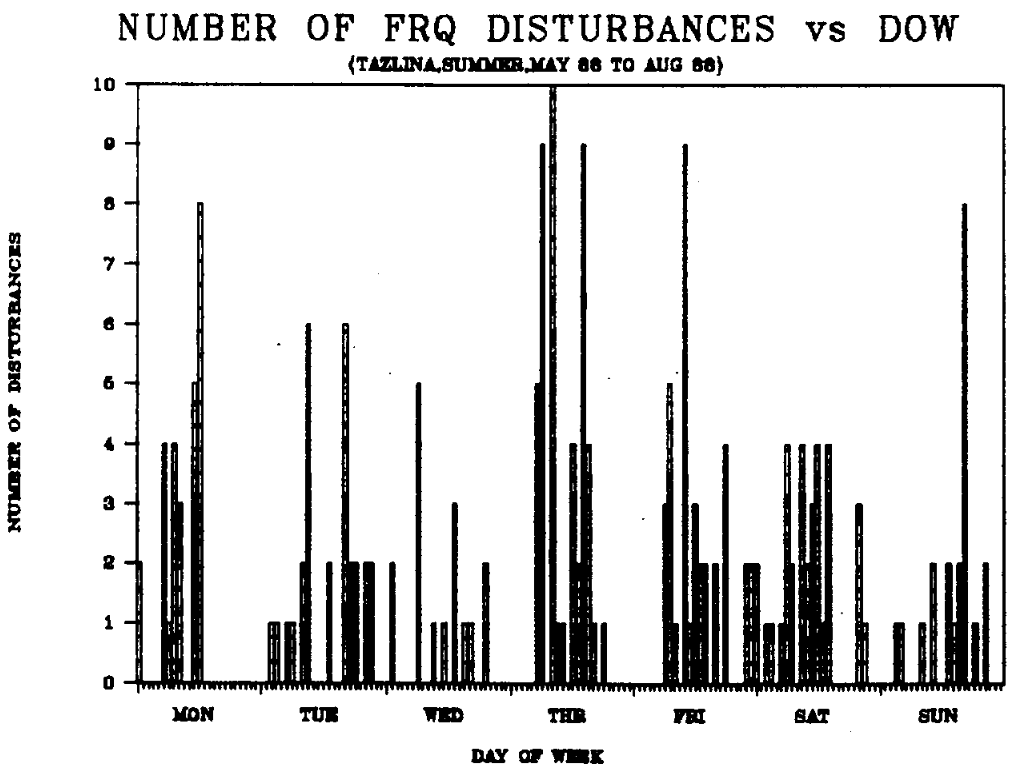


Figure T92

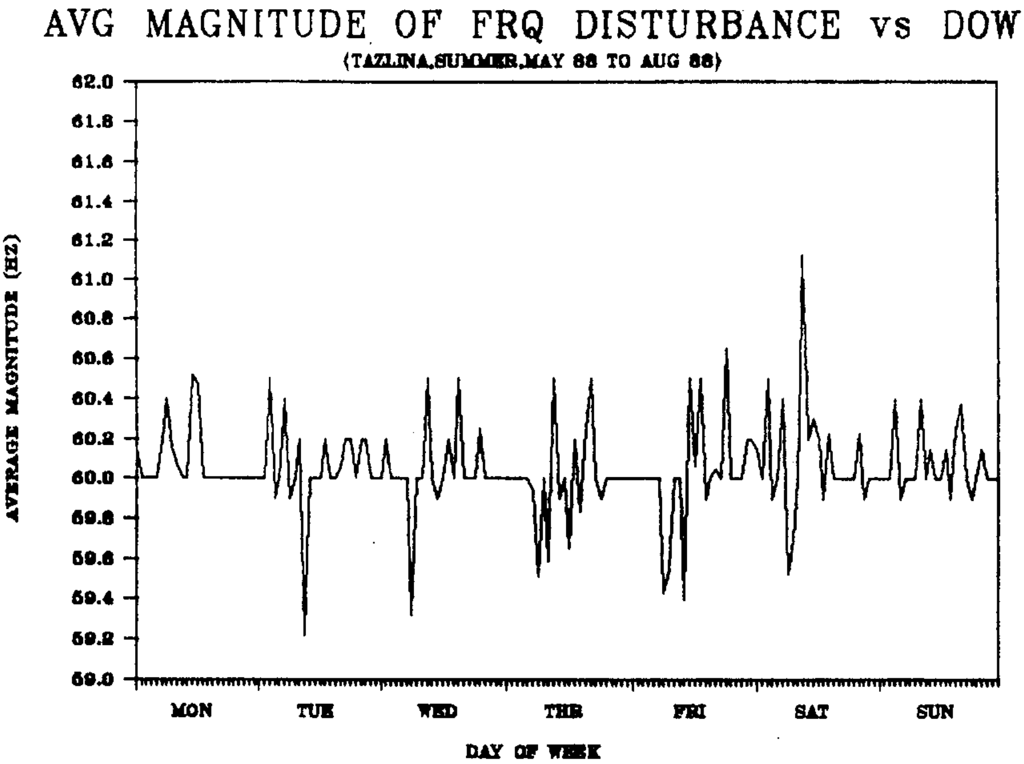


Figure T93

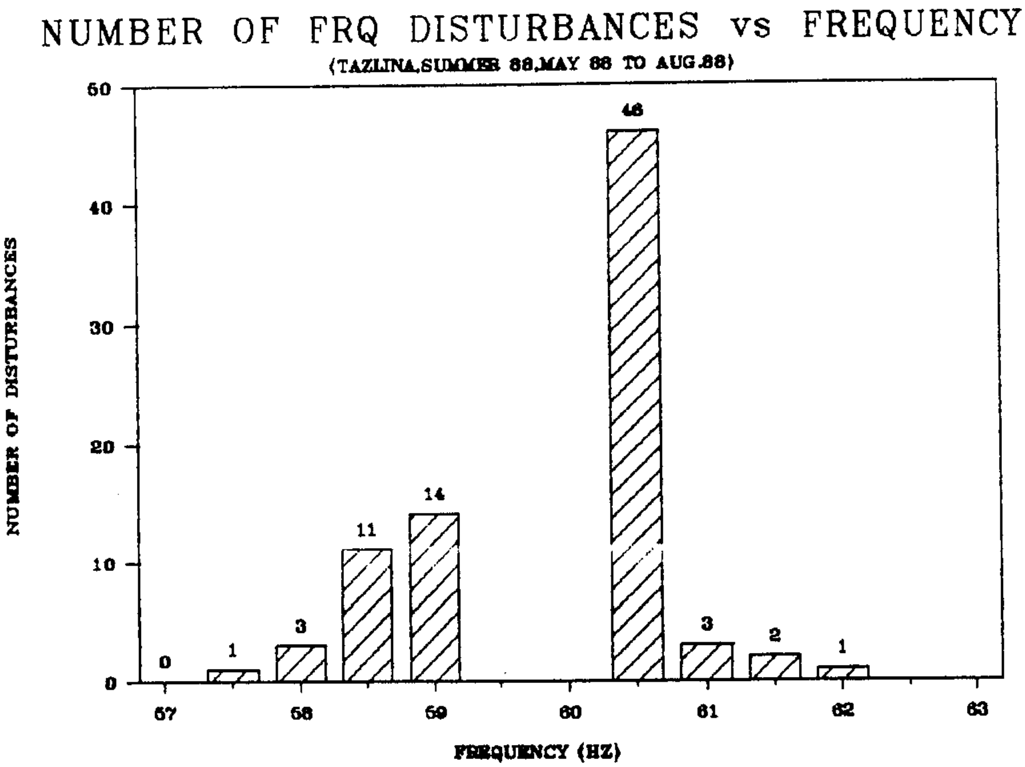


Figure T94

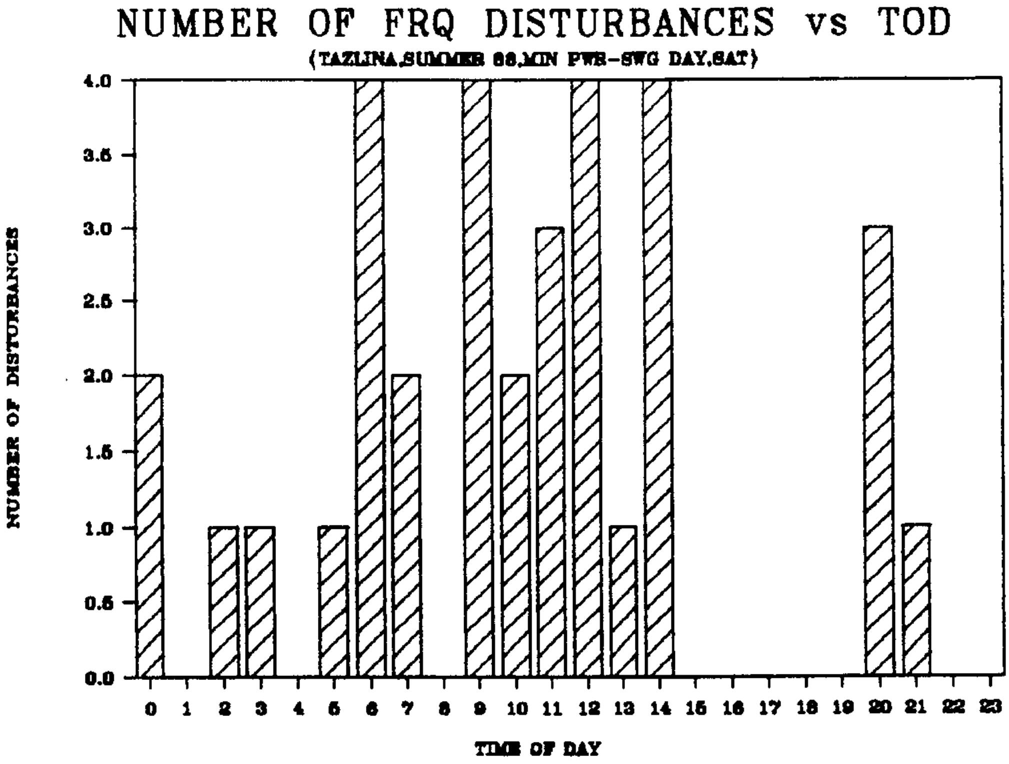


Figure T95

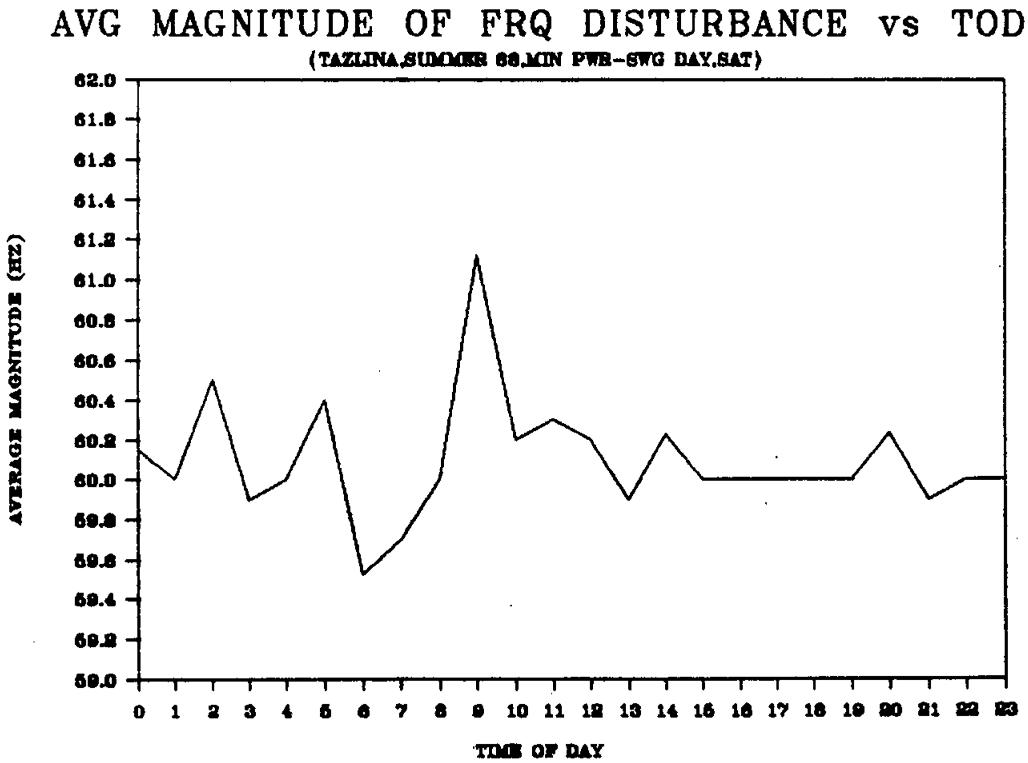


Figure T96

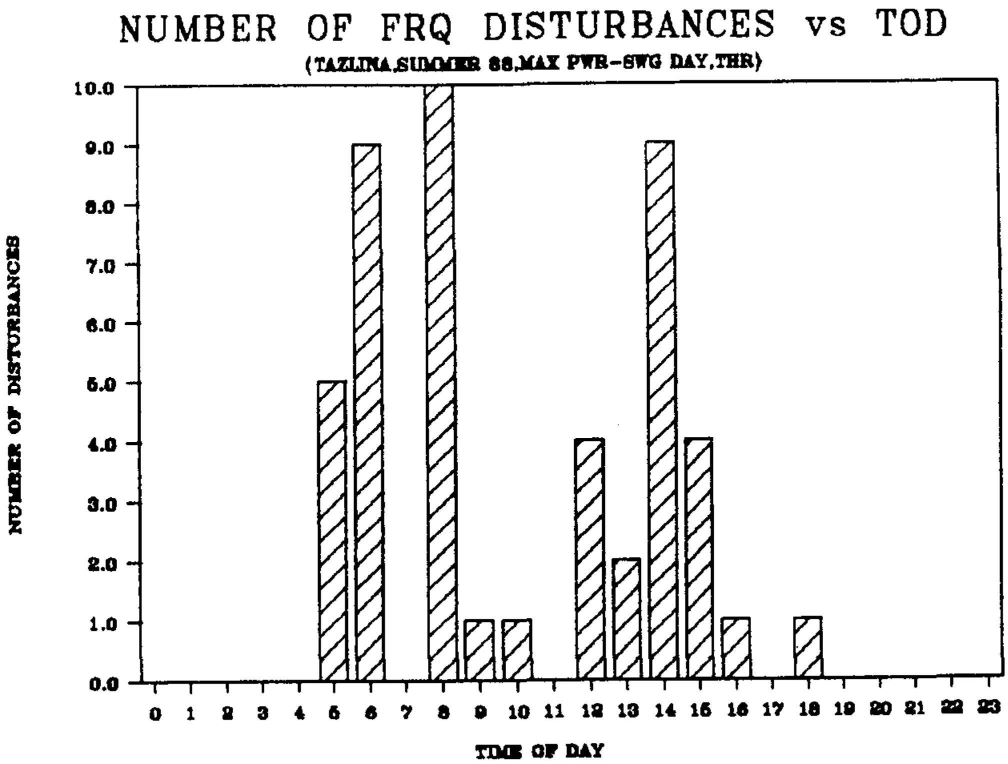


Figure T97

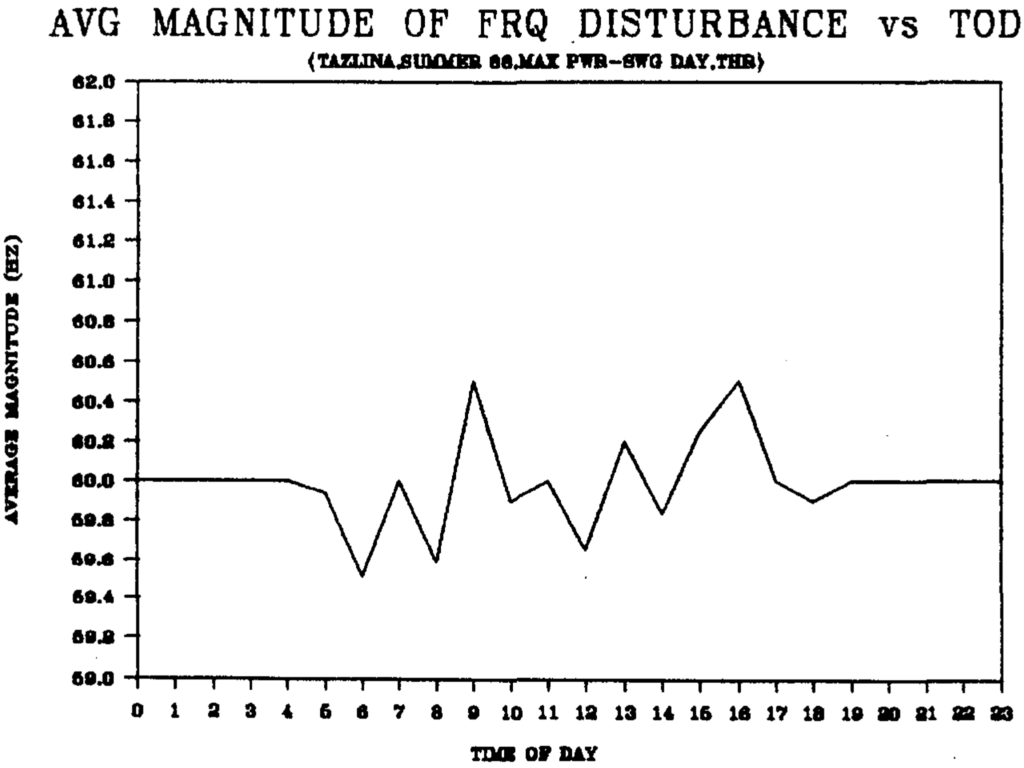


Figure T98

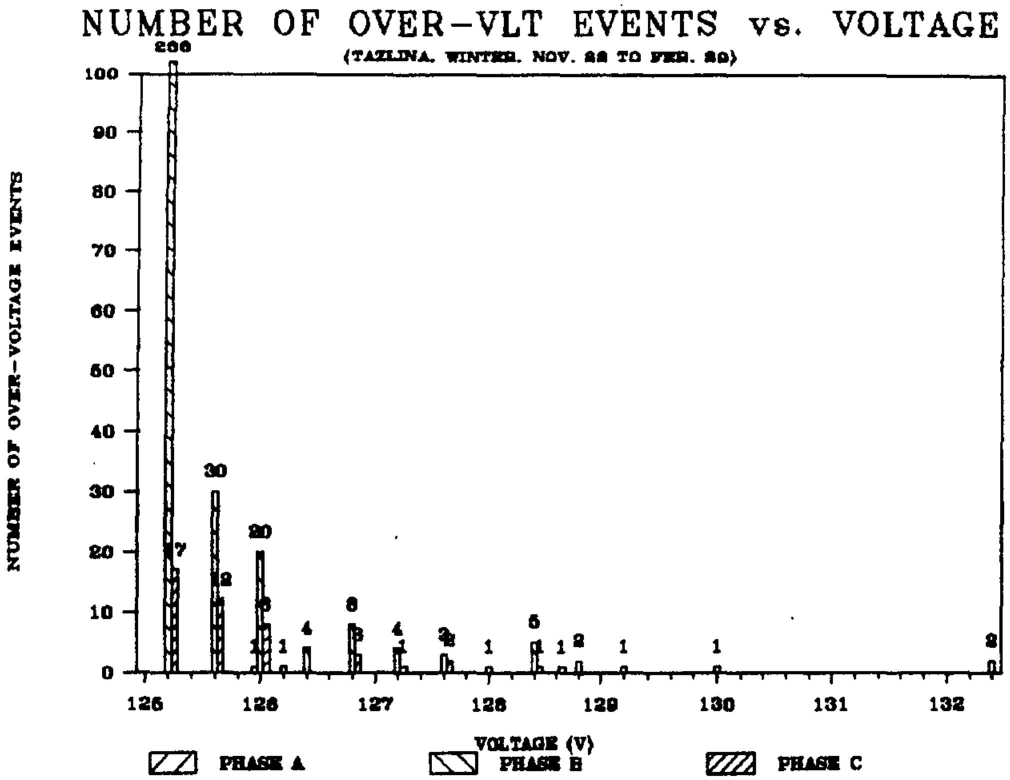


Figure T99

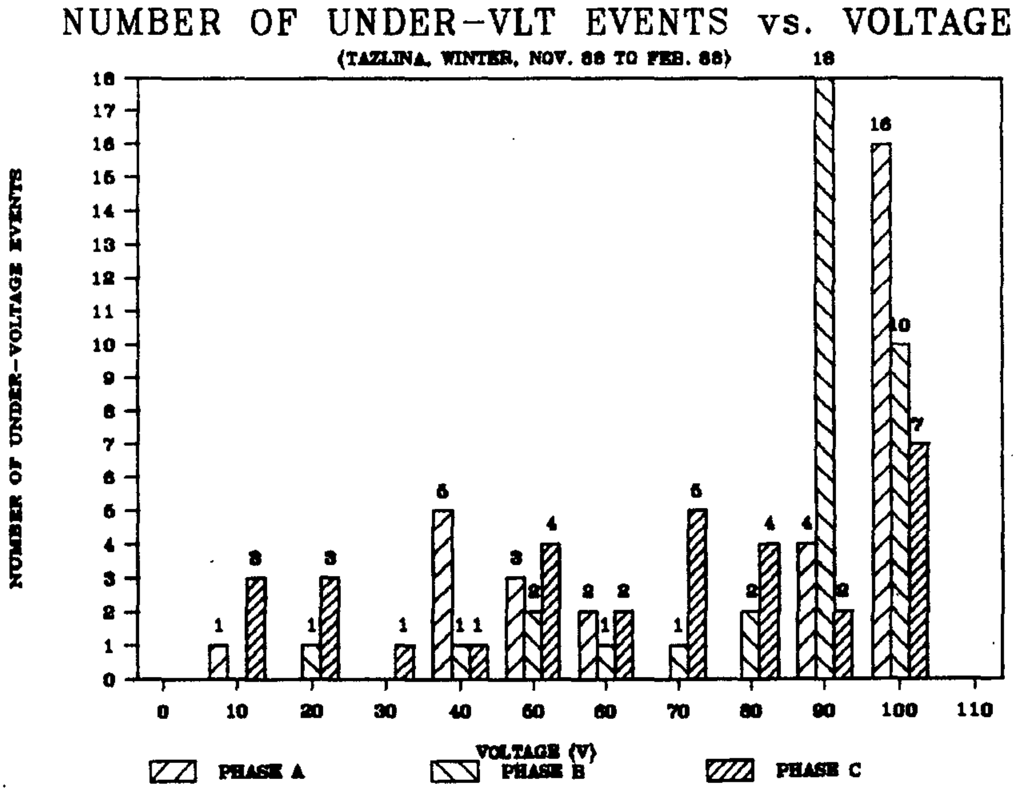


Figure T100

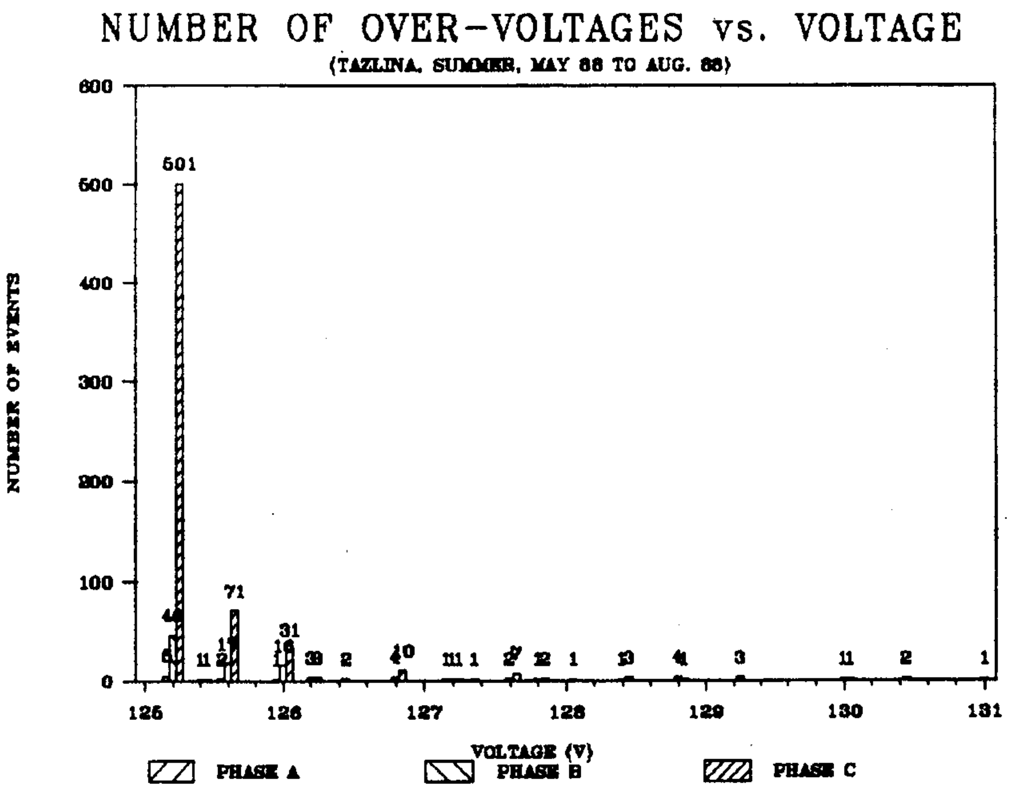


Figure T101

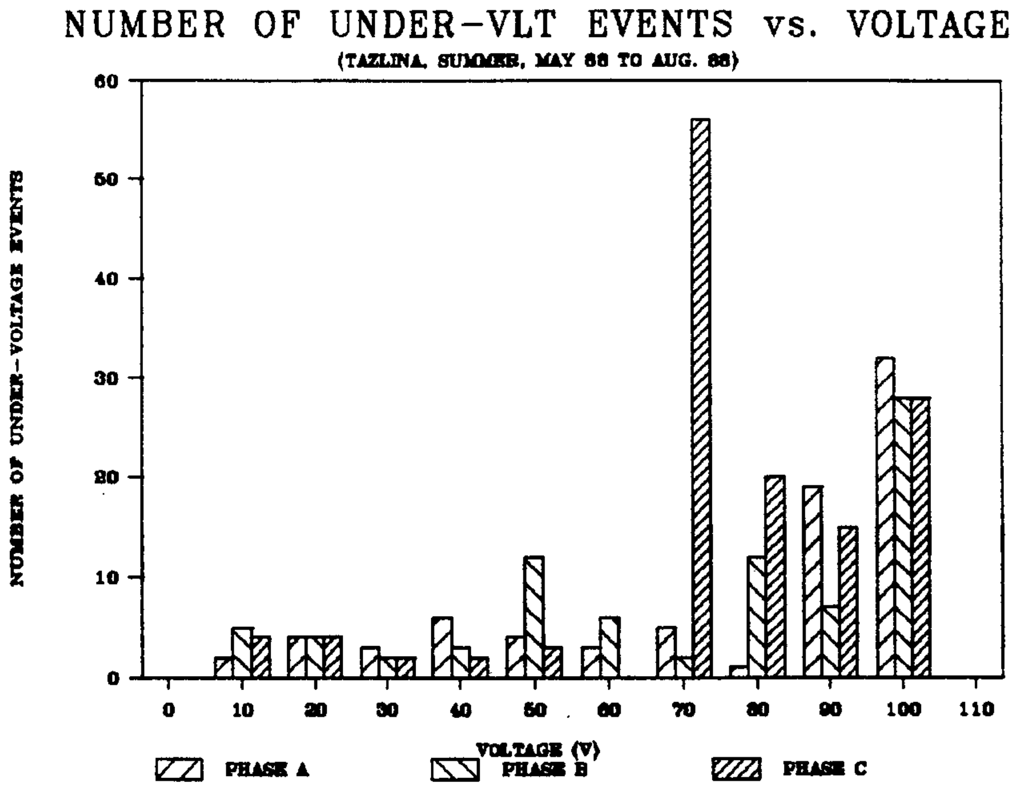


Figure T102

3.3 Power system disturbance data summary

The outage summary for both sites and both seasons is presented in Table I.

3.3.1 Kotzebue site

As previously noted, Figures K1 through K18 show data from the Dranetz Model 808 electric power/demand analyzer. Average values of several variables are plotted with the horizontal time axis calibrated in day of week or time of day. In all cases, since the sampling interval of the Model 808 was set at 15 minutes or four samples per hour, there were 96 sample points per day. Each sample point set of values for a specific time of day was averaged over the season (winter or summer). The average was again taken among the four points in the same hour. Thus, one average variable value per hour resulted and was subsequently plotted.

Figures K1 through K9 present plots of average power demand, average voltage and average power factor as functions of day of the week, time of day (minimum power swing day) and time of day (maximum power swing day) for the winter season. Figures K10 through K18 present plots of the same variables as functions of the same time scales but for the summer season.

For the winter season, average power demand varies between approximately 4 and 16 MW with nights and weekends being periods of relatively low demand. The minimum average power swing day is Sunday, with the maximum average power swing on Friday. Figures K4 through K9 are expanded views of Figures K1, K2 or K3. Average voltage ranges between approximately 117.5 and 121.5 V. Average power factor is always above 0.91 and approaches 0.99 during periods of maximum load. Average power demand and average power factor have similar time variations while average voltage varies inversely with average power demand.

Table I. Outage Summary

Location	Season	Total Days	Known Duration Outages	Total Outages	Total known duration outage time (minutes)	Average outage duration (minutes)	Average Number of days between outages	Average number of outages per month
Kotzebue	Summer	123	1	3	2	2	41	0.74
Kotzebue	Winter	52	3	3	18	6	17.3	1.76
Tazlina	Summer	123	2	4	35	17.5	30.8	0.99
Tazlina	Winter	120	1	2	120	120	60	0.51

For the summer season, average power demand varies between approximately 3 and 13 MW with a similar daily and weekly characteristic as winter. Average voltage stays within a range between 118.8 and 121.6 V. The minimum power swing day is Saturday and the maximum power swing day is Wednesday. Average power factor varies between 0.89 and 0.99.

Figures K19 through K29 provide information about voltage impulses measured during the winter. Plotted are: number of impulses versus day of week and time of day (minimum power swing day and maximum power swing day), average absolute impulse magnitude and average impulse duration versus the same time variables, and number of impulses versus magnitude and versus duration. Comparing Figures K1 and K19, K4 and K24, and K7 and K27 shows a strong correlation between power demand and number of impulses. This leads to the conclusion that impulses are often caused by loads, either by themselves or through load switching. Impulse magnitude and duration are not as strongly correlated with power demand, although two of the three highest average magnitudes correspond to periods of high demand and the third is on the shoulder of the Wednesday demand peak. The relatively large impulse magnitudes and durations on Tuesday and Wednesday (Figures K20 and K21) are correlated. Apparently those large impulses were also of relatively long duration. However, the large average impulse on Friday was not of long average duration.

