QUESTION
Why does the AASM scoring manual recommend specific sampling rates for recording digital polysomnography?

ANSWER
To fully understand the answer to this question, a number of very important basic concepts about the recording and playback of electrophysiological signals must be understood. Let’s begin by explaining the difference between analog and digital data. Although we probably all use these terms very freely, I would venture to guess that most sleep technologists do not understand how the signals we see on the computer monitor are generated.

To begin with, although nearly all of today’s polysomnograms are “digital,” those squiggly lines that we see on the computer monitor actually begin as analog signals. A very basic example of an analog signal is a sound wave. When we listen to someone singing a song, we hear a continuous fluctuation of sounds, varying in pitch; this is actually an analog signal.

“Analogue” involves a “continuous transmission of information.”1 VHS movies and audio-cassette tapes are examples of recorded analog signals. The devices that make these recordings continuously capture data in a linear fashion from one data point to the next. In polysomnography, we continuously sample physiological events, such as electroencephalogram (EEG) activity or electrocardiogram (EKG) rhythms, and convert this biological activity into an electrical voltage. The old-style, paper polysomnogram is another example of an analog recording.

You may be wondering, if today’s recordings still originate as analog signals, then what makes them “digital” recordings? First, you must realize that for any type of data to be analyzed and stored by a computer, the signals must be in a digital format. In order to do this, we utilize an analog-to-digital converter to take samples of data at very discrete intervals in time. Each individual sample is then converted into a number (digitized), based on its voltage value. Although analog signals can have an infinite value, digital signals are limited to a finite number; therefore, some data are inevitably lost during the digitization process. It is not feasible to sample and convert data in a continuous fashion at each and every point in time.

To minimize any data loss, we want to use the highest possible sampling rate to accurately recreate the original analog signal. However, very high sampling rates come at a cost: extremely large file sizes. At some point in time we have all had the storage drives on our computers filled to capacity with voluminous PSG files. Logically, there must be a trade-off: We must limit the amount of data that gets sampled, collected and stored. This is why we must determine the digital sampling rate for all the signals that we collect during the night. The AASM Manual for the Scoring of Sleep and Associated Events, published in 2007, recommends different sampling rates for different signals, such as 500 Hz for electrooculogram (EOG) and 100 Hz for airflow.2 This article, however, will focus on EEG signals.

The “desirable” EEG sampling rate is 500 Hz, and 200 Hz is the “minimal” sampling rate. This means that at a minimum, in one second of time, 200 data points of the analog EEG signal must be sampled; but capturing 500 data points in one second of time will more accurately represent, or recreate, the analog EEG signal.

Why does the sampling rate need to be set so high when EEG frequencies are nowhere near this fast? The answer lies within the “Nyquist theorem,” or “Shannon's sampling theorem.”

This theorem states that the sampling rate for analog-to-digital conversions must be at least two times the value of the highest frequency of the waveform you want to capture. Theoretically, a signal can be digitized and then restored to its original analog value if the signal is sampled at twice the highest frequency contained in the signal. Again, although EEG activity is not this fast, we need to allow for capture of high-frequency background electrical interference, fast muscle twitching, and spike-wave activity. By design, digital systems will ignore any voltages that occur between sampling points. Therefore, if the specified sampling rate is faster than the rate of change in the actual electrical signals themselves, the digital representation of the signal should be adequate.

Keep in mind that epileptic spikes or other rapidly changing activity cannot be sampled at too wide of a sampling range (i.e., a low sampling rate), or the sample points will not provide an accurate picture of the original waveform. The peak amplitude in a spike-wave complex can be approximated only by the amplitude at the nearest sampled point in time. It is for these reasons that we must be very careful to select the proper sampling rate for each signal that we record.

It is imperative that sleep technologists understand the science behind the digital equipment that we use on a routine basis. We must be certain that the equipment we are using is collecting accurate data for the proper diagnosis of the sleep disorders that affect our patients.

REFERENCES


ADDITIONAL READING