Motionlogger®
User's Guide

Version 2K1.1

Ambulatory Monitoring, Inc.
731 Saw Mill River Road
Ardsley, New York 10502

Phone: 1-914-693-9240
Toll Free: 1-800-341-0066
(International Users May Dial AT&T USA Direct® Access Code for their country and then enter the above toll free number)
Fax: 1-914-693-6604

Email: info@ambulatory-monitoring.com
Website: http://www.ambulatory-monitoring.com

Introduction

SleepWatch®- O is sometimes referred to as the "Octagonal" SleepWatch to differentiate it from its predecessor which resembled the BASIC with an LCD display. This configuration of SleepWatch® features 2Mb of non-volatile memory (for a data storage capacity far exceeding its 60 day battery life), a Time-of-Day LCD, two buttons for event marking, time-set, etc. and a fuel-gauge style indicator which can be used to present a variety of information. In the standard configuration this model can collect single mode (ZC, TAT, PIM) or Tri-Mode data. The "fuel-gauge" indicator presents a visual feedback of motion sensitivity. Other optional features are available for SleepWatch and are designated by additional suffixes. "L" indicates the presence of a light sensor. "S" indicates sleep estimation on the wrist with presentation of estimated sleep parameters on the display. "U" indicates the ability for user input of subjective information (fatigue, mood, etc) or different event types via the two buttons on the face of the device.

System Requirements

Computer:	Available Serial Communications (COM) Port
	166 MHZ Pentium or faster processor
	32 MB RAM
	Microsoft Windows 95/98
	10 MB available on hard drive
	1 MB Video Card (800 x 600 resolution minimum)
From AMI:	Motionlogger®
	Interface for initialization and data retrieval (in some cases requiring a power supply, or user changeable batteries)
	Standard serial (RS232) cable

Applicable Warnings

Leakage Current

Motionlogger® models (including but not limited to the BASIC, ULTRA, and SleepWatch®) with gold contact pins for serial communications present a small leakage current amounting to 2.33 mA DC between the case and the I/O pins. This is caused by the polling of the instrument for possible communications to it from an interface connection. While this leakage current presents no detectable sensation to the user and no adverse outcome has ever been associated with the wearing of a Motionlogger, patients with heart disease or who wear an electronic pacemaker, are advised to cover these communications pins with insulating tape, or to use the MicroMini model which uses an optical technique for communications.

Environmental Conditions for Transport and Storage

1. Temperature Range: 0 to 55 degrees C.

2. Relative Humidity: Storage & Transport 0 to 99%; running 0-100% (short term submersion).
3. Atmospheric Pressure: 0 – 40,000 feet nonimpulsive for Motionloggers. SleepWatches (with LCD windows) must have the battery cover loosened to allow pressure equalization and prevent positive internal pressure build-up which may damage the LCD.

Battery Disposal

Motionloggers utilize Lithium batteries. In order to minimize environmental risk, these batteries should be disposed of properly.

Intended Use

Motionlogger actigraphs are not intended to diagnose or treat any medical condition. Just as a stethoscope can have many applications, it is considered a medical device only when it is used in medical applications. Results from the Motionlogger device can be used by a trained medical professional when information about activity levels, activity distribution, activity rhythms and estimates of sleep quantity and quality are required.

Risk of Skin Irritation

Motionloggers are typically attached with straps commercially available for wristwatches. If any skin irritation or discomfort arises from wearing the Motionlogger, discontinue use. Alternatively, Motionloggers may be worn over a commercially available "Terri-cloth" sweatband as long as the device is securely fastened to provide a good coupling between wearer and the device.

Motionlogger® Actigraphy

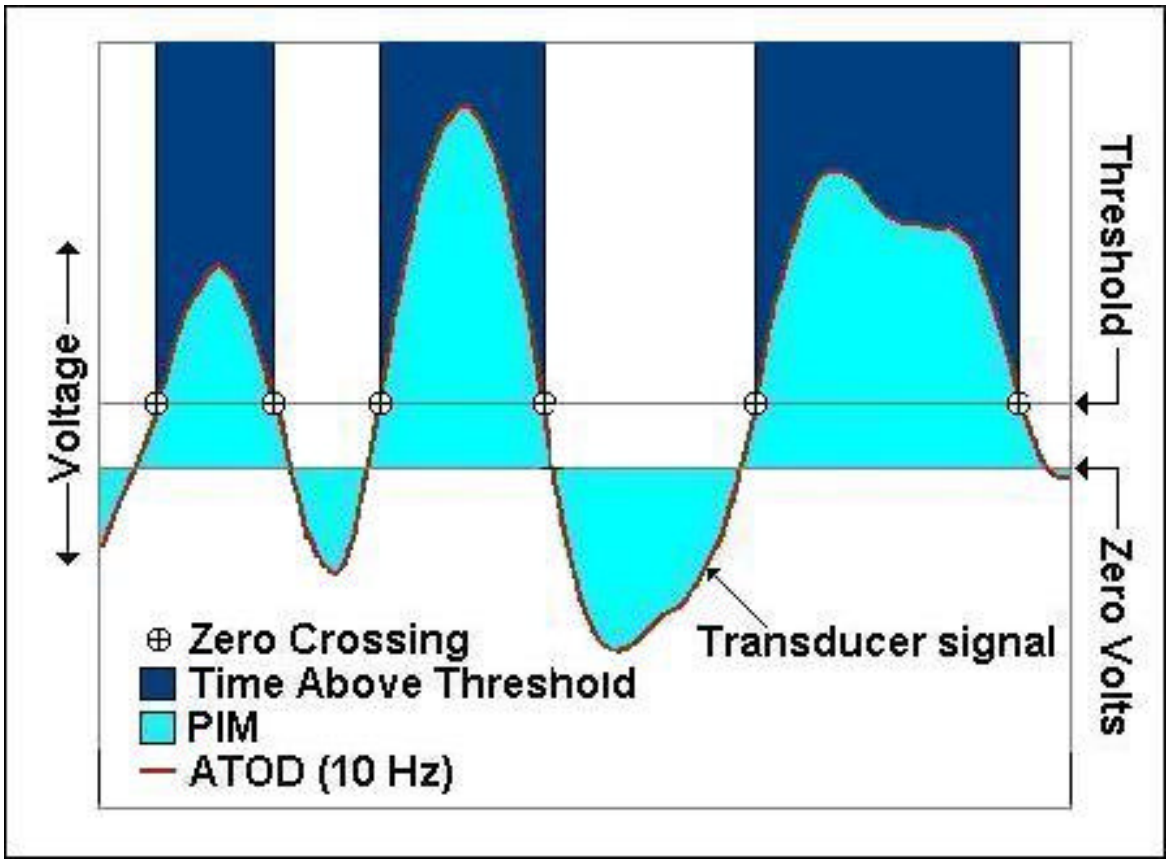
While Motionloggers vary in features, the following section is designed to explain the general technology and define the terms used with the equipment.

How the Motionlogger® Works

The Motionlogger utilizes a precision piezoelectric bimorph-ceramic cantilevered beam, which generates a voltage each time the actigraph is moved. That voltage is passed to the second essential element of the Motionlogger, the analog circuitry. Here the original signal is amplified, and filtered according to user-selected (or factory set at 2-3 Hz in the case of the most models) settings. What is done with this conditioned signal depends on the mode of operation employed by the Motionlogger. Typically, derived information based on the mode of operation is accumulated over a user-selectable (fixed at 1 minute for the MicroMini) time period know as an epoch length before being stored in the memory of the device. Once memory is full, data collection stops. Memory is never overwritten unless the Motionlogger has been re-initialized.

Motionlogger® Modes of Operation

Not every Motionlogger has every mode available. The following is a discussion of the most common modes of operation. The conditioned analog activity signal can be processed in many different ways to provide information about the subject's motion.



Zero Crossing (ZC) Mode

The conditioned transducer signal is compared with a sensitivity threshold. This threshold is fixed for most actigraphs but can be user selectable in some devices like the ULTRA model. The number of times the signal voltage crosses the reference voltage is accumulated in temporary memory storage until the user-defined epoch length has transpired. *Zero Crossing is a measure of frequency of movement.*

Time-Above-Threshold (TAT) Mode

In this mode, the amount of time (in units of tenths of a second, the sampling rate) spent above the sensitivity threshold is accumulated during the course of an epoch. *Time-Above-Threshold is a measure of time spent in motion or duty-cycle.*

Dual Mode

ZCM and TAT data may be collected simultaneously in what is known as the DUAL mode. Mini Motionloggers® with version 8.00 firmware or higher (Motionlogger firmware version number is displayed when manual communications are established. See section on Act2000) have the ability to record ZCM and TAT data simultaneously. Two data points (TAT followed by ZCM) are recorded for each epoch. Naturally, this mode uses memory twice as fast as any single mode.

Proportional Integrating Measure (PIM) Mode

A high-resolution (maximum value is 32,000) measurement of area under the rectified (absolute value) conditioned transducer signal is known as the PIM (Proportional Integrating Measure) Mode. *Proportional Integrating Measure is a measure of activity level or vigor of motion.*

Tri-Mode (PZT)

This measure collects Proportional Integrating Measure, Zero Crossing and Time-Above-Threshold measurements simultaneously. *Tri-Mode is useful when information about frequency, duration, and vigor of motion is necessary.*

Which Mode is Right for My Application?