Table II further summarizes impulse data. During the Kotzebue winter, by far the largest number of events (77.6%) occurred on power system phase B. Maximum magnitude was 240 V on phase A. Average absolute magnitude ranged from 57.6 V on phase B to 75.4 V on phase A. Figures K22 and K23 show that 97.6% of all impulses were smaller than 90 V and 97.1% were shorter than 100 microseconds in duration. The disturbance analyzer impulse threshold was set at 50 V, so impulses smaller than that threshold were not recorded.

Figures K30 through K40 provide information about voltage impulses measured during the summer and relate the same variables as Figure K19 through K29 described above.

Table II. Additional Impulse Data

Location	Season	Total Days	Phase	Number of Events	Average Absolute Magnitude (V)	Maximum Magnitude (V)	Minimum Magnitude (V)	Number of Impulses Per Day
Kotzebue	Summer	123	A	26	74.2	207	50	0.2
			B	750	58.6	213	50	6.1
			C	255	62.0	225	50	2.1
Kotzebue	Winter	52	A	46	75.4	240	50	0.9
			B	731	57.6	210	50	14.1
			C	165	61.3	204	50	3.2
Tazlina	Summer	123	A	42	108.6	225	50	0.3
			B	76	67.2	250	50	0.6
			C	273	77.0	258	50	2.2
Tazlina	Winter	120	A	71	100.2	279	50	0.6
			B	95	82.8	339	50	0.8
			C	227	79.7	315	50	1.9

* Impulse magnitude threshold level = 50 V

Comparing Figures K10 and K30, and K16 and K38 again shows a strong correlation between average power demand and number of impulses. The relationship between Figures K13 and K35 is inconclusive, most probably because the variation in average power demand throughout the minimum power swing day is so small.

A comparison of Figures K10 and K31 and K10 and K32 shows no obvious correlation between power demand and impulse average absolute magnitude or average duration. Comparing Figures K31 and K32 shows that relatively large average absolute magnitude impulses have longer than usual average duration. The four largest events in both figures occur at the same times.

Table II reports that for the Kotzebue summer, 72.7% of all recorded impulses occurred on Phase B. Maximum impulse magnitude was 225V on Phase C. Average absolute magnitude ranged from 58.6 V on Phase B to 74.2 V on Phase A. Figures K33 and K34 show that 97.6% of all recorded impulses were smaller than 90 V and 97.0% were shorter than 100 microseconds in duration. It is interesting to note that these statistics are essentially identical to the winter results.

Figures K41 through K45 provide voltage sag information for the winter season. No sags were recorded on either the maximum average power swing day (Friday) or the minimum average power swing day (Sunday) so figures corresponding to T46 through T51 do not appear. The same is true for the Kotzebue summer minimum power swing day (Saturday) so figures corresponding to T57 through T59 are not present.

During the 52 Kotzebue winter days that data were recorded, 37 sags occurred with a minimum magnitude of 75 V and a maximum duration of between 0.35 and 0.40 seconds. 67.6% of the 37 sags had magnitudes greater than 100 V. (The threshold was 105 V or -13% of the nominal 120 V). 83.8% of all sags had magnitudes greater than 95 V.

Figures K46 through K53 give voltage sag information for the Kotzebue summer season. Thirty-six sags were recorded in 123 days. Minimum sag voltage was between 10 V and 20 V (one event). All but two sags had minimum voltages greater than 70 V. Maximum sag duration was between 0.65 and 0.70 seconds. Approximately 70% of all sags had minimum voltages in excess of 90 V.

Voltage surges are reported in Figures K54 through K58 for the Kotzebue winter season. Only three surges were recorded. Two had a magnitude of 125 V. The magnitude of the remaining surge was 127 V. Maximum surge duration was 2.5 seconds.

Figures K59 through K69 give voltage surge information for the Kotzebue summer season. Forty-one surges were recorded. Maximum surge magnitude was 130 V. Maximum surge duration was between 1.9 and 2.0 seconds. 87.8% of all surges had magnitudes less than 126.5 V. A comparison of Figures K10 and K59 shows that most surges occurred during periods of relatively high average power demand on Wednesdays and Thursdays.

