Embedded Security

EECE 5698-08: Special Topics: Cyber-Physical Security of IoT Systems in the Age of AI

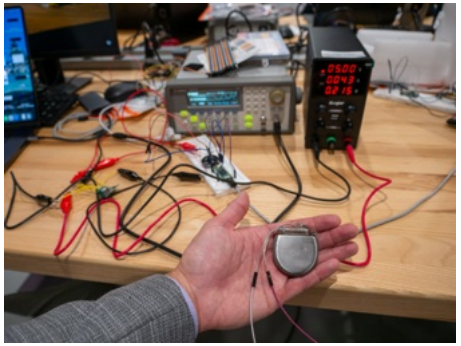
Lecture 8: Sound and Availability

Prof. Kevin Fu

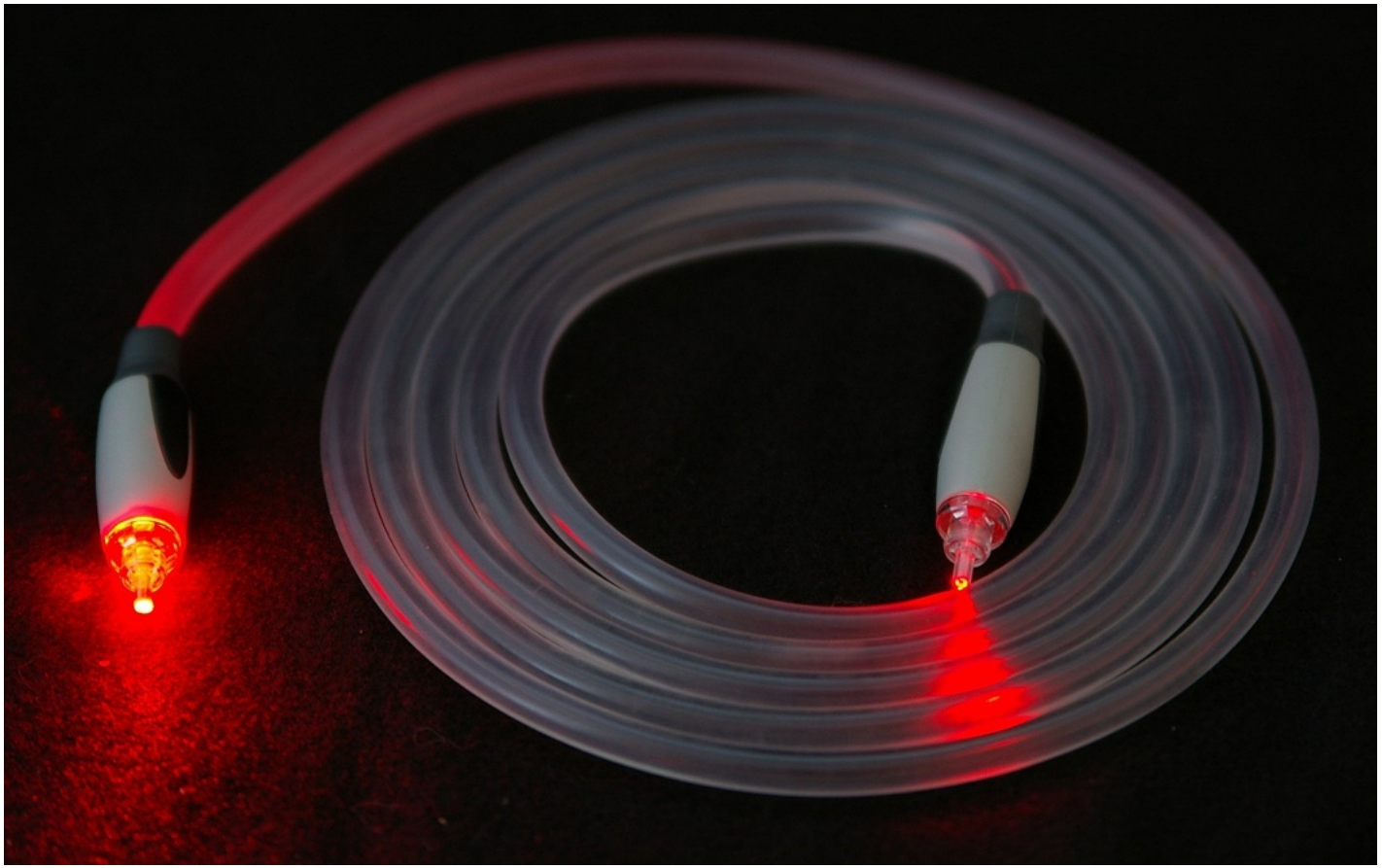