Historically, Zero Crossing was chosen as the mode of operation because of its ability to estimate sleep with a high degree of accuracy. The bulk of the literature published to date has been using this mode of operation, particularly on the topic of sleep. Recent studies have show that the great resolution of the PIM mode is at least as good, if not better, at evaluating sleep. Further PIM mode has proven very useful in studies on energy expenditure and hyperactivity. Tri-Mode is useful for experimentation because it captures a large amount of information about motion without actually recording the raw motion signal. In practice many experimenters are able to choose the *best* mode of operation for their investigation by recording these *three* modes in pilot studies.

Motionlogger® Actigraph Header Information

The programming and use of the Mini Motionlogger can be compared to that of a VCR (Video Cassette Recorder). One specifies when it will start, how long it will run, and what type of information it will record.

The Motionlogger collects activity data based on user-programmable header information. The following is a sample header with discussion of all the possible elements and options:

Epoch Length – data resolution

Epoch is the unit of time in which the actigraph collects data in a temporary area before storage. Do not confuse epoch length with sampling rate, which remains constant at 10 Hz (16 Hz for the MicroMini). In practice, epoch length can vary anywhere from 1 second to 10 minutes (except for the MicroMini which uses *fixed* 1 minute epochs). The longer the epoch length, the longer it will take for the actigraph to fill its storage area. (Once memory is full, data collection stops). The smaller the epoch the more specific the data will be. Typically, epoch lengths of 1 minute are standard for most applications but finer resolution is necessary for the study of certain phenomenon like PLM (Periodic Leg Movement). In general, it is a good practice to makes the best use of the devices resources and to choose an epoch length that will fill your Motionlogger's memory in the amount of time that is planned for the study.

Packing Option – how memory is utilized

Choice of Packing Option is usually calculated by the operational software and is thus, transparent to the user. But understanding how it works is of value in understanding how

Motionloggers manage memory. The number of bits set aside for each data value in the device's memory must be specified explicitly. The lowest Packing Option "A" utilizes 8 bits of memory for each stored data point. An additional bit of memory is allocated if Event Marking is enabled. Packing Options are calculated by the operational software such that the maximum number of counts generated by a particular mode of operation at the devices sampling rate will not saturate the data point (reach the maximum possible value). Because of the high resolution of the PIM mode a higher packing option is set by default when this mode is chosen compared to ZC or TAT.

Wakeup Time and Date – future or immediate startup

All Motionlogger® models have the capability of immediate startup (within 2 minutes) or future startup. "Future" startup is useful when two or more Motionloggers are to start simultaneously. Remember, since Motionloggers synchronize with the time on your computer's clock, it is important to make sure it is accurate. Also, time is expressed in military format (i.e. 1 PM is expressed as 13:00).

Common Problem: Improper use of Military (24 Hour) style time, either in the header or in setting the time of your computer can result in 12 hour time discrepancies.

ID Field - Identify your Motionlogger data

This is a field of 20 characters available for text entry (30 for the MicroMini). Use it to identify the test, group or subject.

Run Time Duration and considerations for choosing header parameters

The amount of time that a Motionlogger will run is limited either by the memory of the device or the battery capacity. The two header parameters described above determine the amount of time necessary to fill the memory of the device. The following table compares the some of the more common models using 1 minute epochs for different modes against the battery life.

Table 1- Run Time Duration in Days Based on Memory with Battery Life for Comparison

Model	Memory (Bytes)	Single Mode ZC or TAT with 1 minute epochs	Single Mode PIM with 1 minute epochs	Tri-Mode with 1 minute epochs	Battery Life in Days
SleepWatch-O	2M**	1059	728	364	60

** Non-Volatile Memory – data are retained even if the battery is exhausted.

Special Features and Limitations

PIM mode Auto-Zero Feature

Auto-Zeroing is a special feature that prevents baseline drift due to aging of components within the actigraph. An actigraph with a zero drift is evident by blocks of data at a constant level during periods when the actigraph is off. This drift is automatically corrected by a firmware technique called Auto-zeroing.

Auto-Zeroing is a PIM mode feature that is not supported by all Motionlogger actigraphs. MicroMini and SleepWatch-O support this feature. If your actigraph does support this feature then typically one should have the feature enabled unless specifically instructed not to by AMI technical staff. If your device doesn't support this feature then inadvertently enabling the feature in this window here has no consequence. One will merely be warned that the feature is not supported, but initialization will continue.

Full-Time Waterproofing

Full-Time Waterproofing is a feature that is critical to the precise and consistent calibration that has made the Motionlogger Actigraph a commercial success. Seen by many as simply a convenience to prevent device damage, it was a design feature for the Motionlogger for another reason. The motion sensing element in all commercially available actigraphs is a piezoelectric element. The nature of this material causes it to be hygroscopic. This means the material will absorb moisture if it is present. In the absorption of moisture the motion-sensing characteristics of the transducer will change. While waterproofing the device in some temporary way (rubber plugs, sealant, or covering) would prevent the device from being damaged in the event of submersion, it does not allow for strict calibration standards to be maintained from one usage to the next or across actigraphs.

Motionlogger® Operations

This section provides general instructions for installing interfaces, specific operating instructions for the various types of Motionloggers and general instructions for wearing and caring for Motionloggers.

The Motionlogger Interfaces

There are several types of interfaces that may be used with Motionloggers. SleepWatch-O uses an interface similar to the "FIU with auto switching."

Reset Button

All interfaces come with a RESET button. The purpose of this button is to signal the Motionlogger Microprocessor to reset. **It does <u>NOT</u> clear the memory of the device and can do no damage to a Motionlogger or data at any time.** Resetting the Motionlogger is recommended after each battery change or if communication with the Motionlogger fails.

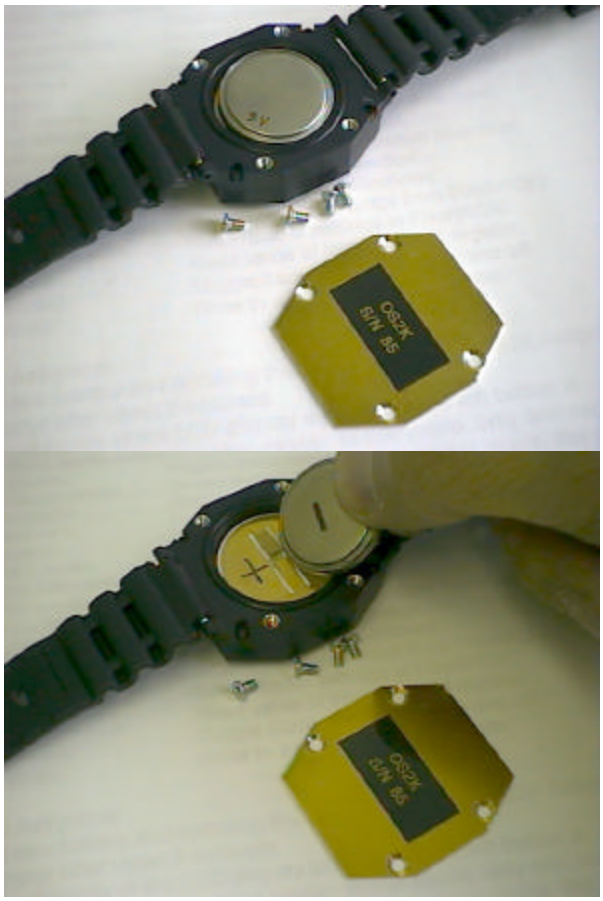
Operating the Sleep Watch®- 0 – The "Octagonal" Sleep Watch®

While coming with varying features, the basics of using and operating the SleepWatch-O (also referred to as the Octagonal or "OS2K") with version "OCT 0.10" firmware are presented in this section:

The Sleep Watch – O is designed to combine the features of a Tri-Mode BASIC Motionlogger® with the features of a digital wristwatch. Besides providing the time-of-day display other information may be presented depending on the model. Light levels, amount of sleep estimated in the last 24 hours, subjective input and performance

estimates are just some of these. Left and right button presses are used to access (and in some cases input) this information. The arc-shaped gauge is used to provide an analog scale for some of this information. In the Sleep Watch – O model the gauge is used to provide visual feedback that the actigraph is running and collecting data. The gauge will cycle from left to right in response to motion.

SleepWatch-O Battery Changing



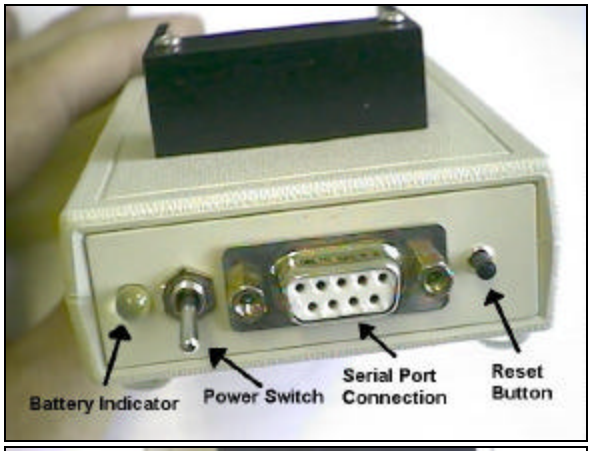
The Sleep Watch-0 uses a DL2430 or compatible Lithium Coincell battery commonly used in standard wristwatches. Fresh batteries from a reputable manufacturer are recommended for longest performance. The battery life is approximately 60 days. Because this device utilizes non-volatile memory for data storage, data will not be lost if the battery becomes exhausted. While the battery voltage can be displayed while the device is in the interface, it is important to note that battery voltage cannot predict the remaining capacity in a battery. Lithium batteries are characterized by an excellent discharge profile, maintaining very close to their nominal voltage until almost exhausted. This means that the voltage may appear normal (approximately 2.7 to 2.9 Volts) while very little capacity is left in the battery. For this reason, the battery log maintained internally by the SleepWatch is the sole criteria that should be judged when deciding to change a battery. The battery log can be found by downloading data from an instrument (or opening the most recently saved data file) using ACT2000. Use the Summary command from the File menu and inspect the value for "Battery Runtime Days."