Figures K70 through K81 provide frequency disturbance information for the Kotzebue site. The horizontal time variables are day-of-week or time-of-day. Figures K70 through K76 give winter season data while Figures K75 through K81 show similar information for the summer season.

A comparison of Figures K1 and K70 and Figures K10 and K75 does not disclose any obvious correlation between average power demand and number of frequency disturbances as a function of time. This is reasonable since the load at the Kotzebue site is a small fraction of the total system generation.

Figure K72 shows that, for the winter season, there were 224 frequency disturbances, defined as the power system frequency deviating from the 60.0 Hz nominal value by more than 0.5 Hz. Sixty-four disturbances or 28.6% of the total were within the range of 59 to 61 Hz while 120 disturbances, or 53.6% of the total, were within the range of 58 to 62 Hz. The minimum frequency recorded was in the range of 45 to 45.5 Hz while maximum frequency was in the range of 63 to 63.5 Hz.

Figure K77 indicates that for the summer season, there were 1537 frequency disturbances. Of these, 635 or 41.3% of the total were in the range of 59 to 61 Hz, and 1443 or 93.9% of the total were in the range of 58 to 62 Hz. The minimum frequency recorded was in the range of 53.5 to 54 Hz and the maximum frequency was in the range of 65 to 65.5 Hz.

Figures K82 and K83 show the number of overvoltage and undervoltage events as functions of power system voltage for the winter season. There were only four overvoltage events with a maximum of less than 127 V. All occurred on Phase A. There were a total of 190 undervoltage events. 81% had a minimum voltage greater than 90 V and 6 had minimum voltages between 10 and 20 V. There was an average of 3.7 undervoltage events per day. This is 4.46 times more events per day than in the summer. 40.0% were on Phase A, 26.3% on Phase B, and 33.7% on Phase C.

Figures K84 and K85 provide the number of overvoltage and undervoltage events as functions of power system voltage for the summer season. 116 overvoltage events were recorded with the maximum less than 126.5V. None occurred on Phase A, 69.0% occurred on Phase B, and 31.0% on Phase C. There were 102 undervoltage events. 68.6% had a minimum voltage greater than 90 V and two had minimum voltages between 20 and 30 V. There was an average of 0.829 undervoltage events per day in the summer. 40.2% were on Phase A, 31.4% on Phase B, and 27.5% on Phase C.

3.3.2 Tazlina site

Figures T1 through T18 show data from the Dranetz Model 808 electric power/demand analyzer. Figures T1 through T9 show plots of average power demand, average voltage and average power factor as functions of day of the week, time of day (minimum power swing day) and time of day (maximum power swing day) for the winter season. Figures T10 through T18 present plots of the same variables as functions of the same time scales but for the summer season.

For the winter season, average power demand varies between approximately 9 and 30 MW with nights and weekends being periods of relatively low demand. The minimum average power swing day is Sunday with the maximum average power swing on Tuesday. Figures T4 through T9 are expanded views of Figures T1, T2 or T3. Average voltage ranges between approximately 120.0 and 121.4 V. Average power factor is always above 0.925 and approaches 0.99 during periods of maximum load. Average power demand and average power factor have similar time variations. Average voltage varies inversely with average power demand.

For the summer season, average power demand varies between approximately 3.8 and 17.5 MW with a similar daily and weekly characteristic as winter. Average voltage shows a range between 120.2 and approximately 122.0 V. The minimum power swing day is Saturday and the maximum power swing day is Thursday. Average power factor has values between approximately 0.86 and 0.99.