October 6, 2025

https://spqrlab1.github.io/emsec/




Review: Everything is Microphonic

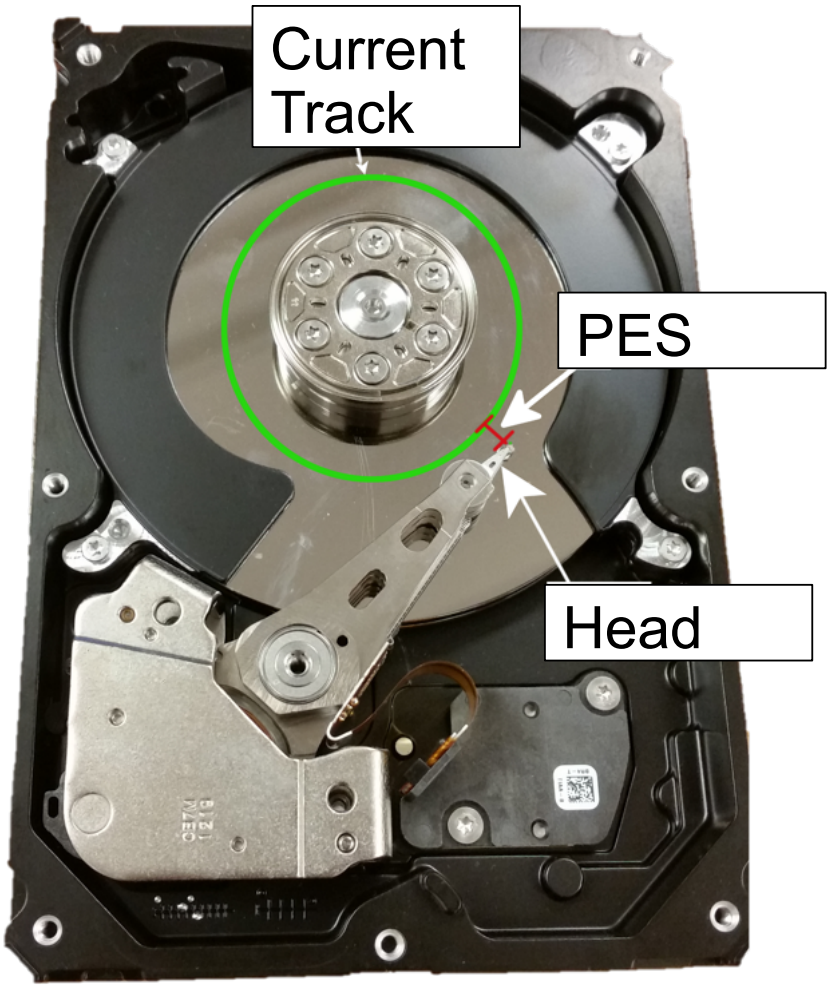


The first fiber-optic acoustic sensors published in 1977 [Cole et al. and Bucaro et al.]