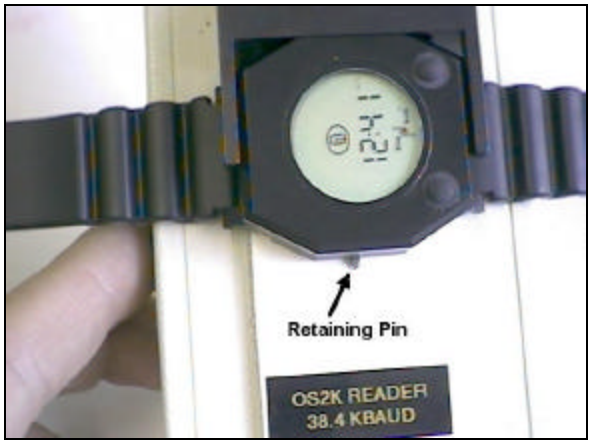
When the battery is first installed, all segments of the LCD will turn on. If the left button is pressed at this time the display switches to a single-segment test mode. In this mode, only one segment is turned on at a time. If the right button is pressed in this single-segment mode, the display advances to the next segment. These display modes are provided to test the LCD display.

The time of day on the display may be set by hand at this point (see below) and the SleepWatch-O will function as a wristwatch without data collection. (**Note that version 0.10 firmware does not have the "auto-start" capabilities of the SleepWatch-R model**). Initializing the SleepWatch also sets the Time-of-Day display.

The Interface "OS2K Reader"

This interface is powered by a single 9-volt battery that can be accessed by a sliding compartment door on the bottom. Thus powered the interface should supply approximately 100 hours of operation. When the interface battery needs changing the battery indicator will change from green to red, or not come on at all. Remember to keep a fresh 9-volt battery on hand for replacement. Insert the SleepWatch-O into the interface face-up by aligning the 4 gold contacts with the 4 gold pins of the interface. The SleepWatch is held in place by a retaining pin on the opposite side.





Reading the SleepWatch-O Battery Voltage

While inspection of the battery log (presented with other header information upon download, or viewed from the last downloaded file via the File:Summary command). It is useful to view the battery voltage of the SleepWatch battery to simply ascertain if the battery is currently viable. With the SleepWatch-O in its interface (power on), choose "Telecom:Direct Communication" or click on the direct comm  icon.

The battery voltage of the SleepWatch is displayed as seen below. "2v78" indicates a battery voltage of 2.78 Volts. The SleepWatch will run with a battery voltage between 2.7 and 2.9.

Using the buttons

If the LEFT button is pressed while the device is running/collecting toggles between Time-of-Day display and a seconds display. The seconds display will remain until the LEFT button is pressed again. The seconds display is provided as a wristwatch-like convenience for timing purposes.

The RIGHT button is used for event marking if this feature is enabled during initialization. No audible feedback is provided in the SleepWatch-O

Setting Time

At any point the Time-of-Day display can be modified. This is a wristwatch-like convenience provided to accommodate time-zone changes or changes in Daylight Savings Time. Note that modifying the Time-of-Day display does NOT effect the internal time of the SleepWatch. This remains synchronized with the time set at intialization by the host computer. The procedure for setting/modifying the Time-of-Day Display is as follows:

1. Press and hold the LEFT button on the SleepWatch for 2 seconds. At the end of this time the "hours" value is shown flashing. Release the left button.
2. Press the RIGHT button briefly to increment the "hours" value. After "12" is reached the display cycles back to "1." There is no provision on the display for AM/PM or military style time display (hours 13-23).
3. When the "hours" value is correct, press the LEFT button once, briefly. The "hours" value is locked in. The current time display is shown with the "tens-of-

minutes" digit flashing.

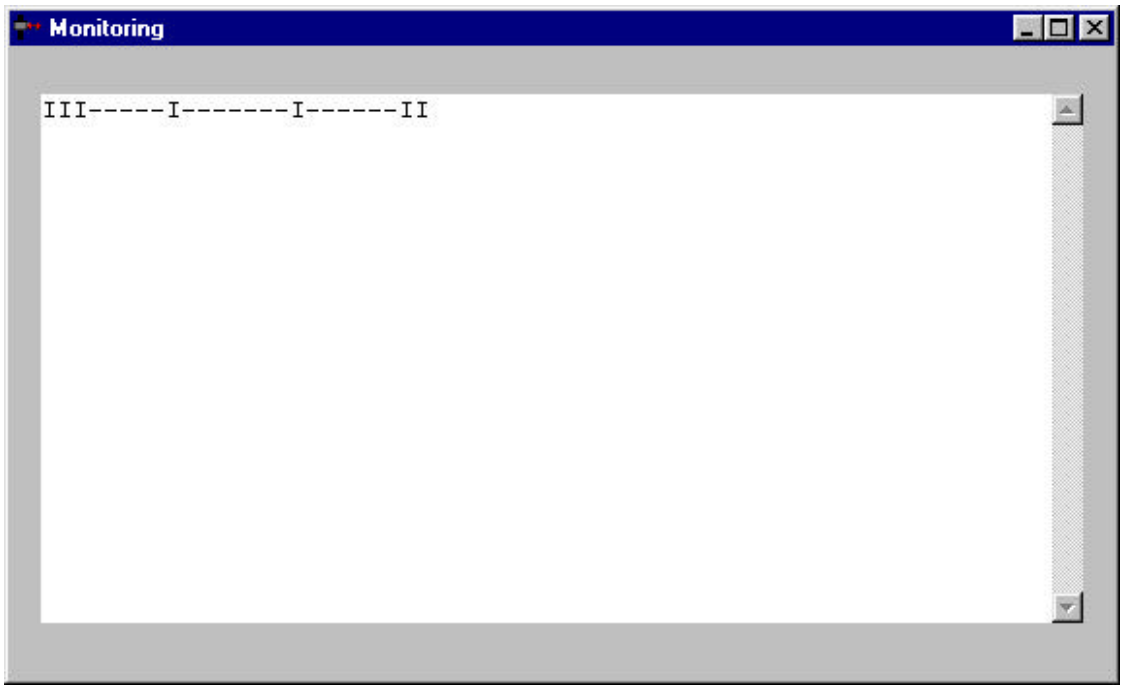
4. Press the RIGHT button briefly to increment the "tens-of-minutes" value. After "5" this value cycles around to "0."
5. When the "tens-of-minutes" value is correct, press the LEFT button once, briefly to lock in this value. The current time is now shown with the "minutes" value flashing.
6. Press the RIGHT button briefly to increment the "minutes" value. After "9" this value cycles around to "0."
7. When the "minutes" value is correct, press the LEFT button once, briefly to lock in this value. The two digit "seconds" value is now flashing. Pressing the RIGHT button clears the "seconds" value to 0. The Time-of-Day display is incremented a minute if the seconds value is 30 or more. This feature is useful for time synchronization with other sources.
8. Press the LEFT button to return to the Time-of-Day Display.

Checking that a Motionlogger is Running

Once you have initialized one or more Motionloggers, you may want to verify that they are collecting data. There are multiple methods of obtaining this information, usually. Note that some operational modes do not provide data collection feedback. See the section on Special Features and Limitations.

Using ACT2000 Monitor Feature

To monitor the actigraph (to see if it is running or collecting data) select the Telecom: Monitor menu item or click on the  Button. The window shown in the figure below is displayed permitting you to monitor the actigraph while it is in the interface. 'I's represent the 1 second clock signal from the actigraph indicating that the device is running. If the device is currently collecting data (wakeup time has been reached and memory is not full), slight movements of the interface (with the actigraph still in its receptacle) will produce dashes on this screen, indicating that the device is collecting. This technique also provides a rough indication of the sensitivity to motion.



Visual Feedback (SleepWatch-O only)

When collecting data SleepWatch-O provides constant feedback via its arc-shaped gauge indicator. This arc-shaped gauge moves forward and backward in response to motion. When the memory of this device is full or when the device has been set for a "future" startup, the arc-shaped gauge does not appear on the SleepWatch display.

Wearing a Motionlogger

Actigraph Placement

Historically most studies have applied actigraphs to the non-dominant wrist. Such placement would give a conservative measure of human activity, since sedentary activities (writing, reading, snacking) tend to employ the dominant hand primarily. Placing the actigraph on the dominant wrist would attain a more confident discrimination of completely quiescent periods. Of course, specialized applications may require other actigraph placements. For instance, studies investigating activity levels, ADHD, and energy expenditure have historically used a belt or truncal placement, while investigations into periodic leg movement have employed an ankle or knee placement. Some such studies may require a specialized band for placement. Contact AMI for more information.

Consistency in Orientation and Placement

In wrist-worn applications where movement is primarily rotational about the ulna, elbow and shoulder, orientation of the actigraph is not very important. Studies using precision tri-axial measurements have shown that human motion is fairly evenly distributed in space. However in studies of energy expenditure, etc, where the gross locomotion of the body against gravity is a key measure, Motionloggers should be mounted flat against the body in a consistent manner.

Wrist Attachment

For wrist-worn application Motionloggers should be worn at the location where a wristwatch would be worn. If the subject is wearing a wristwatch on this wrist the actigraph may be placed just above the actigraph (towards the elbow).