Figures T19 through T29 give information about voltage impulses measured during the winter. Plotted are: number of impulses versus day of week and time of day (minimum power swing day and maximum power swing day), average absolute impulse magnitude and average impulse duration versus the same time variables, and number of impulses versus magnitude and versus duration. A comparison of Figures T1 and T19, T4 and T24, and T7 and T27 shows no obvious correlation between average power demand and number of impulses recorded for a given time interval. A surprisingly large number of impulses were recorded for the low average power demand weekend days. The largest number of impulses recorded per time interval was between 0100 and 0200 on Fridays which was a time of very low average power demand.

Table II provides additional impulse information. During the Tazlina winter, 57.8% of the measured impulses occurred on phase C. Average absolute magnitude ranged from 79.7 V on phase C to 100.2 V on phase A. The maximum impulse measured during the entire project was 339 V on phase B. Figures T22 and T23 show that 77.1% of all impulses were smaller than 90 V and 72.0% were shorter than 100 microseconds in duration. The disturbance analyzer impulse threshold was set at 50 V.

Figures T30 through T40 provide information about voltage impulses measured during the summer and relate the same variables as Figures T19 through T29 described above.

A comparison of Figures T10 and T30 shows that Monday and Thursday peaks in average power demand coincide with periods of high numbers of impulses. However, this is not true for daily peaks on Tuesday, Wednesday and Friday, so it is difficult to draw meaningful conclusions. Again, by comparing Figures T10 and T31 and T10 and T32, no correlation is noted between average power demand and impulse average absolute magnitude or average duration.

Table II shows that for the Tazlina summer, 69.8% of all recorded impulses occurred on phase C. Maximum impulse magnitude was 258 V on phase C. Average absolute magnitude ranged from 67.2 V on phase B to 108.6 V on phase A. Figures T33 and T34 show that 81.8% of all recorded impulses were smaller than 90 V and 43.5% were shorter than 100 microseconds in duration.

Figures T41 through T51 provide voltage sag information for the Tazlina winter season. During the 120 days that data were recorded, 76 sags occurred or 0.633 sag/day. 46.1% of the sags had magnitudes greater than 100 V and 63.2% had magnitudes greater than 90 V. Sixty-two, or 81.6% of the total number of sags were of less than 0.1 second duration. Minimum sag voltage was between 0 and 10 V. A comparison of Figures T1 and T41 shows no apparent correlation between average power demand and measured sags.

Figures T52 through T62 give voltage sag information for the Tazlina summer season. Data were recorded for 123 days and 151 voltage sags were measured for an average of 0.815 sag/day. Minimum sag voltage between 10 V and 20 V occurred for one event and four other sags had voltages less than 70 V. Fifty-two, or 34.4% of the total number of sags had magnitudes greater than 100 V and 43.0% had magnitudes greater than 90 V. An inspection of Figures T10 and T52 shows that the relatively large number of sags measured on Mondays and Thursdays occurs during the periods of high average power demand on those days.

Voltage surges measured during the Tazlina winter season are reported in Figures T63 to T73. One hundred seventy-four voltage surges were measured in 120 days for an average of 1.45 surges/day. Maximum surge magnitude was 132 V with 75.3% of the total having magnitudes less than 126.5 V. It is interesting to note that 33.3% of all surges occurred between 1900 and 2000 hours on Tuesdays.

A total of 86 voltage surges recorded during the summer season at Tazlina are described in Figures T74 to T84. Maximum surge voltage was 132 V. 77.9% of the surges had magnitudes less than 126.5 V. A comparison of Figures T10 and T74 shows no correlation between average power demand and number of surges as a function of time.

Figures T85 through T91 show frequency disturbances recorded during the Tazlina winter season. A comparison of Figures T1 and T85 shows that most of the frequency disturbances occurred during periods of relatively low average power demand. In fact, many were on weekends. A total of 67 frequency disturbances occurred in 120 days. 64.2% of these were between 59.0 and 61.0 Hz. The minimum frequency recorded was between 56 and 56.5 Hz (two events) and the maximum frequency was between 61.5 and 62 Hz (one event).

Figures T92 through T98 provide information on frequency disturbances recorded during the Tazlina summer season. Eighty-one disturbances were recorded in 123 days. Of these, 74.1% were between 59.0 and 61.0 Hz. The minimum frequency recorded was between 57.5 and 58.0 Hz (one event) and the maximum frequency was between 62 and 62.5 Hz (one event). A comparison of Figures T10 and T92 shows no discernable correlation between average power demand and number of frequency disturbances as a function of time.

Figures T99 and T100 show the number of overvoltage and undervoltage events as functions of power system voltage for the Tazlina winter season. There were 326 overvoltage events (2.72 events/day). The maximum voltage recorded was 132.4 V for two events on phase B. 79% of the overvoltages had magnitudes less than 125.9 V and 93% were less than 126.9 V. One overvoltage occurred on phase A (0.3% of the total), 282 occurred on phase B (86.5% of the total), and 43 overvoltages occurred on phase C (13.2% of the total). There were 99 undervoltage events (0.825 events/day). Minimum undervoltage recorded was between 10 and 20 V (four events). 57.6% of all events had minimum voltages greater than 90 V. The undervoltages were very evenly divided between the three phases (31 on phase A, 36 on phase B, and 32 on phase C).

Figures T101 and T102 give the number of overvoltage and undervoltage events as functions of power system voltage for the Tazlina summer season. There were 742 overvoltage events (6.03 events/day). The maximum voltage event was 131 V on phase B. 86% of the events had magnitudes between 125 and 125.9 V, while 95% had magnitudes less than 126.9 V. Ten overvoltages (1.3%) occurred on phase A, 92 (12.4%) on phase B, and 640 (86.3%) on phase C. There were 291 undervoltage events (2.37 events/day). 44.0% had a minimum voltage greater than 90 V and 11 had minimum voltages between 10 and 20 V. 26.8% of the total number of events occurred on phase A, 27.1% on phase B, and 46.0% on phase C.

4.0 CONCLUSIONS

The following conclusions are drawn from data presented in this report and data appearing in references [1] and [6].

1. Both data collection sites have high power factor loads. Average voltage varies ±1.8 V at Kotzebue and -0, +2.0 V at Tazlina. Average power demand at Kotzebue ranges between 4 and 16 kW in the winter and between 3 and 13 kW in the summer. At Tazlina, average power demand approximately doubles in winter compared to the summer load with a winter range of 9 to 30 kW. Thus, a seasonal variation of disturbances would be expected to be less at Kotzebue, if any load dependence exists. The electric utilities serving both sites are substantially larger than utilities at three of the four sites reported in [1]. Kotzebue was selected for the second study because it appeared in the first and, at that time, had a persistent overvoltage problem and a large number of impulse disturbances. The Tazlina site was chosen because it is served by a larger, but still isolated, utility system than was investigated in the Phase I data collection and analysis effort [1].

2. The incidence of outages reported in Table I show a total outage rate of 0.87 outages per month, compared with 4.9 outages per month reported in [1] and 0.6 outages per month presented in [6], a 1974 report of an extensive power system disturbance study done in the contiguous 48 states. Table I shows a 25-minute average outage duration. If the 120-minute outage is removed, average outage duration becomes 9.2-minutes per outage. Reference [6] reported a 1.0-minute mean outage time. Reference [1] presented an adjusted average outage duration of 10.9 minutes.

3. Overvoltages, reported in detail in the disturbance data summary, were not a significant factor at either site. At Tazlina (summer), 95% of the 742 overvoltages measured were less than 127

V. The maximum overvoltage was 131 V. Three hundred twenty-six overvoltages were recorded in the winter at Tazlina with 93% below 127 V. Two overvoltages reached the maximum of 132.4 V. The Kotzebue site had a total of 120 overvoltage events (summer plus winter). All were less than 127 V. Recall again that the Kotzebue winter data collection effort spanned 52 days, compared with 120 days for Tazlina.

4. Figures K83, K85, T100 and T102 show the distribution of undervoltage events as a function of minimum voltage. Of a total of 190 events at Kotzebue (winter), 81% had a minimum voltage greater than 90 V and 6 had minimum voltages between 10 and 20 V. There was an average of 3.7 undervoltage events per day. At Tazlina (winter), 99 undervoltage events occurred at an average rate of 0.83 events per day. Fifty-eight percent of the events had a minimum voltage greater than 90 V and 4 had minimum voltages between 10 and 20 V. As noted in the disturbance data summary, the total number of undervoltage events at Kotzebue (winter) was approximately two times greater than in the summer despite a summer data collecting period 2.4 times longer. Conversely, the number of undervoltage events during the summer at Tazlina was approximately three times as large as the winter total. This is interesting, since the summer represents a period of smaller load at the site.

   Undervoltage duration data were not accessible. This makes it difficult to assess the hazard present for electric motor loads.

5. A small number of sags below 90 V occurred at all sites and seasons with the exception of Tazlina (summer) where nearly 70 sags in the range of 70 to 80 V were recorded. Since sags are, by definition, less than 2.56 seconds in duration, they should have less effect on motors than undervoltages with the same minimum voltage magnitude.

6. Most surges have magnitudes less than 127 V at both sites and for both seasons. Maximum surge magnitude is 130 V at Kotzebue and 132 V at Tazlina.

7. Table II and Figures K22, K33, T22, and T33 show that most impulses have magnitudes less than 100 V (the minimum threshold was 50 V). The maximum impulse magnitude was 240 V at Kotzebue and 339 V at Tazlina. Number of impulses per phase per day ranged from 0.2 (Kotzebue, summer, Phase A) to approximately 14 (Kotzebue, winter, Phase B). Number of impulses per site per month ranged from 54 (Kotzebue, winter) to 94 (Tazlina, summer). These numbers are higher than the 50.7 voltage spikes at a 30 V threshold reported in [6] but substantially lower than presented in [1]. In [1], 6270 impulses per month at a 50 V threshold were reported for the Kotzebue data site. In the earlier study [1] the disturbance analyzer was located in an office and not at the service entrance, as in the data collection effort reported here, which would reduce the effect of load-generated impulses. This, plus service upgrades over the five year interval separating the two studies could account for a significant decrease in impulses measured at the same site.

8. Relationships between average power demand and power system disturbances are not consistent. For example, during both seasons at the Kotzebue site, a strong correlation between power demand and number of impulses was noted. However, a similar result did not occur at Tazlina. At Kotzebue, during the summer, most voltage surges occurred during periods of relatively high average power demand on Wednesdays and Thursdays. There was, however, no discernable correlation between average power demand and number of frequency disturbances as a function of time. At Tazlina, no obvious correlation existed between average power demand and measured sags in the winter but a relatively large number of sags measured in the summer on Mondays and Thursdays occurred during the periods of high average power demand on those days. No

correlation was evident between average power demand and number of surges as a function of time at Tazlina during the summer. During the winter at Tazlina, most frequency disturbances occurred during periods of relatively low power demand. No apparent correlation existed between the same variables during the summer.

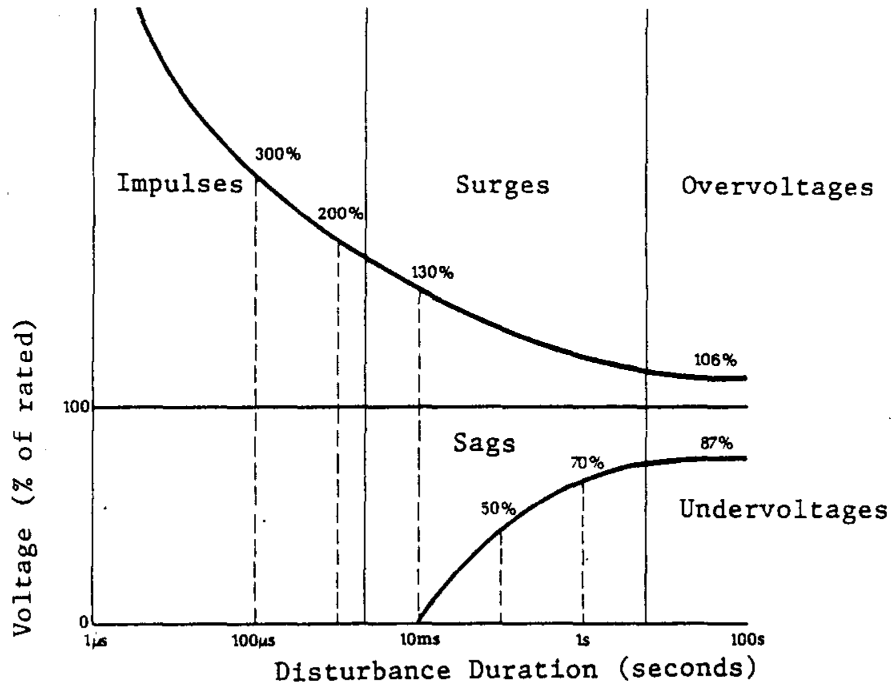
9. Frequency disturbances, defined as the power system frequency deviating from the 60.0 Hz nominal value by more than 0.5 Hz, were more prevalent at Kotzebue than Tazlina. A total of 1761 events (10.1 events/day) occurred at Kotzebue. 39.7% of these were in the range of 59 to 61 Hz. Minimum frequency measured was between 45 to 45.5 Hz and maximum frequency was between 65 and 65.5 Hz. 148 frequency disturbance events were recorded at Tazlina (0.61 events/day). 69.6% of this total were in the range of 59 to 61 Hz. Minimum frequency measured was between 56 and 56.5 Hz and maximum frequency was between 62 and 62.5 Hz.