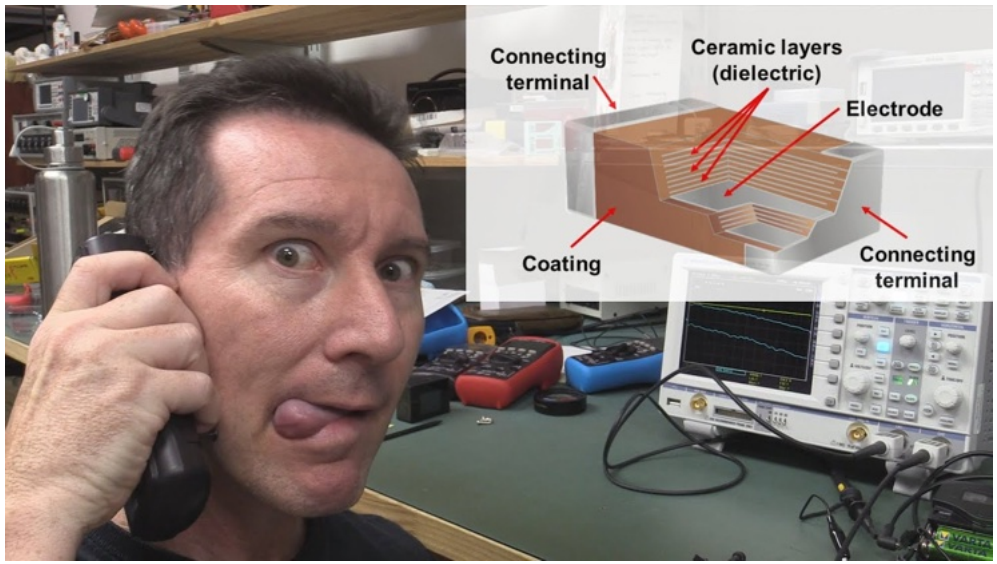
https://en.wikipedia.org/wiki/Fiber-optic_cable

HDD as a microphone

- Head stack assembly actuates the read/write head as the disk spins beneath it
  - Head follows a track
  - can tolerate only tiny errors
- Position Error Signal(PES):
  - Head's offset from center of current track



Review: Multi-Layer Ceramic Capacitors



https://www.youtube.com/watch?v=RqEy8QekLDw

https://www.youtube.com/watch?v=F2gX-R1k7MM

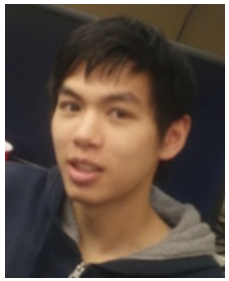
Today's Learning Goals

- Learning how audible sound can interfere with sensors
- Discuss group project

Blue N💩te:

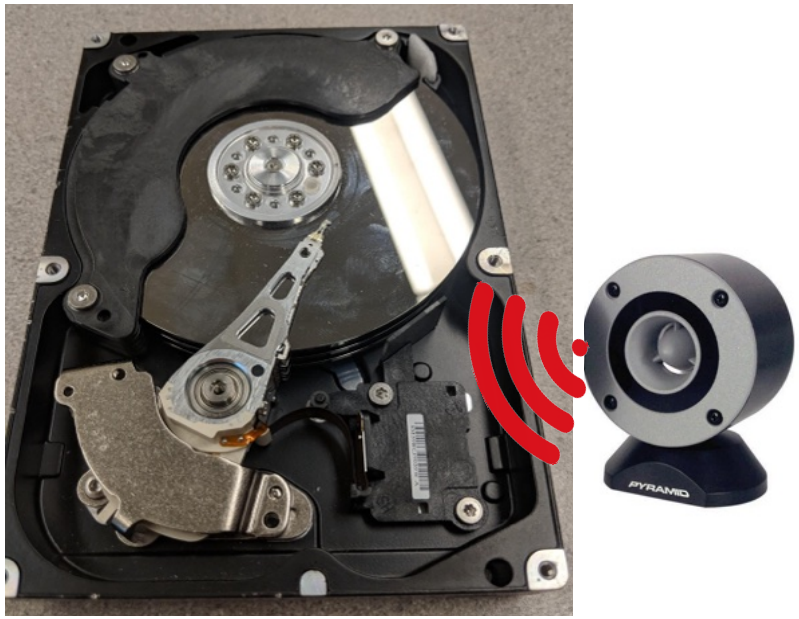
How Intentional Acoustic Interference Damages Availability and Integrity in Hard Disk Drives & Operating Systems [Oakland '18]