Care and Maintenance of the Motionlogger Actigraph

The actigraph superficially resembles a digital watch. It is easy for the user to assume that it will operate under the same conditions that we all expect from expensive wristwatches. A digital watch, of even the most sophisticated variety, is quite simple in comparison, requiring much less power to operate, and having the advantages of a much lower parts count and no external interfacing. The Motionlogger is really more like a scientific calculator than a wristwatch, and has durability somewhat better than most calculators but somewhat less than a sports watch.

Exposure to Moisture

The waterproof case of the SleepWatch-O has been tested at great depths, but prolonged submersion in contaminant laden water could cause corrosion of a communications pin on the case. As a rule, submersion should be kept less than 10 feet.

Physical Shock

All watch wearers avoid dropping the watch onto hard surfaces from great heights, or striking it into concrete walls, steel posts, etc., when moving about. The actigraph should be afforded the same physical respect by the wearer. The accelerometer, time base components, and the internal circuitry mountings can be damaged from extreme physical shock. When shipping or transporting the unit, damage can also occur through sustained mechanical vibration. Always use the supplied padded shipping containers.

Maintaining Electrical Contact

An important consideration in "maintaining contact" with Motionloggers (when initializing or retrieving data) involves the cleanliness of the wrist unit. The small gold-plated circles on the side plate of the actigraph are electrical connectors. These contacts engage mating spring-loaded pins in the interface unit. It is important that good electrical contact occur on all connections for reliable interface operation. Excessive dirt, sebum, tape residue, and other accumulations of foreign materials can block electrical contact in the interface. Inspect the I/O connections periodically for contamination, particularly prior to interface insertion. The contacts may be cleaned while the instrument is taking data, with no fear of data loss, by the method explained below.

The small gold-plated circles on the actigraph may be cleaned with 70% or 90% isopropyl alcohol applied with a lint-free towellete. "Alcohol Preps" for injections are quite inexpensive, widely available, and are the method recommended by AMI for I/O pin cleaning. Use them to clean the contacts with a brisk rubbing motion. Clean the contacts first. You may then use the remainder of the prep to clean the entire instrument, if necessary. If the actigraph is taking data, make sure the instrument is fully dry before interface insertion.

AVOID using rubber erasers, linty cotton swabs, any other solvent. Damage to pin plating and melted plastic parts can result which void warranty.

Troubleshooting

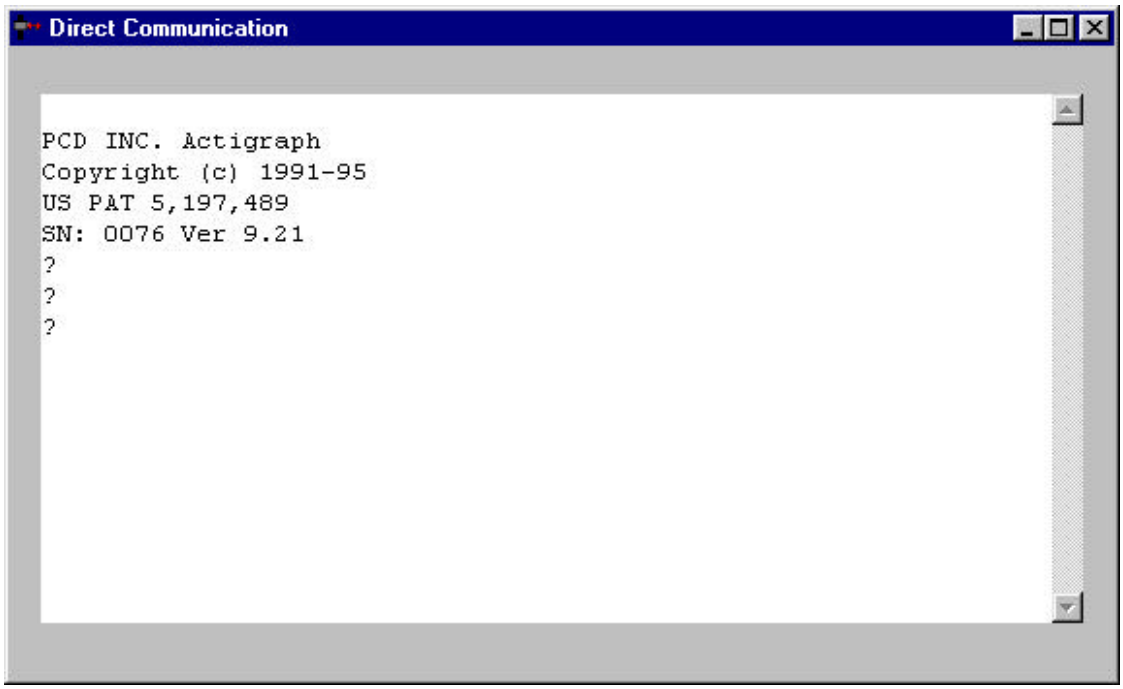
Motionlogger will not Download Data (or will not Initialize)

- Make sure interface power is on. If a battery-powered interface is being used, make sure the batteries are still good.
- RESET the Motionlogger – put the Motionlogger into the interface and press the RESET button on the interface. This will not affect any data residing in the Motionlogger's memory. Try to download data (or Initialize) again.
- Run the Loop Test as described in a previous section. This will verify that you are connected to the serial port configured by ACT2000 and that the interface is functioning properly.

Troubleshooting Communications

You can verify proper communications by accessing the Direct Communication window. AMI technical service may direct you to this feature when troubleshooting a difficulty over the phone.

ACT2000 supports interactive communications with the actigraph. To go into direct communication mode simply select Telecom: Direct Communication or click on the  button. A communication window opens as shown in the figure below. Pressing the **RETURN** key a couple of times should log in the actigraph (if inserted into an interface unit and the interface is ready to communicate).



Now any keys pressed will be directed to the actigraph via the serial port. Establishing communications this way can be used to determine the serial number of a device, should its external markings be removed or become illegible (downloading a data file and examining the header is another way). Pressing Ctrl-H here will cause the actigraph to present its header information. This window can be left open during initialization or data download. During the course of these processes one may encounter transmissions that appear to be requesting responses from the user. However, the initialization and download procedures are totally automated and ACT2000 will provide the proper response to the Motionlogger.

More ACT2000

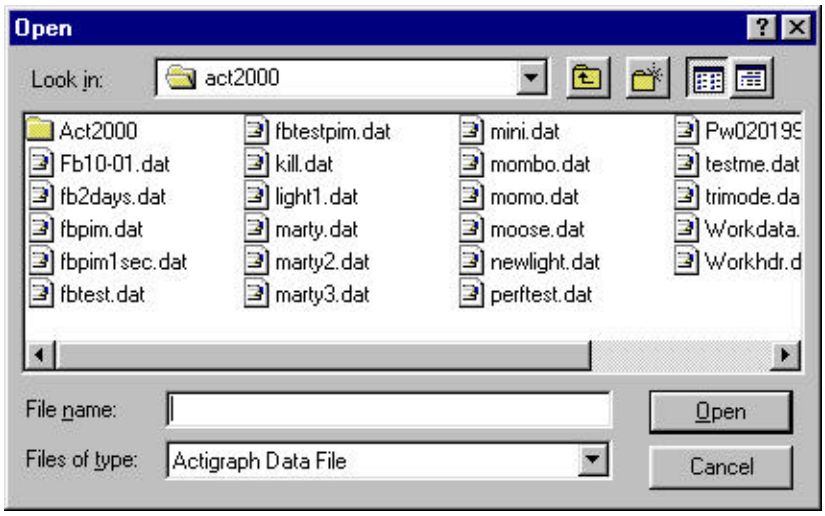
File Submenu

The File submenu contains items that permit you to open, save, and print actigraph files. An exit item is also included in this submenu to leave the program. Actigraph submenu contains items that permit you to initialize and download Actigraphs. The Telecom menu permits you to have direct communication with the Actigraph. The Configuration menu permits you to make various ACT 2000 setup changes such as Baud Rate, Communication Port, Actigraph Type, and Interface Type. The Diagnostics submenu contains items which permit you to perform testing operations on the actigraph and interface unit.

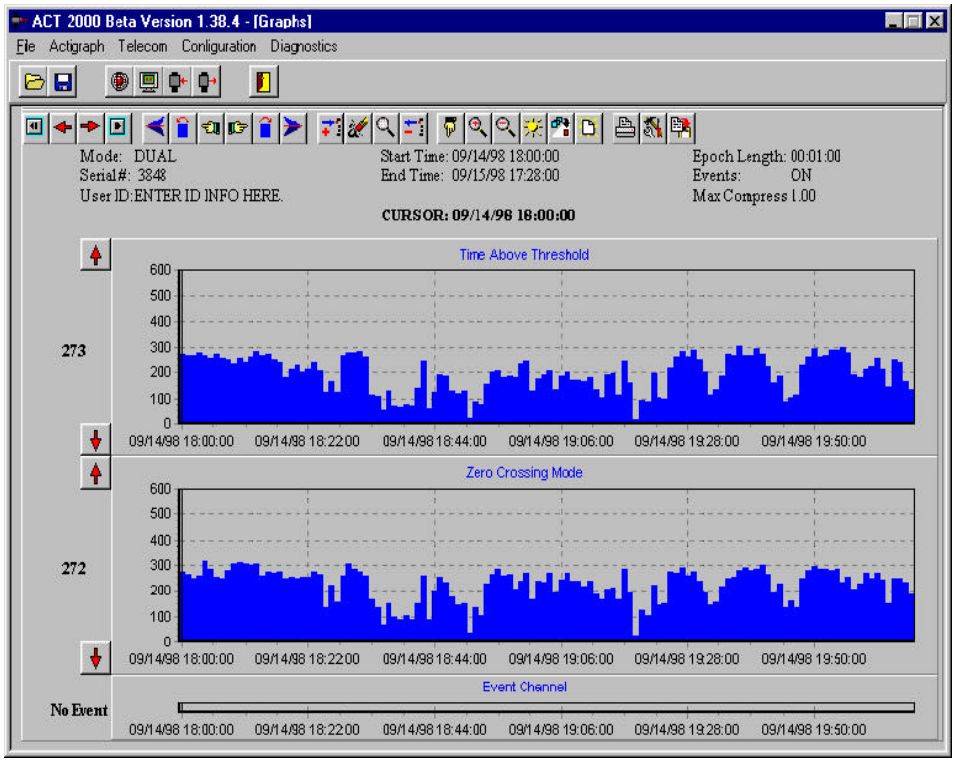
Opening a File

To open a file with ACT 2000, simply select File:Open from the menu or click the  Button from the ToolBar. An Open dialog box like the figure below should appear which will permit you to choose a file to open. Notice that you have the option of changing the

file type. Currently ACT 2000 supports DAT and AMI file formats. Both version 3 and 4 AMI files can be read with this software. You can either double-click the desired file or single-click it and click the Open button on the dialog box to open the file.