10. What are the reported power system disturbances' impacts upon normally present loads? Is there a potential problem at either site? Although there are no industry-wide standards that specify "acceptable" AC power quality, several references define acceptable power quality limits for computer systems [7, 8, 9, 10 for example] and at least one addresses communications systems [8]. General agreement exists that +6% and -13% rated voltage steady-state limits are necessary, although at least one computer manufacturer is reported to require ±4% tolerance [7]. Opinions about acceptable power quality differ for transients lasting less than two seconds. The American National Standards Institute (ANSI) Standard C84.1 requires +15% and -20% voltage tolerance for transients between 0.05s and 0.5s duration, and +20% and -30% voltage tolerance for transients between 0.008s and 0.05s duration, as reported in [7]. A different tolerance envelope is suggested in [10], resulting from U.S. Navy tests and computer manufacturers' information. It is generally more restrictive than the C84.1 standard for voltage surges and impulses with the

tolerance boundary rising smoothly from +6% rated voltage for a 2s disturbance to +30% for 8.33 ms. +100% for 1 ms and +200% rated voltage limit on a 100 μs disturbances. The undervoltage limits of this tolerance envelope include -13% rated voltage for a 2s disturbance, -30% for 0.5s, -42% for 0.1s, -70% for 16.7ms and -100% for an 8.33ms disturbance.

Frequency tolerance for a 60 Hz source is reported to be ±0.5 Hz in some instances [7], although at least one major computer company specifies ±1.0 Hz [5].

An AC power susceptibility profile for a specific electronic instrument, appearing in the Dranetz 626 product literature, is shown below. It is less restrictive than the tolerance envelope described in [12].



AC POWER SUSCEPTIBILITY PROFILE

Given the above background, average voltage fluctuations at either site are definitely not a problem. They are well within the +6% to -13% tolerance (127.2 V to 104.4 V). All overvoltages measured at Kotzebue were less than 127 V. At the Tazlina site, maximum overvoltage was 132.4 V (2 events) and approximately 95% of all overvoltages were less than 127 V.

Considering undervoltages at Kotzebue (winter), six events had minimum voltages below 20 V. However, 81% of the 190 events did not drop below 90 V. In the summer, two undervoltage events were below 30 V and 69% of the 102 events were above 90 V. At Tazlina (winter), four events were below 20 V and 58% of the 99 undervoltages were above 90 V. In the summer, eleven events were below 20 V and of a total of 291 undervoltages, 44% were above 90 V. Undervoltages pose a definite hazard to electric motors. The degree of danger is related to both the voltage level and duration of the undervoltage condition. Since manufacturers are reluctant or unable to provide quantitative susceptibility profile information, one can only speculate about the possibility of motor damage at Kotzebue or Tazlina. If no problems were noted during the data collecting periods, there may be nothing to worry about. If problems were noted, undervoltage relays or other motor protection may be justified. Undervoltage also can cause computer shutdowns and consequent loss of data. The most effective (and most expensive) protection against data loss is an uninterruptible power supply (UPS).

Maximum surge voltage at Kotzebue was 130 V. Nearly 90% of all surges were less than 127 V. Maximum surge voltage at Tazlina was 132 V, while more than 75% of all surges were less than 127 V. Therefore, surges are unlikely to cause problems at either site.

Minimum sag voltage at Kotzebue was below 20 V and was below 10 V at Tazlina. These were, however, very infrequent events and, since sags are defined to be less than 2.55 seconds in duration, the possibility of motor damage from this type of disturbance is remote.

Voltage impulses can cause damage to sensitive micro-electronic devices. However, most impulses measured at both sites were not likely to cause problems. At Kotzebue, 98% of all impulses were less than 90 V and 97% were less than 100 microseconds in duration. Maximum impulse voltage at Kotzebue was 240 V on phase A. At Tazlina, about 80% of all impulses were less than 90 V and averaged longer duration than those at the Kotzebue site. Maximum impulse voltage at Tazlina was 339 V on phase B. It is difficult to extrapolate effects of impulses measured at a service entrance to other parts of a distribution system within a large building. Impulses caused by load switching remote from the instrumentation site could be significantly attenuated by the time they traveled to the disturbance analyzer.

Frequency fluctuations measured at Tazlina were probably not large enough to present an equipment hazard. However, underfrequencies in the range of 45 Hz measured at Kotzebue would be a problem for motor operation if the condition were allowed to persist. If motor burnout problems were experienced during the data collecting period, underfrequency protection may be considered in addition to the undervoltage protection previously mentioned.

5.0 ACKNOWLEDGEMENTS

The authors greatly appreciate the cooperation and assistance of Stephen Kailing and John Rezek of the Alaska Department of Transportation and Public Facilities (ADOT&PF), Bob Price at the Tazlina maintenance facility and personnel at the Chukchi Branch Campus in Kotzebue. Lee Santoro provided excellent field installations and other technical assistance. The University of Alaska Computer Network made a communications link available from Kotzebue to Fairbanks. Ron Clabo wrote software supporting data analysis. ADOT/PF, Division of Planning and Programming, Research Section, provided a grant which supported the work described in this report.

6.0 REFERENCES

[1] Aspnes, J.D., B.W. Evans and R.P. Merritt, "Rural Alaska Electric Power Quality," IEEE Transactions on Power Apparatus and Systems, Vol. PAS-104, No. 3, March 1985, pp. 608-619.

[2] Alaska Energy Authority, "Alaska Electric Power Statistics 1960-1988," Fourteenth Edition, September 1989.

[3] Aspnes, J.D., R.P. Merritt, and B.W. Evans. "Rural Alaska Electric Power Quality." Report No. AK-RD-85-04, State of Alaska, Department of Transportation and Public Facilities, Division of Planning and Programming Research Section, 2301 Peger Road, Fairbanks, AK 99701. 69 pages.

[4] Dranetz Technologies, "Operator's Manual 626-PA-6003 3-phase AC Monitor," TM-110235U, July 1984, Vol 1, pp. 14-17.

[5] Aspnes, J.D., R.P. Merritt, B.D. Spell, K. Woodruff, D. Alden and G. Mulligan. "Rural Electric Power Quality Analysis--Data Base Development." Report No. AK-RD-87-26, State of Alaska, Department

of Transportation and Public Facilities, Research Section, 2301 Peger Road, Fairbanks, AK 99701. March 1987, 54 pages.

[6] Allen, G.W., and D. Segall. "Monitoring of Computer Installations for Power Line Disturbances." IEEE Paper No. C-74-199-6, presented at the IEEE PES meeting, New York, January 27-February 1, 1974.

[7] Key, T.S. "Diagnosing Power Quality-Related Computer Problems." Presented at IEEE Industrial Applications Society Conference in Cincinnati, June 5-8, 1978.

[8] Waterman, J.J., Jr. "A Comparison of High-Rise UPS System Requirements." Specifying Engineer, February 1980, 5 pages.

[9] Kania, M.J., et al. "Protected Power for Computer Systems. The Western Electric Engineer, Spring/Summer 1980, pp. 41-47.

[10] Key, T.S. "Effect of Power Disturbances on Computer Operation." Electrical Construction and Maintenance, September 1978.

7.0 SELECTED BIBLIOGRAPHY

Kesterson, A., and P. Maher. "Computer Power--Problems and Solutions." Electrical Construction and Maintenance, December 1982, pp. 67-72.

Goldstein, M. and P.D. Speranza. "The Quality of U.S. Commercial AC Power." IEEE Paper No. CH1818-4/82/0000-0028.

Cathell, F. "Low Cost Power Transient Protection." Computer Design, May 1981, pp. 87-91.

IEEE Committee Report. "Bibliography on Surge Voltages in AC Power Circuits Rated 600 Volts and Less." IEEE Transactions on Power Apparatus and Systems. Vol. PAS-89 No. 6 July/August 1970, pp. 1056-1061.

Martzloff. F.P., and G. Hahn. "Surge Voltages in Residential and Industrial Power Circuits." IEEE Transactions on Power Apparatus and Systems, Vol. PAS-89, No. 6, July/August 1970, pp. 1049-1056.

Tucker, R. "The Glitch Stops Here." Computer Design, February 1982, pp. 149-154.

Hallinan, P.K. "Power Conditioners Cut System Cost." Digital Design, January 1982, pp. 68-71.

Martzloff, F.D., and T. Gruzs. "Power Quality Site Surveys: Facts, Fiction, and Fallacies." IEEE Transactions on Industry Applications, Vol. 24, No. 6, Nov/Dec 1988, pp. 1005-1018.

Martzloff, F.D. and H.A. Gauper, Jr. "Surge and High-Frequency Propagation in Industrial Power Lines," IEEE Transactions on Industry Applications, Vol. IA-22, No. 4, July/August 1986, pp. 634-640

Goedbloed, J.J. Transients in Low-Voltage Supply Networks," IEEE Transactions on Electro-magnetic Compatibility, Vol. EMC-29, No. 2, May 1987, pp. 104-115.

Standler, R.B. "Transients on the Mains in a Residential Environment," IEEE Transactions on Electromagnetic Compatibility, Vol. 31, No. 2, May 1989 pp. 170-176

8.0 APPENDIX A

8.0.1 AC voltage monitor (Dranetz Series 626) data conversion program

8.0.2 Electric power/demand analyzer (Dranetz Series (808) data conversion program

626 Data Conversion Program

This program was written to convert a 626 ascii data file into files that can be read by Lotus 1-2-3. To run the program place the conversion program disk in the "**A**" drive and type **con626** at the a prompt. You will then be asked a series of questions, each of which is listed below with an explanation.

Question	Explanation
Enter the name of the source file:	Enter the filename and extension of the file to be converted. Example: FILENAME.EXT
Enter the source file date (mm/dd/yy):	Enter the date in which the data was taken, NOT the current date. This date is used in the output files. Example: 01/10/88
Should the date be used for the Destination filename (Y/N)?	If you answer **Y** then the destination files will have the name 01_10_88 (for example). If you answer **N** then the following question will be asked.
Enter the name of the Destination file:	The name you enter will be the name used for the output files. Do not include an extension in the name you supply. If you do, it will be ignored. The program picks it's own extentions for the output files.
Enter the value for the LOW voltage numbers:	This number is used in the voltage output file.
Enter the value for the HIGH voltage numbers:	This number is used in the voltage output file.

After the last question, the program will display "**W O R K I N G**" and begin processing. The specified data file is read in by the program, and 6 files are output. Each of these 6 files have the same filename which was chosen by the operator, but their extentions are different. The output files are:

name.FRQ	Contains frequency data
name.VLT	Contains voltage data
name.SAG	Contains sag data
name.SRG	Contains surge data
name.IMP	Contains impulse data
name.ERR	Contains all data that was not placed into one of the other five files.

Each of these files (except name.ERR) can be read into Lotus by means of its "FILE INPORT NUMBERS" facility. For example, to bring the file named name.FRQ into Lotus the user would type:

\	To get the menu up
F	for file
I	for import
N	for numbers
name.FRQ	the name of the file to be imported.

Note that the extension **must** be specified, otherwise 123 will only look for files with the wk1 extension. The file will then be imported into the current 123 spreadsheet. It will be placed with it's upper left hand corner at the position of the cursor at the time of the importing.