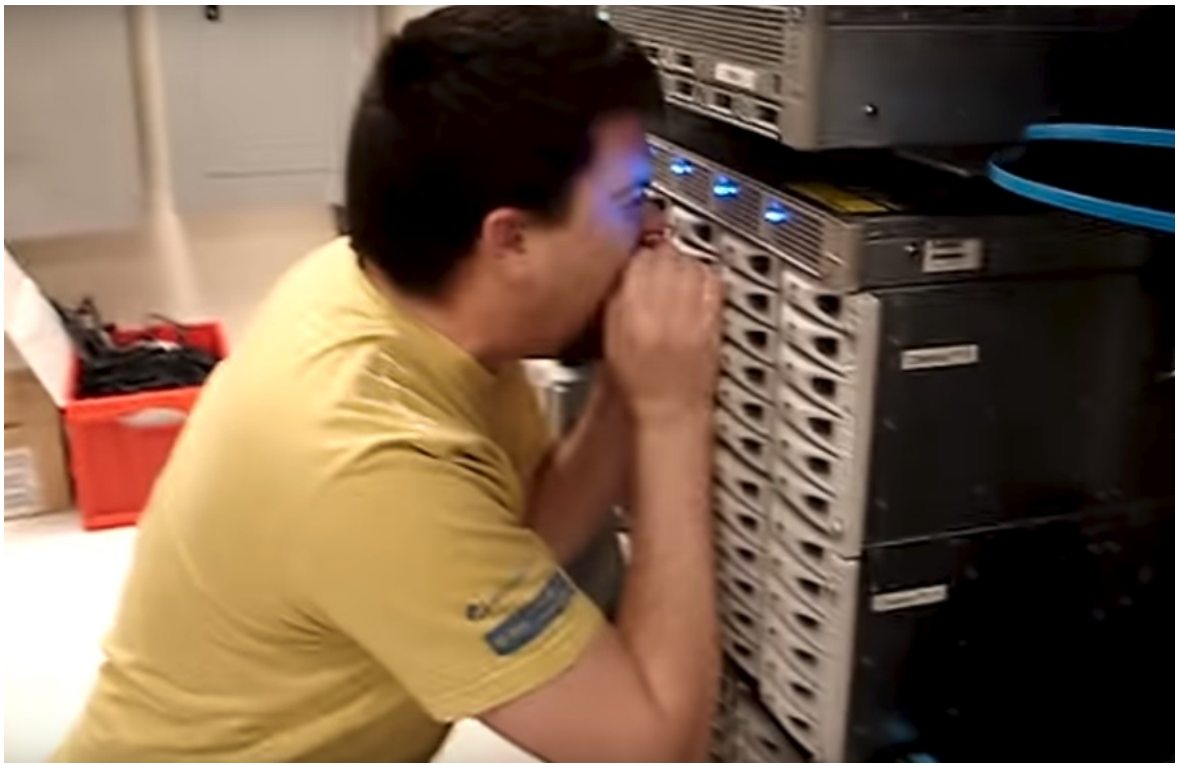
University of Michigan

Zhejiang University



Connor Bolton, Sara Rampazzi, Chaohao Li, Andrew Kwong, Wenyuan Xu, Kevin Fu

Sound Affecting HDDs?



https://www.youtube.com/watch?v=tDacjrSCeq4
Dec 31, 2008

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https://motherboard.vice.com/en_us/article/8q8dqg/a-loud-sound-just-shut-down-a-banks-data-center-for-10-hours

A Loud Sound Just Shut Down a Bank's Data Center for 10 Hours

Dozens of hard drives were knocked down during a fire drill that involved inert gas deployment.