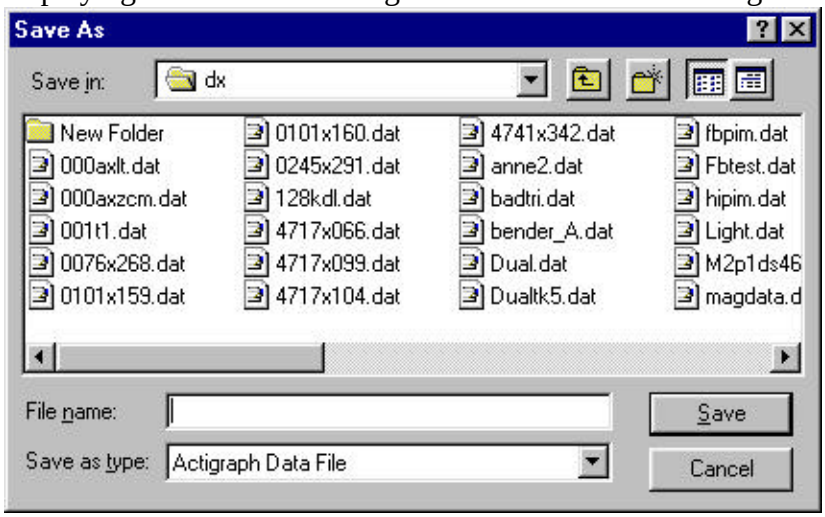


Upon the successful opening of an actigraph file, ACT 2000 will display a graphical representation of the data as shown in the figure below. Note the large number of toolbar buttons in the graphics screen. These functions will be covered in a later section.



Saving an Motionlogger file

After downloading or opening an actigraph file, you can save it by selecting the File:Save menu item or by simply clicking the  button on the Toolbar. ACT 2000 responds by displaying the Save File dialog window as shown in the figure below:



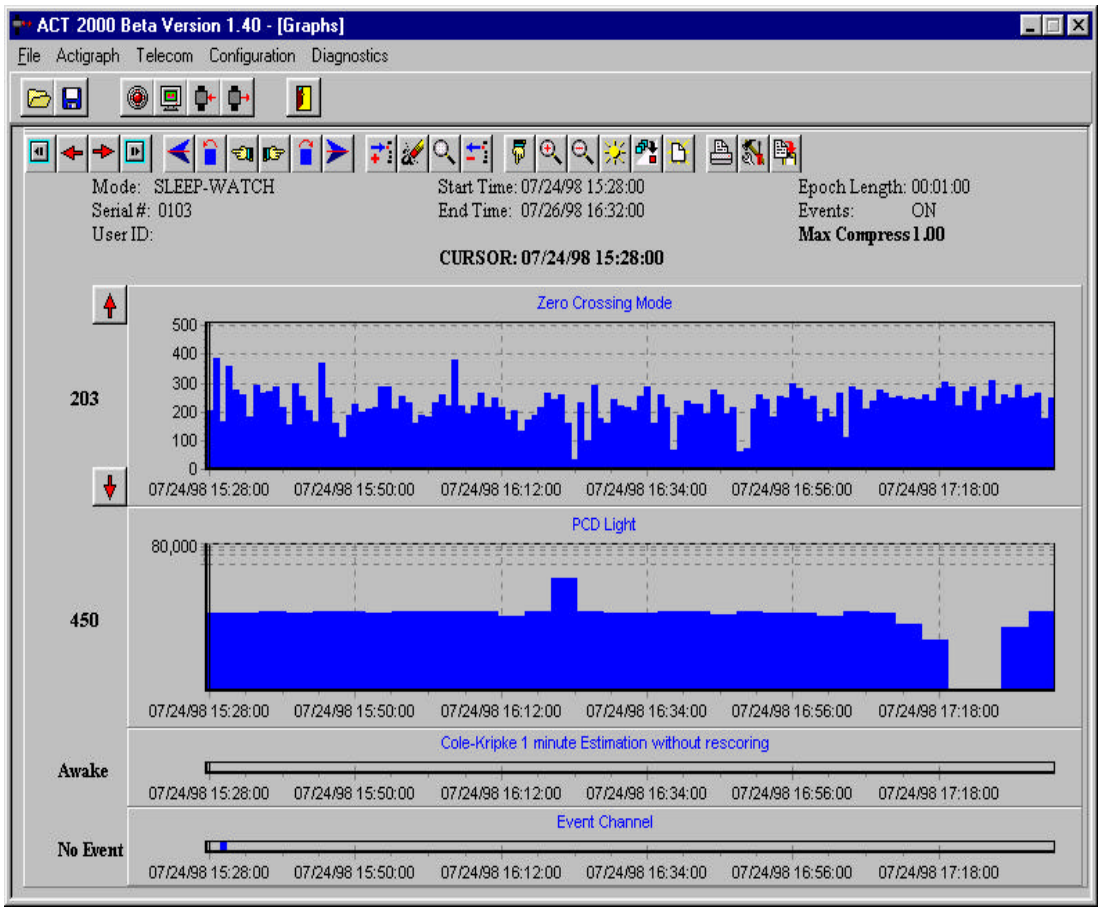
As with the Open File Dialog window, you have the choice of selecting either DAT or AMI (version 4 only) file formats.

ACT 2000 Graphics

Upon successful data download or after loading a file, a graphical presentation of data will appear on the computer screen. These graphics are designed to allow the user to visually inspect data. For data analysis, the user is directed to Action-W for (clinical sleep studies) or Action3 (Action4 for Windows when available) for circadian or more general statistical and mathematical processing.

To illustrate the capabilities of the graphics in ACT2000, let's open the sample file SAMPLE.DAT included in your installation.

Click  or select File:Open and choose SAMPLE.DAT. After presenting header information from the selected file, the graphical presentation will appear.



Notice that we have four seperate graphs displayed: Zero Crossing, Light, Sleep Scoring, and Events. The Zero Crossing and Light graphs are larger than the Event and the Sleep scoring because the latter two have only two possible values (binary graphs). You may also notice that only the Zero Crossing Graph has the  and  keys. They are used for scaling the graph and are not needed for log (light) or binary graphs.

To the left of the graph are four values associated with the data at the current cursor position. The cursor is the thin black vertical bar that appears in each graph and which responds to mouse clicks by moving. Cursor navigation will be discussed in a later section. At the top of the graph the Mode, Serial number, ID, Start Time, End Time, Epoch Length, Event mode and Compression are displayed as the heading.

A Note about Histograms, Epochs, Compression, and Pages

Before proceeding further, a little bit of understanding of how the graphics are displayed might be helpful in understanding some of the controls. For the most part the data are displayed as bars or histograms. Ideally each histogram would represent one epoch of data. This is not always the case due to limitations of the computer's display. Perhaps a working example may help.

Lets say that you have an 800x600 display screen. This means that your monitor can

generate graphics 800 dots wide and 600 dots high. Let's say that we could use all of the width for displaying graphs (not practical because we need space for the window frames and labels.) Now at the absolute minimum we would need 1 dot to describe the width of each histogram (three is probably a more practical minimum). This would mean we could only display 800 epochs of data on the screen at one time. At one minute epoch lengths this would only be about 13 hours.

Most users would like to be able to display much more than 13 hours of data at a time. There are two techniques used to permit the user to view data greater than their screen resolution; Paging and Compression.

Paging is a technique that breaks the graph into equally sized parts that can be easily displayed. You can move through the pages by using the page navigation buttons (or keys) explained below. Page width is controlled my zooming. By default, the graphics display starts out with 128 epochs per page. Increasing the page width will affect the graphics parameter; Compression.

Lets go back to our ideal graphics situation (800 x 600). Lets say that we want to display 1600 epochs. This would mean that each width dot would have two epochs drawn on it (assuming one dot width histograms). From a computer performance issue, one of the slowest operations to do is draw graphics. Most of the time it does not make sense to redraw graphical data on top of each other. First of all, only the largest value would be displayed. Second it would take twice as long as drawing the data only once.

The efficient way of handling this situation is to compress the two epochs and display only one histogram. You may ask "Which epoch value should you use?" This would depend upon your preference. Selecting the maximum value of the two would be equivalent to simply allowing the data to be drawn on top of each other (no compression). The average value of the two epochs could prove useful in displaying rhythms. ACT 2000 supports both modes (explained later).

By default ACT 2000 limits the initial number of histograms to 128. This means that a day's worth of data would have to be compressed by a little over 11 to 1. (Each histogram would contain 11 epochs). ACT 2000 permits the user to change the number of histograms up to 1024 per page. This sometimes helps with graphic details but will cause slower screen updates and some corruptions to the graph.