* NOTE: To use this program you must have files set to 20 in the system's config.sys file.

```
{
*************************************************************************
****
 *                                                  *
 *            Author.........Ron Clabo                     *
 *            Date...........1/11/87                    *
 *                                                  *
 * This program converts "626" data files into files that Lotus 1-2-3 can *
 * inport with it's  /file inport numbers  function.             *
 *                                                  *
 *                                                  *
 *      This program was written using Turbo Pascal ver 3.0          *
*************************************************************************
****
}

{$C-}  {turn CTRL C off}


Program Translator(input,output);

 type string80 = string[80];
     string10 = string[10];
     string3  = string[3];

 var
   Q   : char;              {used in place of the quote mark }
   ch  : char;              {Y/N to convert another file }
   Date : string80;           {the date keyed in by the operator}
   DateNum: Real;             {the Lotus Serial date number}
   LowNum, HighNum: Real;        {entered by the key operator}
   Infile, FrqFile, VltFile, SagFile, SrgFile, ImpFile, errorFile : Text;
   ERROR : boolean;

   Data  : array[1..3] of string80;  {holds the current lines from data file}
   DataLines: integer;          {lines actually being used (1 to 3) }

   SourceFileName, DestFileName: string[80];



{----------------------------------------------------------------------}

 function Julian(Year:integer; Mon, Day: byte) :real;

 var
   Temp : real;

 begin
    if (year < 0) or (mon < 1 ) or (mon > 12)
```

```
              or (day < 1 ) or (day > 31) then
         begin
            Julian := -1.0;              {SIGNAL ERROR CONDITION}
            exit
         end;
      if year < 100 then year := year + 1900;
      temp := int((mon - 14.0)/12.0);
      julian := day - 32075.0 +
            int(1461.0 * (year + 4800.0 + temp)/4.0) +
            int(367.0 * (mon - 2.0 - temp * 12.0) /12.0) -
            int(3.0 * int((year + 4900.0 + temp)/100.0)/4.0) -
            2415019.0;
            {the above term is the diff. between Julian and 123 format}

  end; {function)


{---------------------------------------------------------------------------}

Procedure Prepare_Files;
  var
    ch: char;
    filename: string[80];
    i: integer;

  Begin
   filename := '';
   i:= 1;
   ch:= DestFileName[i];

   while ch = ' ' do i:= i+1;           {trim leading spaces}

   while ((ch <> '.') and (ch <> ' ') and (i <= length(DestFileName) )) do
    begin
      filename := filename + ch;
      i := i+1;
      ch := DestFileName[i];
    end;

   assign(infile, SourceFileName);
   assign(FrqFile, filename+'.FRQ');
   assign(VltFile, filename+'.VLT');
   assign(SagFile, filename+'.SAG');
   assign(SrgFile, filename+'.SRG');
   assign(ImpFile, filename+'.IMP');
   assign(errorfile, filename+'.ERR');
   {$I-} reset(infile); {$I+}
   If IOResult <> 0 then
     begin
      clrscr;
      writeln;
      writeln('<<<ERROR>>> The file ',SourceFileName,' does not exist.');
      writeln;
    writeln('Make sure the Source file exists before running this program.');
```

```
      Halt;  {************EXIT PROGRAM**********}
     end;
   {$I-}rewrite(FrqFile);{$I+}
   If IOResult <> 0 then
    begin
      clrscr;
      writeln;
      writeln('<<<ERROR>>> The specified destination filename is not valid');
      writeln;
      Halt;   {************EXIT PROGRAM***********}
     end;
   rewrite(VltFile);
   rewrite(SagFile);
   rewrite(SrgFile);
   rewrite(ImpFile);
   rewrite(errorfile);

  end;

{--------------------------------------------------------------------------}


Procedure Place_Header_In_FrqFile;

 var
  dashes : string[23];
  i : integer;

 begin
  Q := chr(34);
  dashes := Q+'--------------------'+Q;

  writeln(FrqFile, Q+Q+','+Q+'FREQ.'+Q);

  for i := 1 to 3 do                    {does the dashes}
   begin
    write(Frqfile, dashes);
    write(Frqfile, ',');
   end;
  writeln(Frqfile,Q+Q);

  write(Frqfile,Q+'DATE'+Q+',');
  write(Frqfile,Q+'TIME'+Q+',');
  writeln(Frqfile,Q+'MAG.(HZ)'+Q);

  for i := 1 to 3 do                    {does the dashes}
   begin
    write(Frqfile, dashes);
    write(Frqfile, ',');
   end;
  writeln(Frqfile,Q+Q);

end; {header for FrqFile}
```

```
{-----------------------------------------------------------------------}

Procedure Place_Header_In_VltFile;

 var
  dashes : string[23];
  i : integer;

 begin
  Q := chr(34);
  dashes := Q+'--------------------'+Q;

  writeln(VltFile, Q+'VOLTAGE'+Q);

  for i := 1 to 5 do                    {does the dashes}
   begin
    write(Vltfile, dashes);
    write(Vltfile, ',');
   end;
  writeln(Vltfile,Q+Q);

  write(Vltfile,Q+'PHASE'+Q+',');
  write(Vltfile,Q+'DATE'+Q+',');
  write(Vltfile,Q+'TIME'+Q+',');
  write(Vltfile,Q+'MAG.(V)'+Q+',');
  writeln(Vltfile,Q+'MARK'+Q);

  for i := 1 to 5 do                    {does the dashes}
   begin
    write(Vltfile, dashes);
    write(Vltfile, ',');
   end;
  writeln(Vltfile,Q+Q);

end; {header for VltFile}

{-----------------------------------------------------------------------}

Procedure Place_Header_In_SagFile;

 var
  dashes : string[23];
  i : integer;

 begin
  Q := chr(34);
  dashes := Q+'--------------------'+Q;

  writeln(SagFile, Q+'SAG'+Q);

  for i := 1 to 5 do                    {does the dashes}
   begin
    write(Sagfile, dashes);
```

```
      write(Sagfile, ',');
     end;
    writeln(Sagfile,Q+Q);

    write(Sagfile,Q+'PHASE'+Q+',');
    write(Sagfile,Q+'DATE'+Q+',');
    write(Sagfile,Q+'TIME'+Q+',');
    write(Sagfile,Q+'MIN.(V)'+Q+',');
    writeln(Sagfile,Q+'DUR.(sec)'+Q);

    for i := 1 to 5 do                {does the dashes}
     begin
      write(Sagfile, dashes);
      write(Sagfile, ',');
     end;
    writeln(Sagfile,Q+Q);

end; {header for SagFile}

{--------------------------------------------------------------------------}

Procedure Place_Header_In_SrgFile;

  var
   dashes : string[23];
   i : integer;

  begin
   Q := chr(34);
   dashes := Q+'--------------------'+Q;

   writeln(SrgFile, Q+'SURGE'+Q);

   for i := 1 to 5 do                {does the dashes}
    begin
     write(Srgfile, dashes);
     write(Srgfile, ',');
    end;
   writeln(Srgfile,Q+Q);

   write(Srgfile,Q+'PHASE'+Q+',');
   write(Srgfile,Q+'DATE'+Q+',');
   write(Srgfile,Q+'TIME'+Q+',');
   write(Srgfile,Q+'MAX.(V)'+Q+',');
   writeln(Srgfile,Q+'DUR.(sec)'+Q);

   for i := 1 to 5 do                {does the dashes}
    begin
     write(Srgfile, dashes);
     write(Srgfile, ',');
    end;
   writeln(Srgfile,Q+Q);

end; {header for SrgFile}
```

```
{------------------------------------------------------------------------}

Procedure Place_Header_In_ImpFile;

 var
  dashes : string[23];
  i : integer;

 begin
  Q := chr(34);
  dashes := Q+'--------------------'+Q;

  writeln(ImpFile, Q+'IMPULSE'+Q);

  for i := 1 to 7 do                    {does the dashes}
   begin
    write(Impfile, dashes);
    write(Impfile, ',');
   end;
  writeln(Impfile,Q+Q);

  write(Impfile,Q+'PHASE'+Q+',');
  write(Impfile,Q+'DATE'+Q+',');
  write(Impfile,Q+'TIME'+Q+',');
  write(Impfile,Q+'MAG.(V)'+Q+',');
  write(Impfile,Q+'DUR.(us)'+Q+',');
  write(Impfile,Q+'STR.(V-S)'+Q+',');
  writeln(Impfile,Q+'DIR'+Q);

  for i := 1 to 7 do                    {does the dashes}
   begin
    write(Impfile, dashes);
    write(Impfile, ',');
   end;
  writeln(Impfile,Q+Q);

end; {header for ImpFile}

{------------------------------------------------------------------------}

Procedure Place_Headers_In_Files;

 begin
  Place_Header_In_FrqFile;
  Place_Header_In_VltFile;
  Place_Header_In_SagFile;
  Place_Header_In_SrgFile;
  Place_Header_In_ImpFile;
 end;


{------------------------------------------------------------------------}
{ This function returns true if the date passed to it is a valid one, and    }
```

```
{ false otherwise.  If the date is valid, it then converts that date to it's }
{ date serial number and places that value in the Globel variable DateNum.   }
{                                                                             }

Function Good_date(line:string80):boolean;

 Var Error     : Boolean;
    Errcode   : integer;
    year      : integer;
    mon, day  : byte;
    dayint    : integer;
    monthint  : integer;

 begin
  Error := FALSE;

  val(copy(line,1,2), monthint, Errcode);
  mon := monthint;
  if Errcode <> 0 then Error := TRUE;

  val(copy(line,4,2), dayint, Errcode);
  day := dayint;
  if Errcode <> 0 then Error := TRUE;

  val(copy(line,7,2), year, Errcode);
  if Errcode <> 0 then Error := TRUE;

  if (year < 0) or (mon < 1 ) or (mon > 12)
          or (day < 1 ) or (day > 31) then Error := True;

  if not Error then
   begin
    DateNum := Julian(year,mon,day);        {DateNum is a Globel}
    Good_Date := TRUE;
   end
  ELSE
    Good_Date := FALSE;

end; {Good_date}

{---------------------------------------------------------------------}

Function Build_DestFileName(line:String80) :String80;
 var mon,day,year : string3;

 begin
  mon := copy(line,1,2);
  day := copy(line,4,2);
  year:= copy(line,7,2);
  Build_DestFileName := mon+'_'+day+'_'+year;
 end;

{---------------------------------------------------------------------}
```

```
Procedure Do_Screen;

begin
 clrscr;
 gotoxy(27,2);
 write(' ~~~~~~~~~~~~~~~~~~~~~~~~»');
 gotoxy(27,3);
 write('"                        "');
 gotoxy(27,4);
 write('"  U.A.F 626 CONVERSION  "');
 gotoxy(27,5);
 write('"       PROGRAM          "');
 gotoxy(27,6);
 write('"                        "');
 gotoxy(27,7);
 write('..~~~~~~~~~~~~~~~~~~~~~~~~...');
 gotoxy(27,8);
 write('      by Ron Clabo');

end; {Do_Screen}

{------------------------------------------------------------------------------}

Procedure Ask_Questions;
 var i    :integer;
    ch   : char;
    valid : boolean;

 begin
 for i:= 22 to 24 do
  begin
   gotoxy(1,i);
   clreol;
  end;
 SourceFileName := '';
 While length(SourceFileName) = 0 do
  begin
   gotoxy(1,22);
   write('Enter the name of the Source file: ');
   readln(SourceFileName);
  end;

 writeln;                         {this section gets a valid date}
 valid := false;
 While not Valid do
  begin
   Write('Enter source file date (mm/dd/yy): ');
   readln(Date);
   valid := Good_Date(Date);          {if valid the serial number is calced}
   if not valid then
    begin
     Gotoxy(1,24);
     clreol;
    end;
```

```
end;

for i:= 22 to 24 do
 begin
  gotoxy(1,i);
  clreol;
 end;

gotoxy(1,22);

Repeat
 write('Should the date be used for the Destination filename (Y/N)? ');
 readln(ch);
 ch := UpCase(ch);
 gotoxy(1,22);
 clreol;
Until ( (ch = 'Y') or (ch = 'N') );

If ch = 'N' then
 begin
  DestFileName := '';
  While length(DestFileName) = 0 do
   begin
    gotoxy(1,22);
    write('Enter the name of the Destination file: ');
    readln(DestFileName);
   end;
 end
Else {ch = 'Y'}
 begin
  DestFileName := Build_DestFileName(Date);
 end;

for i:= 22 to 24 do
 begin
  gotoxy(1,i);
  clreol;
 end;

gotoxy(1,22);
write('Enter the value for the LOW voltage numbers: ');
readln(LowNum);
writeln;
write('Enter the value for the HIGH voltage numbers: ');
readln(HighNum);

for i:= 22 to 24 do
 begin
  gotoxy(1,i);
  clreol;
 end;

gotoxy(1,22);
```

```
 textColor(31);              {White Blink}
 write('W O R K I N G');
 textColor(15);              {White}
end; {Ask_Questions}

{------------------------------------------------------------------------}
{ This procedure gets the next group of line to be evaluated.  The group      }
{ will consist of 1, 2, or 3 lines. The number of lines will be stored        }
{ in the Globel Variable  DataLines.                                   }

Procedure Get_Lines;

 Var i     : Integer;
    Blank : boolean;
    Temp  : String80;

{---------------------------}
 Function Blank_Line(line:string80):Boolean;   {determine if a line is blank}
  var i, last:integer;
     blank  : boolean;
     ch : char;

  begin
   Blank := True;
   last := length(line);
   i := 1;
   while ( (i <= last) and (Blank = True) ) do
    begin
     ch := line[i];
