Janet Jackson had the power to crash laptop computers, follow-up

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Raymond Chen

My colleague Dave Plummer checked with Kai, my source for the story of Janet Jackson's *Rhythm Nation* crashing certain old laptops. and tried to reproduce the problem. Kai pointed out privately to Dave and me that Dave used a full-sized hard drive for his test, but the laptops that experienced problems were using small form factor hard drives. This is significant because the extra mass not only changes the natural resonant frequency, but it also acts as a damper.

The traditional solution for mitigating resonant frequency problems is to change the mass of the device, say, by adding some ballast mass, thereby dampening the effect as well as shifting the frequency, hopefully to somewhere less likely to be encountered. However, since these were small form factor laptop hard drives, adding mass was not an attractive solution, because one of the main features of these hard drives was their small size and weight. Adding ballast would make them bigger (no longer fitting in the laptop chassis) and heavier (not what you want in a laptop).

Even if another solution could be found, say, by securing the drive in a different way to the chassis, that would require changes to the manufacturing process, and those changes tend to be very expensive. You have to design a new chassis and go through a new round of testing: Maybe the new chassis design mitigates the resonant frequency problem, but it now fails a vibration test, or the shift in weight causes it to fail balance tests, or moving components around causes the electronics to exceed safety limits,[1] or radio frequency interference now leaks in a way that causes it to exceed government regulations.

It is much less expensive to fix the problem in software.

Note that the software approach is a mitigation, not a solution. The hard drive could still crash if some nearby system were playing *Rhythm Nation* loud enough. But at least it prevented the system from crashing *itself*.

Adam Neely undertook a deeper analysis of the problem, both from a musical standpoint and a physics standpoint. What is musically unique about *Rhythm Nation* that singles it out as the source of the troublesome frequency? And what is physically significant about that frequency?

I encourage you to go check it out. If you're impatient, there are spoilers after the bonus chatter.

Bonus chatter: Note that the disruption from the natural resonant frequency does not crash the hard drive, as a number of outlets erroneously reported. It merely disrupts the hard drive's proper operation long enough for it to result in the operating system crashing. For example, if it causes a kernel page-in I/O operation to fail, that would be considered a fatal system error. The damage is probably not permanent. The sustained disruption was enough to cause a critical I/O to fail, but removing the audio source removes the disruption, and the drive recovers normal operation.

Bonus bonus chatter: Yes, I know which "major computer manufacturer" it is, and no, I'm not telling. This is consistent with longstanding blog policy that companies are not identified in stories, because the point of the story to teach something, not to call out companies for derision.

Bonus bonus bonus chatter: Other mysteries:

- The Roman Mars Mazda Virus
- To get this computer to boot, you have to whack it in just the right place.
- To get this computer to boot, you have to tilt it at just the right angle.
- To avoid problems, don't move the mouse back and forth quickly.
- The bug that reproduces only on one specific unit, and only when the test runs overnight, and only when it was on one specific table.

Spoilers

The *Rhythm Nation* music video is performed at a nonstandard tuning. Instead of using the standard A=440, it uses A=450, which shifts its notes into less-commonly-used frequencies.

Neely also found a paper that studied the natural resonant frequency of 2.5 inch laptop hard drives and matched it up with the frequency of a low E in the nonstandard tuning used by *Rhythm Nation*.

[1] An example of this was demonstrated live on stage at the //build 2011 conference: The rearranged components put the touch sensor too close to an HDMI processor chip that overheated under extended usage, which in turn caused the touch sensor to flip out and then eventually destroy the system.

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