ACT 2000 permits you to change the page width, compression technique and compression ratio in order to optimize your data viewing. The lower right corner of the heading shows the compression type and ratio. They can be changed by simply clicking on them.

Page Navigation

These keys are used to page through the actigraph file. The  button or the Home key

places the graph in the beginning of the data file. The  buttons (Page up and Page Down keys) permit you to page through the actigraphy data like you were paging through a word processing document. The  button (or the End key) will place the graph at the end of the data file.

Cursor Movement

The cursor is a vertical line associated with each graph used to isolate individual epochs and their values.

The  and  buttons with the Left and Right arrow keys move the cursor one epoch to the left or right. Notice the cursor time should change in response to the operation. Additionally, the values to the left of the graphs should change as well. These values are the data stored in the epoch at that cursor position. An important note - If you are viewing data that is compressed, the cursor will not move one histogram position per keystroke. If the compression ratio is 2:1 then it will take two key presses to move the cursor one histogram. Remember there is not always a 1:1 ratio between a histograms and epochs. In compressed graphs the next buttons provide a faster way of moving cursors:

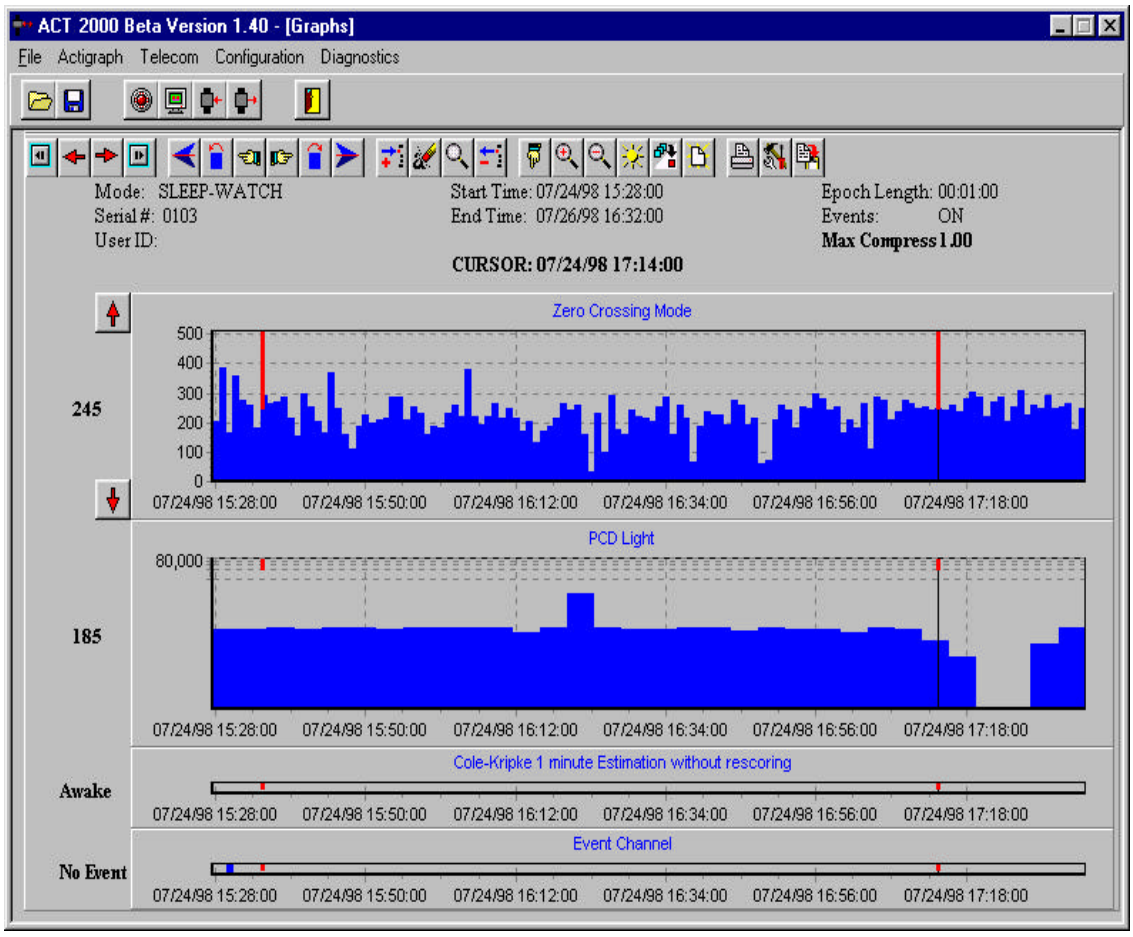
The  and  buttons with the <Shift> Left and Right arrow keys move the cursor exactly one histogram to the left or right. This will change the cursor time as well as the cursor values to reflect the new position. If the compression is 1:1, these buttons operate exactly like the previous two (one epoch).

The  and  buttons with the <Control> Left and Right arrow keys move the cursor 10% of the current graphics window to the left and right. These keys are useful to quickly move the through the graph.

In addition, clicking the mouse on a histogram will cause the cursor to be moved to that location.

Marker Manipulations

Markers are used to select areas of the graph for later zooming. Markers are displayed by red vertical lines extending partially down the graph.



The  button or Insert key causes a marker to be placed at the current cursor position. A maximum of two markers can inserted.

The  button or Delete key causes the marker at the cursor location to be deleted.

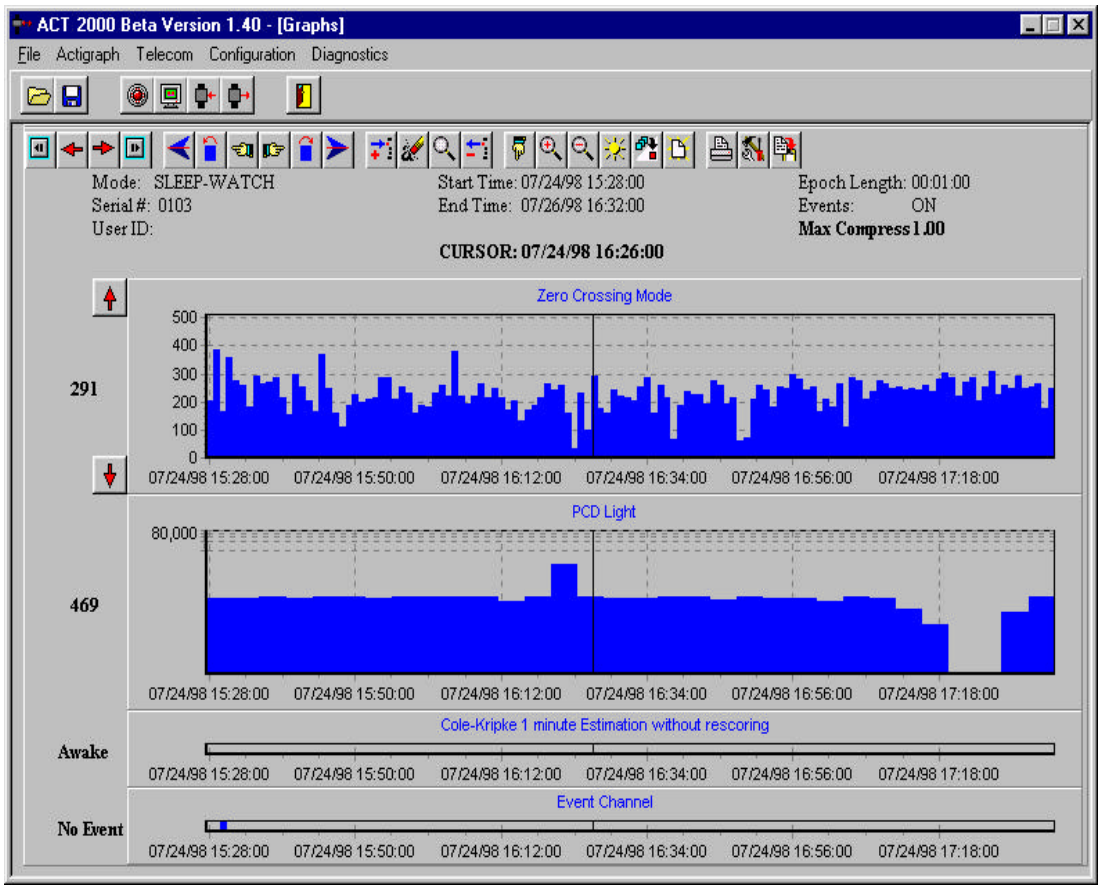
The  button or <Control-Z> keys zooms zooms the graph to the marker values