     if ( (ord(ch) >= 33 ) and (ord(ch) <=126) ) then blank := FALSE;
     i := i+1;
    end;
    Blank_Line := Blank;
  end; {blank_line}

{---------------------------}
Function Clean_Line(line:string80):String80;   {cleans ctrl codes from line}
  var i,j,pos,last:integer;
   . blank  : boolean;
     ch : char;

  begin
   last := length(line);
   i := 1;
   while i <= last do
    begin
     ch := line[i];
     if ( (ord(ch) < 9 ) or
        ( (ord(ch) >= 14) and (ord(ch) <= 31) ) ) then
        begin
          pos := i;
          for j:= pos to last-1 do line[j] := line[j+1];
          line[last] := ' ';
        end;
```

```
    i := i+1;
   end; {while}
   Clean_Line := line;
  end; {blank_line}
{----------------------------}


begin
 Repeat  {until Eof}
  Repeat
   if not eof(infile) then Readln(infile,data[1]);
   Blank := Blank_Line(Data[1]);
  Until ( (not Blank) or (Eof(infile)) );
  Data[1] := Clean_Line(Data[1]);
                               {have one good line}
  if not eof(infile) then Readln(infile,data[2]);
  Blank := Blank_line(Data[2]);
  if Blank then
   begin
    DataLines := 1;
    Exit;              {leave procedure}
   end;
  Data[2] := Clean_Line(Data[2]);

  if not eof(infile) then Readln(infile,data[3]);
  Blank := Blank_line(Data[3]);
  if Blank then
   begin
    DataLines := 2;          {leave procedure}
    Exit;
   end;
  Data[3] := Clean_Line(Data[3]);

  if not eof(infile) then Readln(infile,Temp);
  Blank := Blank_line(Temp);
  if Blank then
   begin
    DataLines := 3;          {leave procedure}
    Exit;
   end;

              {found 4 non-blank lines in a row, ie. ERROR}

  for i := 1 to 3 do writeln(ErrorFile, Data[i]);
  writeln(ErrorFile, Temp);
  Repeat                   {spit out the rest of the continous }
                        {non-blank lines into the Error file}
   if not eof(infile) then Readln(infile, Temp);
   Writeln(Errorfile, Temp);
   Blank := Blank_line(temp);
  Until Blank;
 Until Eof(infile);
```

```
end; {Get_Lines}


{---------------------------------------------------------------------------}
{ converts the line that holds the time into the time serial number.        }

Function Find_Time(line:String80):Real;     {returns -1 if unsuccessful}

 Var colonindex :integer;
   hr,min,sec :integer;
   hnd        :integer;
   time       :real;
   ErrCode    :integer;
   Error      :Boolean;

 Begin

  colonindex := pos(':',line);
  if ( (colonindex > 3) and (colonindex <> 0) ) then
   begin
    val(copy(line,colonindex-2,2), hr, ErrCode);
    val(copy(line,colonindex+1,2), min, ErrCode);
    val(copy(line,colonindex+4,2), sec, ErrCode);
    val(copy(line,colonindex+7,1), hnd, ErrCode);
    if hnd >= 5 then sec := sec + 1;
    time := hr/24 + min/1440 + sec/86400.0;
   end
  else time := -1;

  Find_Time := time;
 End; {Find_Time}


{---------------------------------------------------------------------------}
{ picks the first number out of a string and returns that number in the form }
{ of a string (width 80)                                       }

Function Get_First_Num(line:string80): String80;

 var i,chnum :integer;
   part_of_number:boolean;
   NumString: string80;

 begin
  i:= 0;
  part_of_number:= false;
  while not part_of_number do
   begin
    i := i+1;
    chnum := ord(line[i]);
    if ( ((chnum >= ord('0')) and (chnum <= ord('9')))
                                  or (line[i] = '.') ) then
      part_of_number:= True;
```

```
    end;
    NumString := line[i];

    i := i+1;
    chnum := ord(line[i]);
    if ( ((chnum >= ord('0')) and (chnum <= ord('9')))
                                    or (line[i] = '.') ) then
      part_of_number:= True
    else part_of_number := false;

    while part_of_number do
     begin
      NumString := NumString + line[i];
      i:=i+1;
      chnum := ord(line[i]);
      if ( ((chnum >= ord('0')) and (chnum <= ord('9')))
                                    or (line[i] = '.') ) then
        part_of_number:= True
      else part_of_number := false;
     end;

    Get_First_Num := NumString;
  end;

{------------------------------------------------------------------------}

Function Process_Frq:Boolean;         {return true if successful}
 Var time,Date :real;
    proper   :boolean;
    Mag      :String80;

 Begin
  if copy(Data[2],5,3) = 'FRQ' then proper := True
   Else proper := false;

  if proper then
   begin
    time := Find_Time(Data[2]);
    if time = -1 then proper := False;
    Date := DateNum + time;
    Mag := Get_First_Num(Data[1]);
   end;

  if proper then
   begin
    Writeln(Frqfile, Date,',',Date,','+Mag);
    writeln(Frqfile);
    Process_Frq := True;
   end
  Else
    Process_Frq := False;

 End; {Process_Frq}
```

```
{-----------------------------------------------------------------------}

Function Process_Vlt:Boolean;          {return true if successful}
 Var time,Date : real;
    proper   : boolean;
    Mag      : real;
    Magstring : string80;
    Mark     : String3;
    phase    : char;
    line     : string80;              {the line with the time on it}

 Begin
  Mag := 0;
  proper := True;
  line := Data[DataLines];

  if line[2] ='2' then Phase := 'N'
  else if line[2] = '1' then Phase := line[3]
  else proper := false;

  if proper then
   begin
    time := Find_Time(line);
    if time = -1 then proper := False;
    Date := DateNum + time;
   end;

  if DataLines = 2 then                  { double check 2 liners }
   if Data[1][11] <> 'V' then proper := False;

  if proper then
   begin
    Case DataLines of

     1:begin
       if line[2] = '1' then Mark := copy(Data[1],5,2);
       if line[2] = '2' then Mark := copy(Data[1],4,2);
       if Mark = 'HI' then Mag := HighNum;
       if Mark = 'LO' then Mag := LowNum;

       Write(VltFile,Q+Phase+Q+',',Date,',',Date,',');
       Writeln(VltFile,Mag,','+Q+Mark+Q);
       Writeln(VltFile);
      end;

     2:begin
       Mark := '';
       if ((line[2] = '1') and (length(Data[1]) >=15) ) then
           Mark := copy(Data[1],13,3);
       if ((line[2] = '2') and (length(Data[1]) >=14) ) then
           Mark := copy(Data[1],12,2);
       Magstring := Get_First_Num(Data[1]);

       if Mark = 'MAX' then
```

```
      begin
        Write(VltFile,Q+Phase+Q+',',Date,',',Date,',');
        Writeln(VltFile,HighNum,','+Q+'HI'+Q);
        Write(VltFile,Q+Phase+Q+',',Date,','+Q+Q+',');
        Writeln(VltFile,Magstring+','+Q+Mark+Q);
        Writeln(VltFile);
      end
     else if Mark = 'MIN' then
      begin
        Write(VltFile,Q+Phase+Q+',',Date,',',Date,',');
        Writeln(VltFile,LowNum,','+Q+'LO'+Q);
        Write(VltFile,Q+Phase+Q+',',Date,','+Q+Q+',');
        Writeln(VltFile,Magstring+','+Q+Mark+Q);
        Writeln(VltFile);
      end
     else
      begin
        Write(VltFile,Q+Phase+Q+',',Date,',',Date,',');
        Writeln(VltFile,Magstring);
        Writeln(VltFile);
      end;
    end;
  end; {case}
  Process_Vlt := True;
 end  {if proper}
 Else Process_Vlt := False;
End;

{-----------------------------------------------------------------------}

Function Process_Sag:Boolean;         {return true if successful}
 Var time,Date : real;
    proper    : boolean;
    Mag,Dur   : string80;
    line      : string80;
    Phase     : char;

 Begin
  proper := True;
  line := Data[1];
  if copy(line,5,3) <> 'SAG' then Proper := False;

  line := Data[3];
  if line[2] ='2' then Phase := 'N'
   else if line[2] = '1' then Phase := line[3]
   else proper := false;

  time := Find_Time(Data[3]);
  if time = -1 then proper := False;
  Date := DateNum + time;

  if proper then
   begin
    Dur := Get_First_Num(Data[1]);
```

```
      Mag := Get_First_Num(Data[2]);
      Writeln(SagFile,Q+Phase+Q+',',Date,',',Date,','+Mag+','+Dur);
      Writeln(SagFile);
      Process_Sag := True;
    end
   Else Process_Sag := False;

 End; {Process_Sag}

{------------------------------------------------------------------------}

Function Process_Srg:Boolean;          {return true if successful}
 Var time,Date : real;
    proper    : boolean;
    Mag,Dur   : string80;
    line      : string80;
    Phase     : char;

 Begin
  proper := True;
  line := Data[1];
  if copy(line,5,3) <> 'SUR' then Proper := False;

  line := Data[3];
  if line[2] ='2' then Phase := 'N'
   else if line[2] = '1' then Phase := line[3]
   else proper := false;

  time := Find_Time(Data[3]);
  if time = -1 then proper := False;
  Date := DateNum + time;

  if proper then
   begin
     Dur := Get_First_Num(Data[1]);
     Mag := Get_First_Num(Data[2]);
     Writeln(SrgFile,Q+Phase+Q+',',Date,',',Date,','+Mag+','+Dur);
     Writeln(SrgFile);
     Process_Srg := True;
   end
  Else Process_Srg := False;

 End; {Process_Srg}
{------------------------------------------------------------------------}

Function Process_Imp:Boolean;          {return true if successful}
 Var time,Date : real;
    proper    : boolean;
    Mag,Dur   : string80;
    Vsec,Dir  : string80;
    line      : string80;
    DurPart   : string80;
    charsleft : integer;
    Phase     : char;
```

```
  CommaIndex: integer;

Begin
 proper := true;
 line := Data[DataLines];
 If ( (line[2] = '1') and (copy(line,5,3) <> 'IMP') ) then Proper := false;
 If ( (line[2] = '2') and (copy(line,4,3) <> 'IMP') ) then Proper := false;

 if line[2] ='2' then Phase := 'N'
  else if line[2] = '1' then Phase := line[3]
  else proper := false;

 time := Find_Time(line);
 if time = -1 then proper := False;
 Date := DateNum + time;

 If proper then
  begin
   Mag := Get_First_Num(Data[1]);
   If data[1][2] = '-' then Mag := '-'+Mag;

   if pos('LOAD',Data[1]) <> 0 then dir := 'LOAD'
    else if pos('SRCE',Data[1]) <> 0 then dir := 'SRCE'
    else dir := '';

   case DataLines of
    2:begin
       CommaIndex := pos(',',Data[1]);
       CharsLeft := length(Data[1])-CommaIndex+1;
       DurPart := copy(Data[1],CommaIndex, CharsLeft);
       Dur := Get_First_Num(DurPart);

       Write(ImpFile,Q+Phase+Q+',',Date,',',Date,','+Mag+','+Dur+',');
       Writeln(ImpFile,Q+Q+','+Q+dir+Q);
       Writeln(ImpFile);
       Process_Imp := True;
     end;

    3:begin
       Vsec := Get_First_Num(Data[2]);
       Write(ImpFile,Q+Phase+Q+',',Date,',',Date,','+Mag+','+Dur+',');
       Writeln(ImpFile,Vsec+','+Q+dir+Q);
       Writeln(ImpFile);
       Process_Imp := True;
     end;
   end; {case}
  end {if proper}
 Else Process_Imp := False;

End; {Process_Imp}

{-----------------------------------------------------------------------}
```

```
Procedure Do_Work;

 Var Success: Boolean;
    code   : string[3];
    i      : integer;

begin
  While not eof(Infile) do
   begin
    Get_Lines;

    If DataLines = 1 then
     begin
      Success := Process_Vlt;
     end

    Else if DataLines = 2 then
     begin
      code := copy(Data[2],4,3);
      Success := Process_Frq;
      if not Success then Success := Process_Imp;
      if not Success then Success := Process_Vlt;  {vlt must be after Imp}
     end

    Else if DataLines = 3 then
     Begin
      Success := Process_Sag;
      if not Success then Success := Process_Srg;
      if not Success then Success := Process_Imp;
     end

    Else
     begin
      ClrScr;
      Writeln;
      Writeln('<<<<FATAL ERROR>>>>');
      Writeln(' -> The variable DataLines contains a number our of range');
      Writeln;
      Writeln('Program Terminated');
      Halt;
     end;

    If Not Success then         {the lines could not be identified, put the}
     begin                      {bad lines into the error files.          }

      for i := 1 to DataLines do Writeln(ErrorFile, Data[i]);
      Writeln(ErrorFile);
     end;
  end; {while not eof(infile)}
end;  {Do_Work}
```

```
{---------------------------------------------------------------------------}

begin {main}

 Q := chr(34);
 Do_Screen;

 Repeat
  Ask_Questions;
  Prepare_Files;
  Place_Headers_In_Files;
  Do_Work;

  close(infile);
  close(FrqFile);
  close(VltFile);
  close(SagFile);
  close(SrgFile);
  close(ImpFile);
  close(errorfile);

  gotoxy(1,22);
  Writeln('Process Completed.');
  Writeln;
  Repeat
   gotoxy(1,24);
   clreol;
   write('Would you like to convert another file (Y/N)? ');
   readln(ch);
   ch := UpCase(ch);
  Until ( (ch = 'Y') or (ch = 'N') );

 Until ch = 'N';

 Clrscr;

end.
```