SHARE TWEET

Andrada Fiscutean
Sep 11 2016, 2:00pm

Threat Model

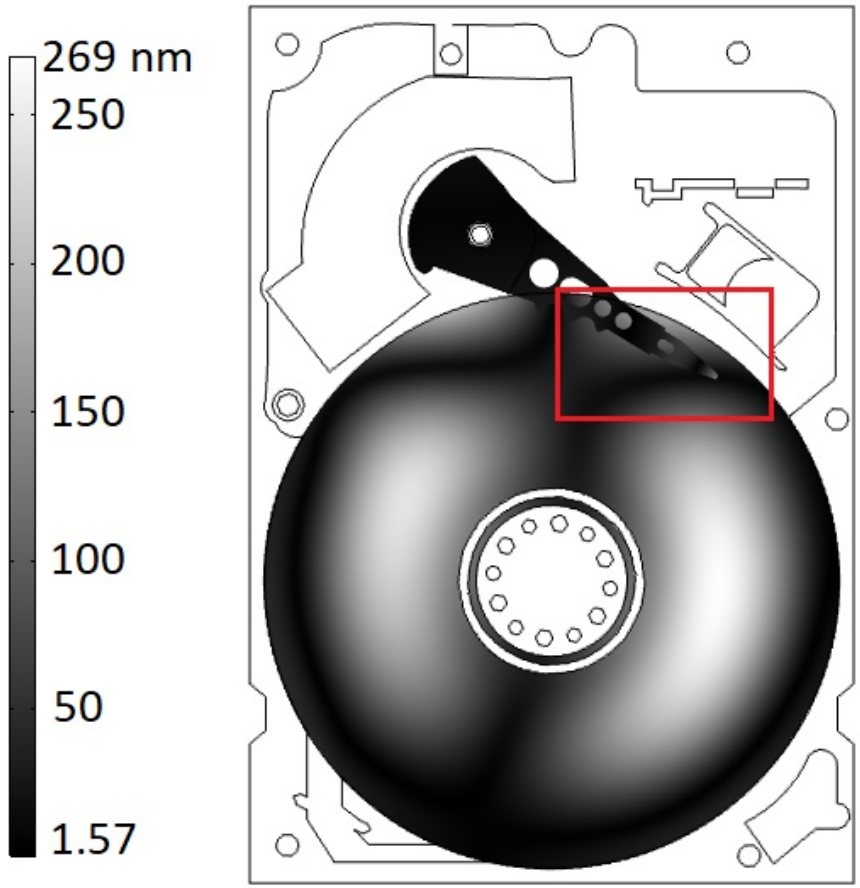
Placed Speaker

Ultrasonic transducer: https://www.vellemanstore.com/en/velleman-ma40a5r-40khz-ultrasonic-sensor-transducer-receiver

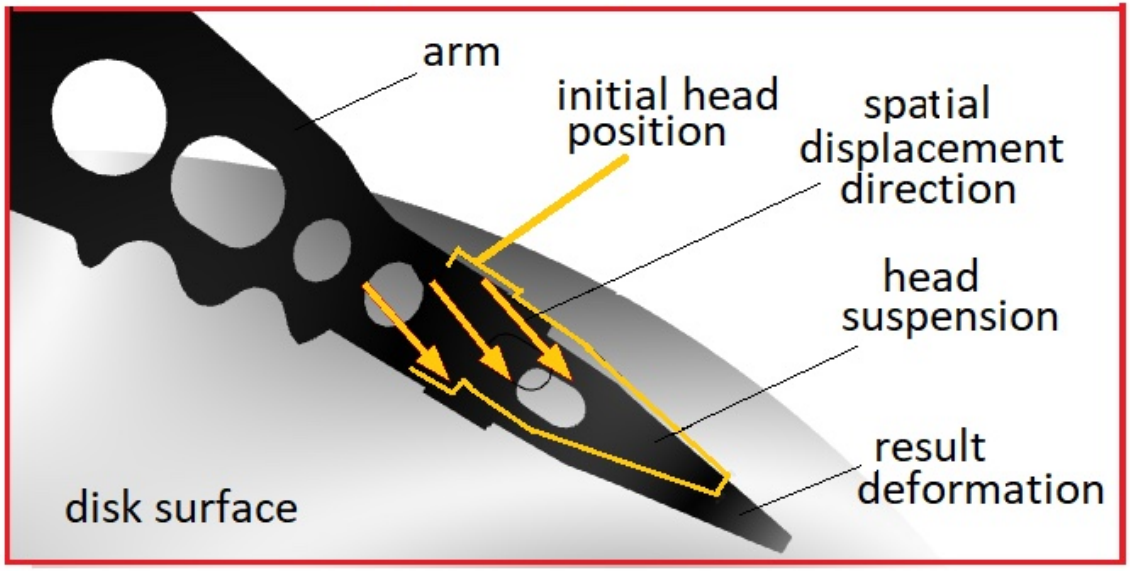
Audible Frequencies:

Vibrating the head and disk platters

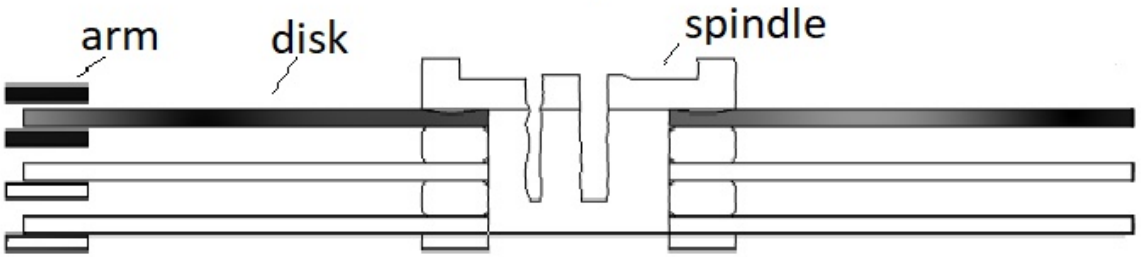
Total displacement



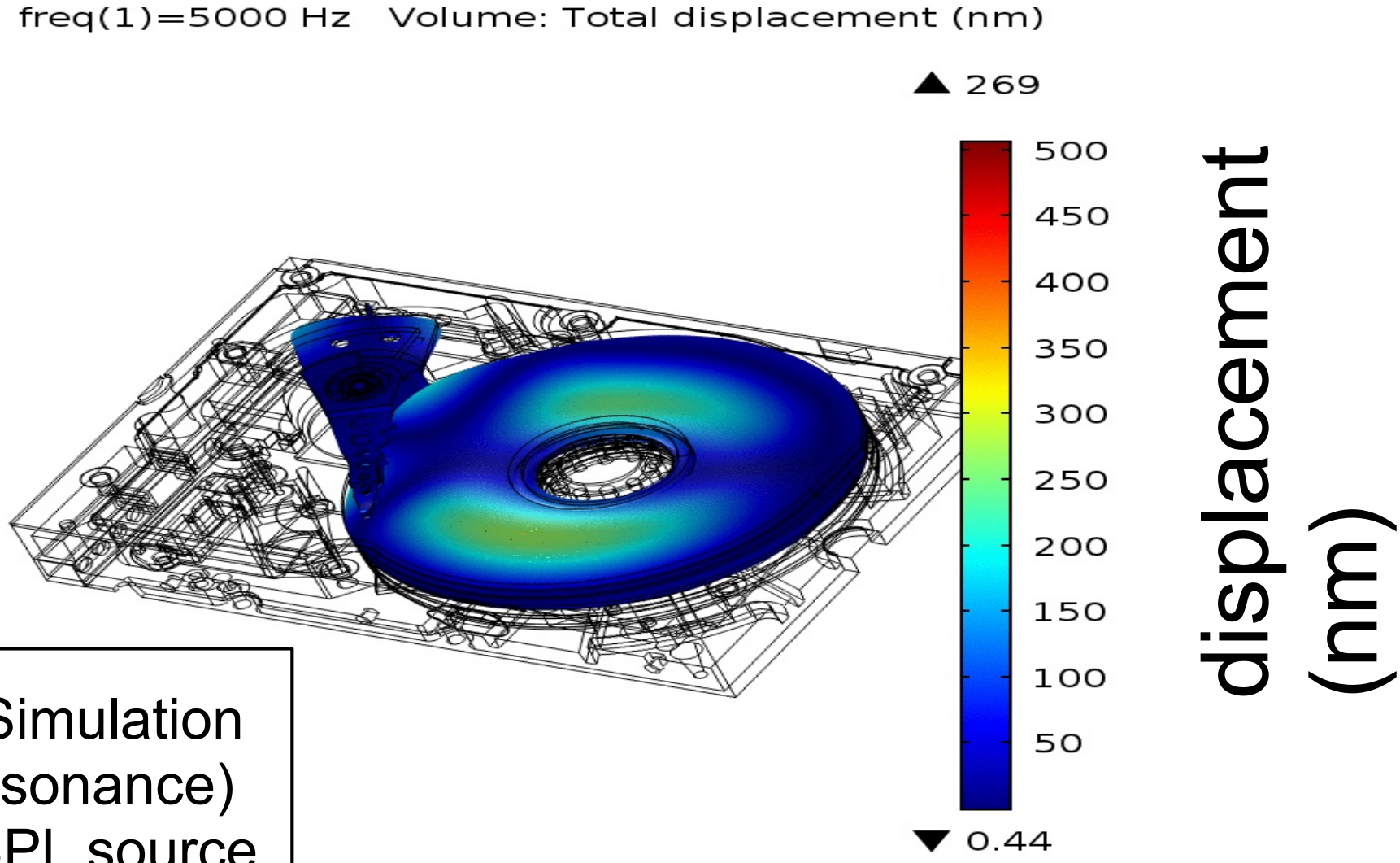