The  button or <Control-M> keys clears all markers

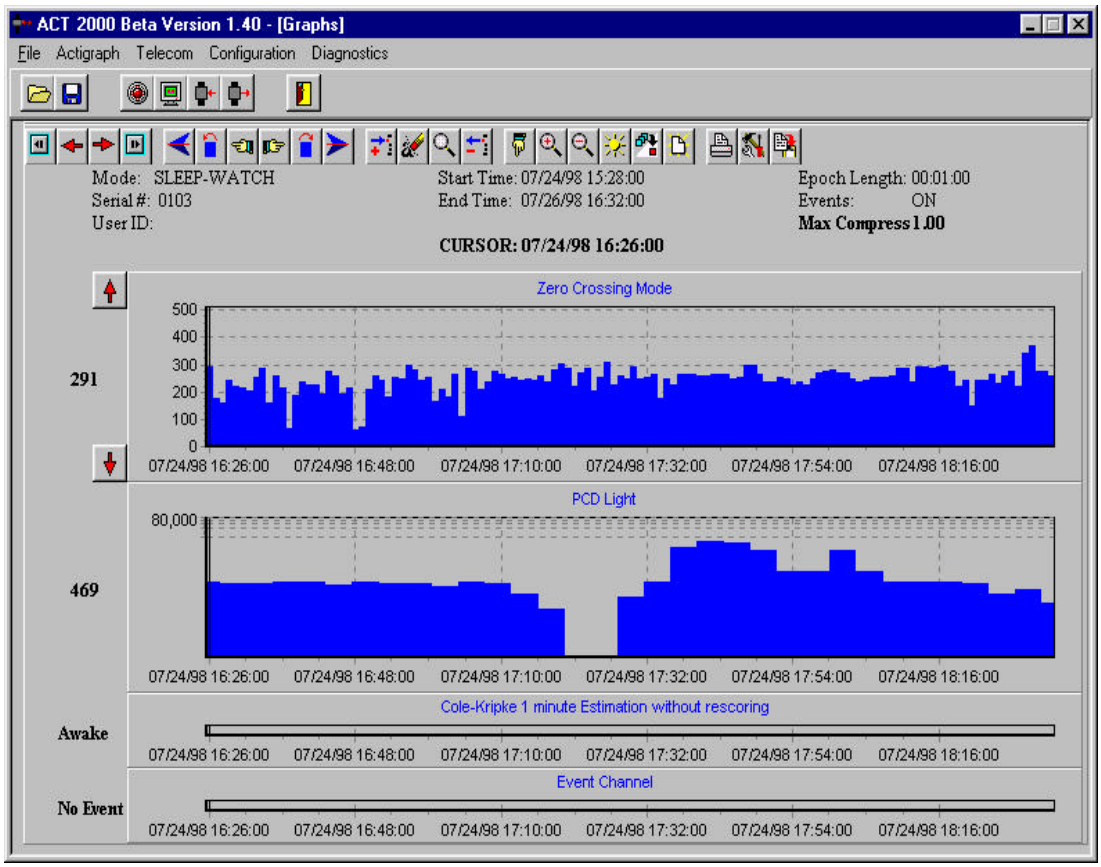
Zooming

Zooming permits you to change the page size (in epochs) of the graphics screen. The compression ratio gets changed to reflect the current resolution setting (more later).

The  button permits you to reposition the start of the page to the location of cursor. Notice in the screen below that the cursor is currently positioned at 7/24/98 16:26:00.

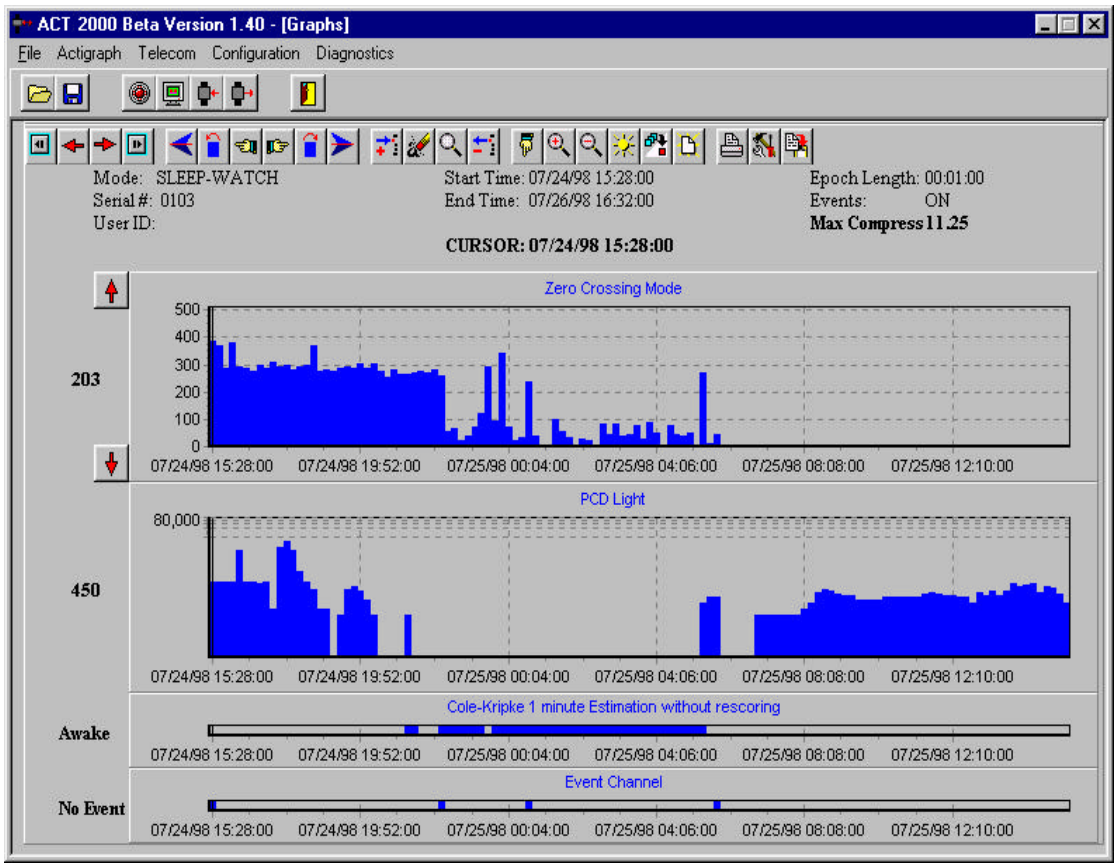


After repositioning, the starting location is now at 7/24/98 16:26:00.



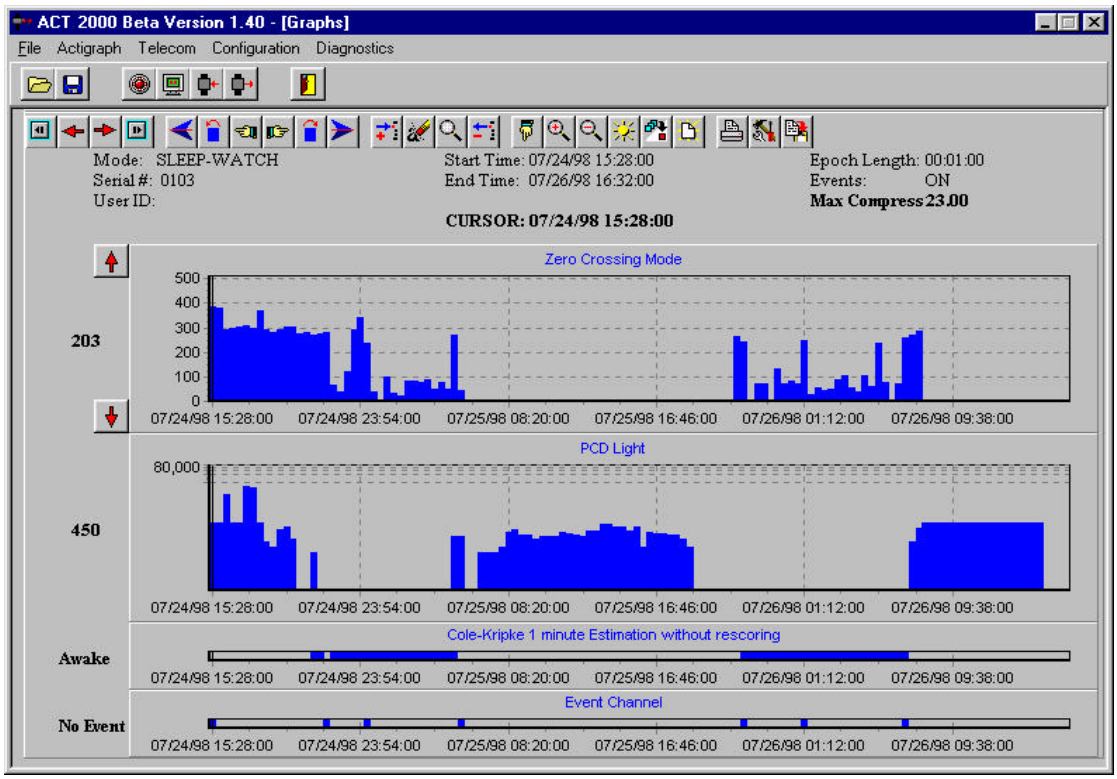
The  and  buttons with the + and - keys permit you to zoom in and out of graphs by a factor of two. ACT 2000 attempts to center the new graph on the last cursor position. Note that the compression ratio should change based on the number of epochs being displayed.

The  button or <Control> D keys displays an entire day's worth of data on one page.



Note that the compression ratio has changed due to the increased number of epochs displayed.

The  button with the <Control> V keys permits the user to display all the epoch data on one graph.