808 Data Conversion Program

This program was written to convert a 808 ascii data file into files that can be read by Lotus 1-2-3. To run the program place the conversion program disk in the "A" drive and type **con808** at the a prompt. You will then be asked the following two questions.

Question	Explanation
Enter the name of the source file:	Enter the filename and extension of the file to be converted. Example: FILENAME.EXT
Enter the name of the Destination file:	The name you enter will be the name used for the output files. Do not include an extension in the name you supply. If you do, it will be ignored. The program picks it's own extentions for the output files.

After the last question, the program will display "**W O R K I N G**" and begin processing. The specified data file is read in by the program, and 2 files are output. Each of these 2 files have the same filename which was chosen by the operator, but their extentions are different. The output files are:

name.808	Contains all understandable data.
name.ERR	Contains all data that was not placed into the other file.

The name.808 file can be read into Lotus by means of its "FILE INPORT NUMBERS" facility. For example, to bring this file into Lotus the user would type:

\	To get the menu up
F	for file
I	for import
N	for numbers
name.808	the name of the file to be imported.

Note that the extension **must** be specified, otherwise 123 will only look for files with the wk1 extension. The file will then be imported into the current 123 spreadsheet. It will be placed with it's upper left hand corner at the position of the cursor at the time of the importing.

NOTE: To use this program you must have files set to 20 in the system's config.sys file.

```
{
*********************************************************************
****
 *                                              *
 *              Author.........Ron Clabo              *
 *              Date...........1/11/87          *
 *                                              *
 * This program converts "808" data files into files that Lotus 1-2-3 can *
 * inport with it's  /file inport numbers  function.        *
 *                                              *
 *                                              *
 *      This program was written using Turbo Pascal ver 3.0        *
*********************************************************************
****
}

{$C-}  {turn CTRL C off}

Program Translator(input,output);

 type string80 = string[80];
     string10 = string[10];
     string3  = string[3];

 var
   Q : char;
   ch: char;
   Infile, Outfile, errorfile : Text;
   ERROR : boolean;

   SourceFileName, DestFileName: string[80];

{---------------------------------------------------------------------}

 function Julian(Year:integer; Mon, Day: byte) :real;

 var
   Temp : real;

 begin
    if (year < 0) or (mon < 1 ) or (mon > 12)
             or (day < 1 ) or (day > 31) then
        begin
           Julian := -1.0;              {SIGNAL ERROR CONDITION}
           exit
        end;
     if year < 100 then year := year + 1900;
     temp := int((mon - 14.0)/12.0);
```

```
    julian := day - 32075.0 +
          int(1461.0 * (year + 4800.0 + temp)/4.0) +
          int(367.0 * (mon - 2.0 - temp * 12.0) /12.0) -
          int(3.0 * int((year + 4900.0 + temp)/100.0)/4.0) -
          2415019.0;

 end; {function)


{-----------------------------------------------------------------------}

Procedure Prepare_Files;
 var
   ch: char;
   filename: string80;
   i: integer;

 Begin
  filename := '';
  i:= 1;
  ch:= DestFileName[i];
  while ( (ch <> '.') and (ch<> ' ') and (i <= length(DestFileName) ) ) do
   begin
    filename := filename + ch;
    i := i+1;
    ch := DestFileName[i];
   end;

  assign(infile, SourceFileName);
  assign(outfile, FileName+'.808');
  assign(errorfile, filename+'.ERR');
  {$I-} reset(infile); {$I+}
  If IOResult <> 0 then
   begin
    clrscr;
    writeln;
    writeln('<<<ERROR>>> The file ',SourceFileName,' does not exist.');
    writeln;
   writeln('Make sure the Source file exists before running this program.');
    Halt;     {*********EXIT PROGRAM*********}
   end;
  {$I-}rewrite(OutFile);{$I+}
  If IOResult <> 0 then
   begin
    clrscr;
    writeln;
    writeln('<<<ERROR>>> The specified destination filename is not valid');
    writeln;
    Halt;  {***********EXIT PROGRAM***********}
   end;
  rewrite(errorfile);

 end;
```

```
{------------------------------------------------------------------------}

Procedure Place_Header_In_File;

 var
  dashes : string[18];
  i : integer;

 begin
  Q := chr(34);
  dashes := Q+'---------------'+Q;

  for i := 1 to 5 do                    {does the dashes}
   begin
    write(outfile, dashes);
    write(outfile, ',');
   end;
  writeln(outfile);

  write(outfile,Q+'DATE'+Q+',');
  write(outfile,Q+'TIME'+Q+',');
  write(outfile,Q+'VOLTAGE'+Q+',');
  write(outfile,Q+'POWER'+Q+',');
  writeln(outfile,Q+'POWER FACTOR'+Q+',');

  for i := 1 to 5 do
   begin                                {does the dashes}
    write(outfile, dashes);
    write(outfile, ',');
   end;
  writeln(outfile);


  write(outfile,Q+'DATE'+Q+',');
  write(outfile,Q+'TIME'+Q+',');
  write(outfile,Q+'MAG. (V)'+Q+',');
  write(outfile,Q+'MAG. (W)'+Q+',');
  writeln(outfile,Q+'MAG.'+Q+',');


  for i := 1 to 5 do
   begin                                {does the dashes}
    write(outfile, dashes);
    write(outfile, ',');
   end;
  writeln(outfile);

end; {procedure header}

{------------------------------------------------------------------------}

Procedure Do_Screen;
 begin
  clrscr;
```

```
 gotoxy(27,2);
 write(' ~~~~~~~~~~~~~~~~~~~~~~~»');
 gotoxy(27,3);
 write('''                    ''');
 gotoxy(27,4);
 write(''' U.A.F 808 CONVERSION ''');
 gotoxy(27,5);
 write('''     PROGRAM        ''');
 gotoxy(27,6);
 write('''                    ''');
 gotoxy(27,7);
 write('~~~~~~~~~~~~~~~~~~~~~~~...');
 gotoxy(27,8);
 write('     by Ron Clabo');

end; {do_screen}
{------------------------------------------------------------------------}

Procedure Ask_Questions;
 var i:integer;
 begin
  for i:= 22 to 24 do
   begin
    gotoxy(1,i);
    clreol;
   end;

  gotoxy(1,22);
  SourceFileName := '';
  While length(SourceFileName) = 0 do
   begin
    gotoxy(1,22);
    write('Enter the name of the Source file: ');
    readln(SourceFileName);
   end;

  Writeln;

  DestFileName := '';
  While length(DestFileName) = 0 do
   begin
    gotoxy(1,24);
    write('Enter the name of the Destination file: ');
    readln(DestFileName);
   end;

for i:= 22 to 24 do
  begin
    gotoxy(1,i);
    clreol;
   end;

  gotoxy(1,22);
  textColor(31);              {White Blink}
```

```
  write('W O R K I N G');
  textColor(15);              {White}

end; {Ask_Questions}

{------------------------------------------------------------------------}

Function UpperCase(line:string3):string3;
 var i:integer;
 begin
  for i:= 1 to 3 do line[i] := UpCase(line[i]);
  UpperCase := line;
 end;

{------------------------------------------------------------------------}

Function find_date(line:string80):real;

 Var ch: char;
    Errcode    : integer;
    i          : integer;
    year       : integer;
    month, day : byte;
    dayint     : integer;
    monthcode  : string[3];
    Date       : real;
    hr,min,sec : real;
    time       : real;
    colonindex : integer;

 begin
  val(copy(line,2,2), dayint, Errcode);
  day := dayint;
  val(copy(line,9,2), year, Errcode);
  monthcode := copy(line,5,3);

  monthcode := UpperCase(monthcode);
  if monthcode = 'JAN' then month :=1
  else if monthcode = 'FEB' then month :=2
  else if monthcode = 'MAR' then month := 3
  else if monthcode = 'APR' then month := 4
  else if monthcode = 'MAY' then month := 5
  else if monthcode = 'JUN' then month := 6
  else if monthcode = 'JUL' then month := 7
  else if monthcode = 'AUG' then month := 8
  else if monthcode = 'SEP' then month := 9
  else if monthcode = 'OCT' then month := 10
  else if monthcode = 'NOV' then month := 11
  else if monthcode = 'DEC' then month := 12;

  Date := Julian(year,month,day);

  colonindex := pos(':',line);
  if colonindex > 3 then
```

```
   begin
    val(copy(line,colonindex-2,2), hr, ErrCode);
    val(copy(line,colonindex+1,2), min, ErrCode);
    val(copy(line,colonindex+4,2), sec, ErrCode);
    time := hr/24 + min/1440 + sec/86400.0;
   end
  else ERROR := True;

  Date := Date + time;
  find_date := Date;
end; {find_date}

{--------------------------------------------------------------------------}
Procedure find_Watt_PF(line:string80;var Watt, PF:string10);

 var i,chnum :integer;
    part_of_number:boolean;

 begin
                 {*** this section is for Watt***}
  i:= 0;
  part_of_number:= false;
  while not part_of_number do
   begin
    i := i+1;
    chnum := ord(line[i]);
    if ( ((chnum >= ord('0')) and (chnum <= ord('9')))
                                 or (line[i] = '.') ) then
      part_of_number:= True;
   end;
   Watt := line[i];

   i := i+1;
   chnum := ord(line[i]);
   if ( ((chnum >= ord('0')) and (chnum <= ord('9')))
                                 or (line[i] = '.') ) then
     part_of_number:= True
   else part_of_number := false;

   while part_of_number do
    begin
     Watt := Watt+line[i];
     i:=i+1;
     chnum := ord(line[i]);
     if ( ((chnum >= ord('0')) and (chnum <= ord('9')))
                                 or (line[i] = '.') ) then
       part_of_number:= True
     else part_of_number := false;
    end;


                      {*** this section is for PF***}

    while not part_of_number do
```

```
    begin
     i := i+1;
     chnum := ord(line[i]);
     if ( ((chnum >= ord('0')) and (chnum <= ord('9')))
                                   or (line[i] = '.') ) then
        part_of_number:= True;
    end;
    PF:= line[i];


    i := i+1;
    chnum := ord(line[i]);
    if ( ((chnum >= ord('0')) and (chnum <= ord('9')))
                                   or (line[i] = '.') ) then
       part_of_number:= True
    else part_of_number := false;


    while part_of_number do
     begin
      PF := PF+line[i];
      i:=i+1;
      chnum := ord(line[i]);
      if ( ((chnum >= ord('0')) and (chnum <= ord('9')))
                                   or (line[i] = '.') ) then
        part_of_number:= True
      else part_of_number := false;
     end;
 end;



{------------------------------------------------------------------------}
Function find_voltage(line:string80):string10;
 var i          :integer;
   volt         :string10;
   part_of_number:boolean;
   chnum        :integer;

 begin
   i:= 0;
   part_of_number:= false;
   while not part_of_number do
    begin
     i := i+1;
     chnum := ord(line[i]);
     if ( ((chnum >= ord('0')) and (chnum <= ord('9')))
                                   or (line[i] = '.') ) then
       part_of_number:= True;
    end;
    volt := line[i];

    i := i+1;
```

```
    chnum := ord(line[i]);
    if ( ((chnum >= ord('0')) and (chnum <= ord('9')))
                                        or (line[i] = '.') ) then
       part_of_number:= True
    else part_of_number := false;

    while part_of_number do
     begin
      volt := volt+line[i];
      i:=i+1;
      chnum := ord(line[i]);
      if ( ((chnum >= ord('0')) and (chnum <= ord('9')))
                                        or (line[i] = '.') ) then
         part_of_number:= True
      else part_of_number := false;
     end;

     Find_Voltage :=volt;
end; {find_voltage}

{-----------------------------------------------------------------------}

Procedure Do_Work;

 Var
  i        : integer;
  line     : array[1..7] of string80;
  temp     : string80;
  dm_found : boolean;
  date     : real;
  PF,Volt,Watt : string10;


 begin
  Repeat
   ERROR := FALSE;
   dm_found := false;
   while ((not dm_found) and (not eof(infile)) )do
    begin
     readln(infile,temp);
     if (copy(temp,1,3) = '#Dm' ) then dm_found := True
     else
       writeln(errorfile, temp);
    end;

   line[1] := temp;
   for i:= 2 to 7 do
      if not eof(infile) then readln(infile, line[i])
       else line[i] := '';

   date := find_date(line[2]);
   Volt := find_voltage(line[7]);
   find_Watt_PF(line[1],watt,PF);
```

```
  if not ERROR then
   begin
     write(outfile,date,',');
     write(outfile,date,',');
     write(outfile,volt+',');
     write(outfile,watt+',');
     writeln(outfile,PF);
   end
  else for i := 1 to 7 do writeln(errorfile, line[i]);

 Until eof(infile);

end; {Do_Work}


{---------------------------------------------------------------------------}


begin {main}

 Q := chr(34);

 Do_Screen;
 Repeat
  Ask_Questions;
  Prepare_Files;
  Place_Header_In_File;
  Do_Work;

  close(infile);
  close(outfile);

  gotoxy(1,22);
  Writeln('Process Completed.');
  Writeln;
  Repeat
   gotoxy(1,24);
   clreol;
   write('Would you like to convert another file (Y/N)? ');
   readln(ch);
   ch := UpCase(ch);
  Until ( (ch = 'Y') or (ch = 'N') );

 Until ch = 'N';

 Clrscr;
end.
```