Head and arm spatial displacement



Disk and arm vertical displacement

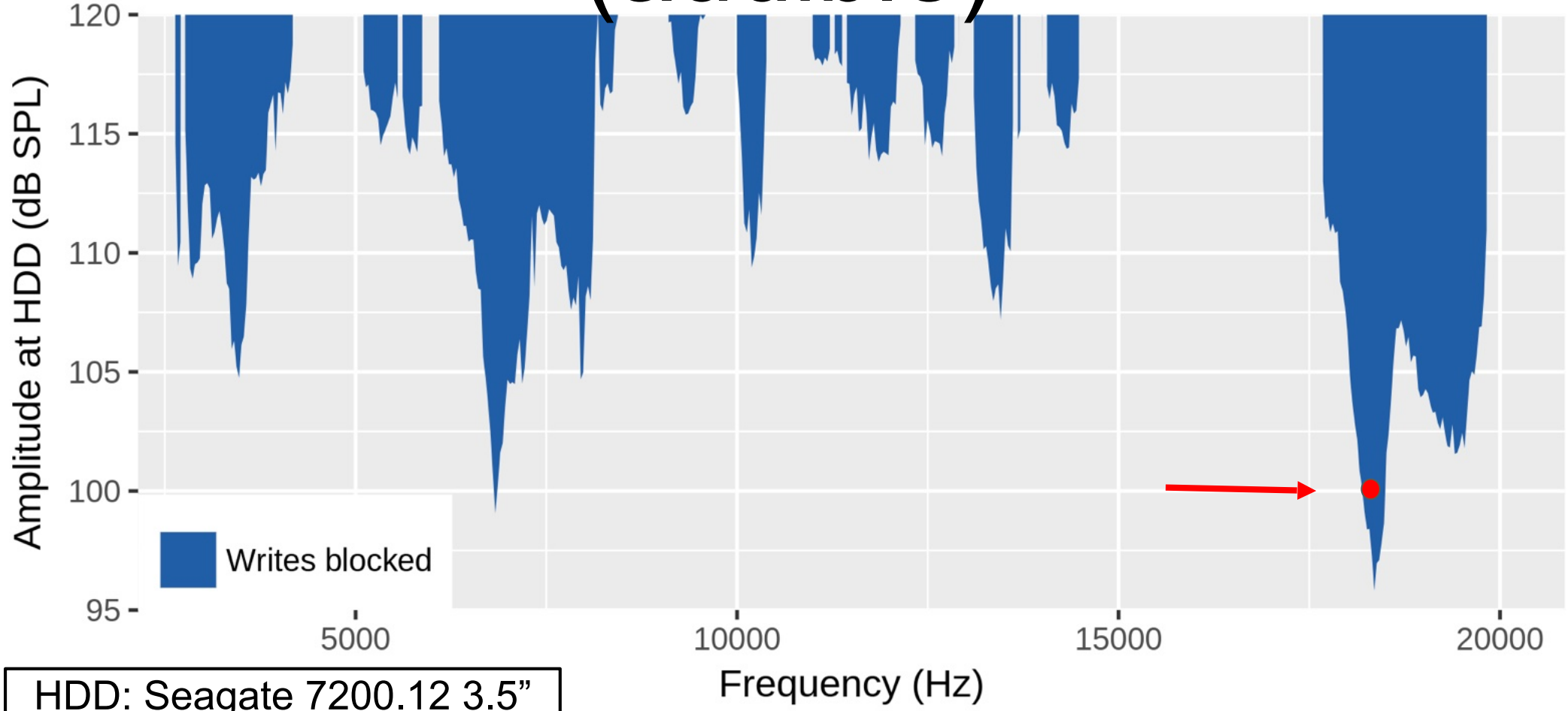


Sound distorts the HDD