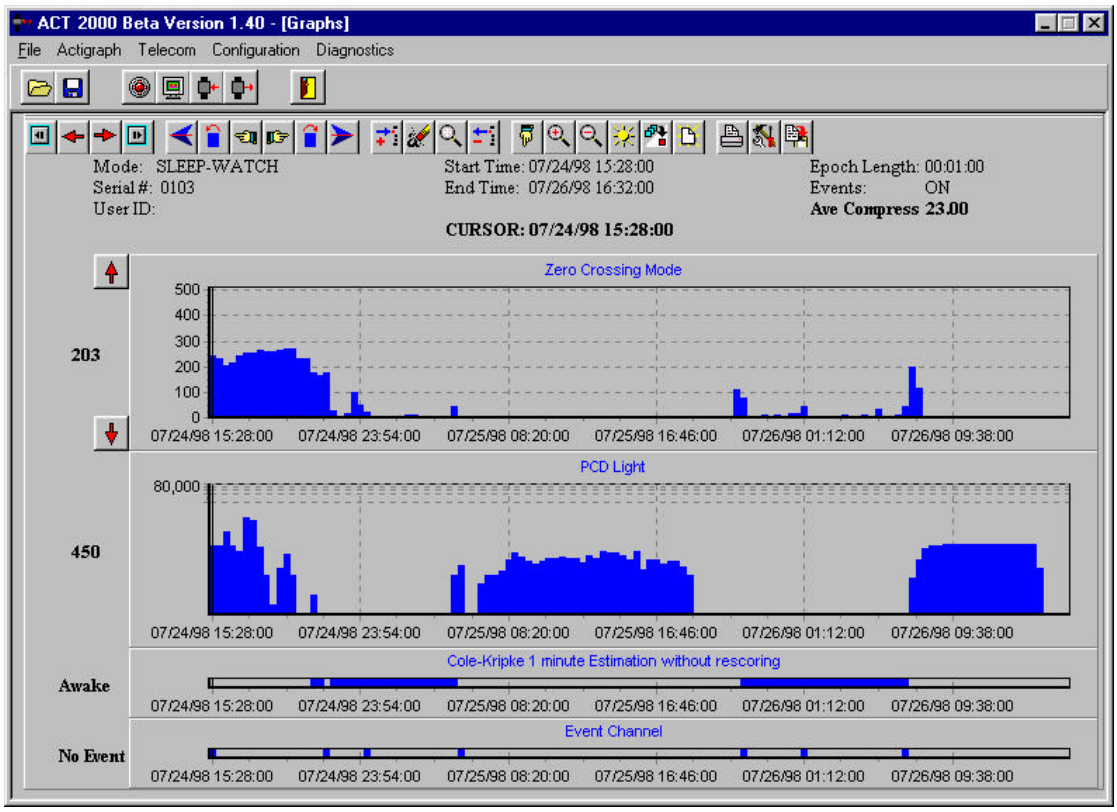


Again the compression ratio will change based upon the increased number of epochs.

The  button with <Control> R simply resets the graph and displays it with original settings (128 epochs per page).

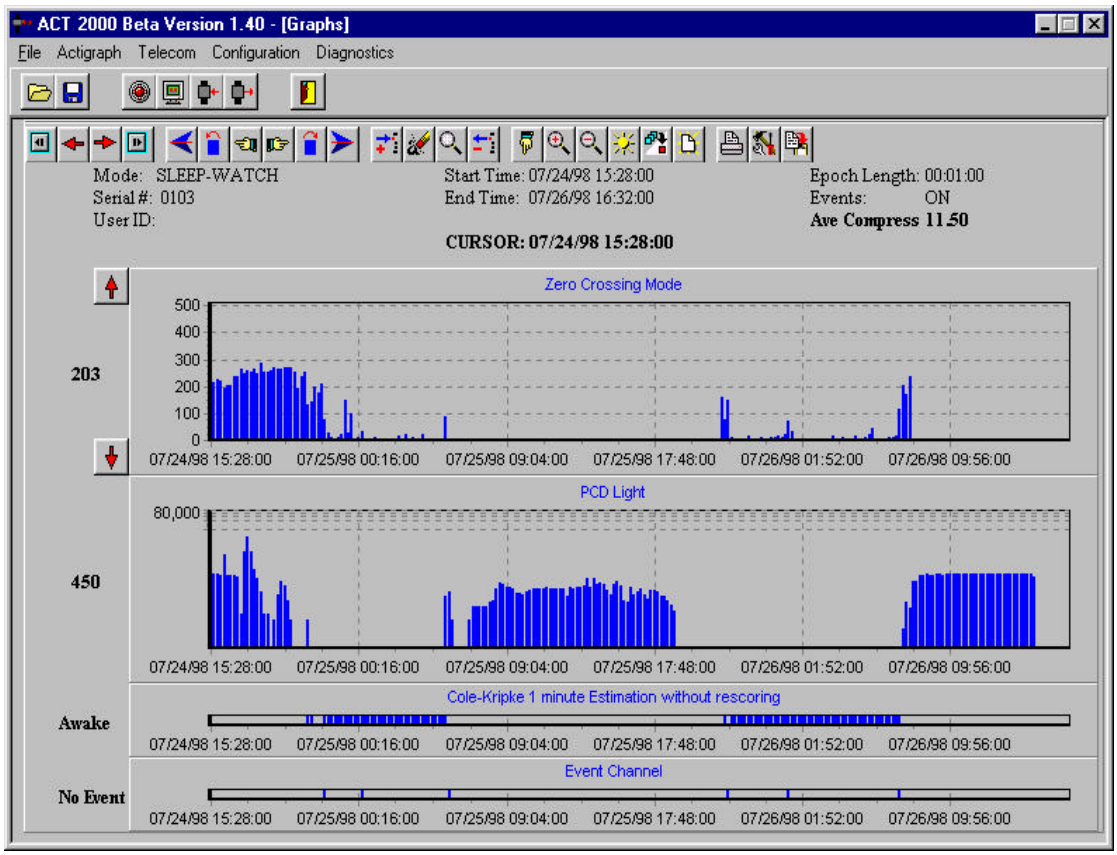
Compression

Lets say you have your entire data displayed on one page. Clicking on the **Max Compress** label will switch the compression mode to average.

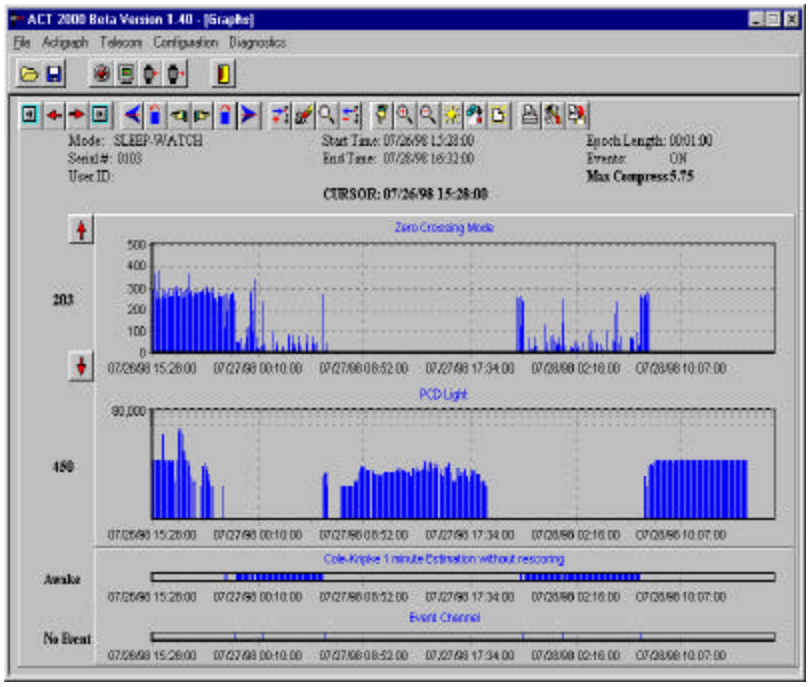


Notice the label now displays Ave Compress. The overall graph appears to have lower values since we are now using average values rather than maximum values to compress our epochs.

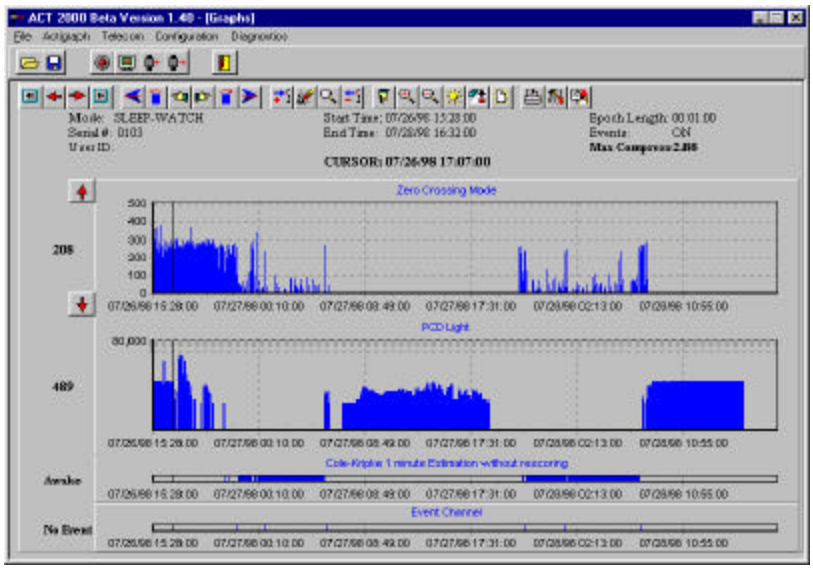
Pressing the compression value label (23.00) will double the number of histograms displayed.



Now we are using 256 epochs per page, the compression ratio has dropped to 11.5. You can see that the graph looks a little rough. This is because the histograms are overlapping each other. Clicking the ratio label again yields this display:



Finally for the finest resolution (1024 epochs per page):



This presentation of this graph is good. However moving the cursors around much is not recommend (very slow). Clicking on the ratio label (now 2.88) will restore the graph to full compression (23).

Printing and Copying

The above Icons represent, respectively, print, print setup and copy to clipboard. These functions should be self-explanatory to Windows users. For further explanation please consult your Windows manual.

ACT2000 Diagnostics

Except for functions specifically designated in this manual such as the LOOP TEST, diagnostic features should not be used without consultation with AMI technical staff.