If we do not sample fast enough then the digitial samples will not accurately represent the real-world signal. The video recording was made at 24 frames/sec. When the spokes on the wheel rotate faster than 12 revolutions per second, the video image looks like the wheel is stopped, is rotating the wrong direction, or is rotating very slowly. This error is called aliasing,

VIDEO 14.5. ALIASING DEMONSTRATION: THE WAGON WHEEL EFFECT

Help

C14 5 Wagon wheel effect YouTube

3:59 / 3:59 **1.0x**

DR. JONATHAN VALVANO: Today, we're going to demonstrate aliasing,

which is what happens if we violate the Nyquist theorem.

I've invited our videographer, Justin, to participate

in this next demonstration.

Hey Justin, does your video camera capture data in digital form?

JUSTIN: Yes, it does.

DR. JONATHAN VALVANO: Oooh, so it must have a sampling rate.

So, do you know what that sampling rate is?

JUSTIN: 24 frames per second.

DR. JONATHAN VALVANO: Oooh, so I wonder what

happens if I rotate the motor at 12 rotations per second.

I wonder what would happen?

DR. RAMESH YERRABALLI: Oh, I guess it has to violate the Nyquist theorem,

so we should see the aliasing effect.

JUSTIN: Stop talking, let's see it.

DR. JONATHAN VALVANO: So we're now at 1.3 volts,

and we're spinning at that rate.

So I'm going to increase the voltage so it should spin faster.

And it slowly spins up faster and faster.

DR. RAMESH YERRABALLI: OK, ramping up.

Ramping up to two frames per second, so two rotations per second.

Three-- And steady at three.

DR. JONATHAN VALVANO: So, we're still under the 12 rotations per second,

so you should still see the blue dot.

So let's go faster and see what happens.

Increasing voltage from two to three volts.

So it should be speeding even faster.

DR. RAMESH YERRABALLI: So we're at six and rising.

DR. JONATHAN VALVANO: Let's go even faster.

At four volts.

We cranked up the voltage so the motor will spin very fast.

As it spins faster and faster, watch the white spokes

as they appear to first spin clockwise and then counterclockwise.

Next we cut the power and the motor will start slowing down.

As it spins slower and slower again, the spokes

will appear to spin clockwise and then counter clockwise.

What we have witnessed is aliasing.

Aliasing occurs when the input signal oscillates

at a rate greater than or equal to one half the sampling rate.

In this case, the camera samples at 24 frames per second.

So any image moving at a rate greater than 12 times per second will get all messed up.

Aliasing causes the apparent rotations per second

to be different than the actual rotations per second.

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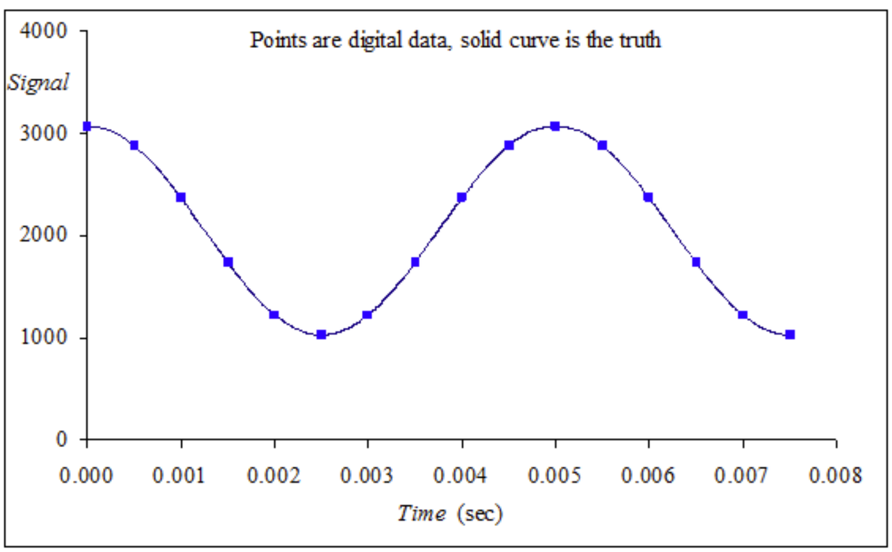
Figure 14.4 shows what happens when the Nyquist Theorem is violated. In both cases a signal was sampled at 2000 Hz (every 0.5 ms). In the first figure the 200 Hz signal is properly sampled, which means the digital samples accurately describe the analog signal. However, in the second figure, the 2200 Hz signal is not sampled properly, which means the digital samples do not accurately describe the analog signal. This error is called aliasing. Aliasing occurs when the input signal oscillates faster than the sampling rate and it characterized by the digital samples "looking like" it is oscillating at a different rate than the original analog signal. For these two sets of sampled data, notice the digital data are exactly the same.



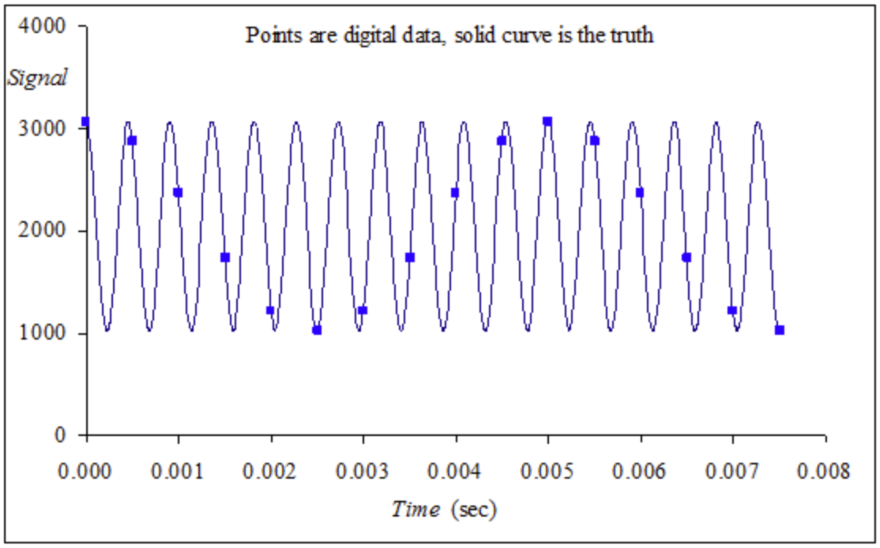


Figure 14.4. Aliasing occurs when the input analog signal oscillates faster than the rate of the ADC sampling.

Valvano Postulate: If f_{max} is the largest frequency component of the analog signal, then you must sample more than **ten** times f_{max} in order for the reconstructed digital samples to look like the original signal when plotted on a voltage versus time graph.

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