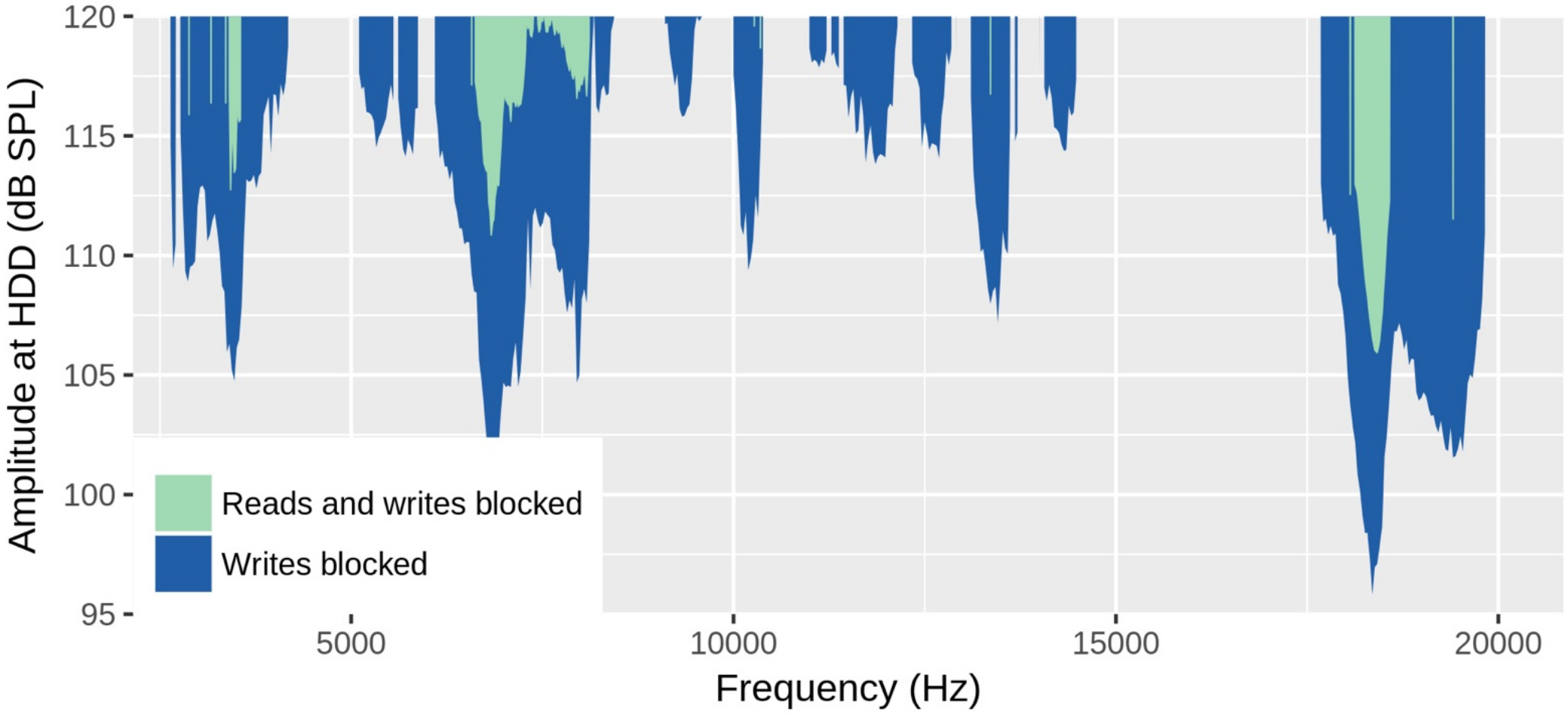
Comsol Simulation
5 kHz (resonance)
120 dB SPL source
70 dB SPL at disk

Resonant Frequencies (audible)



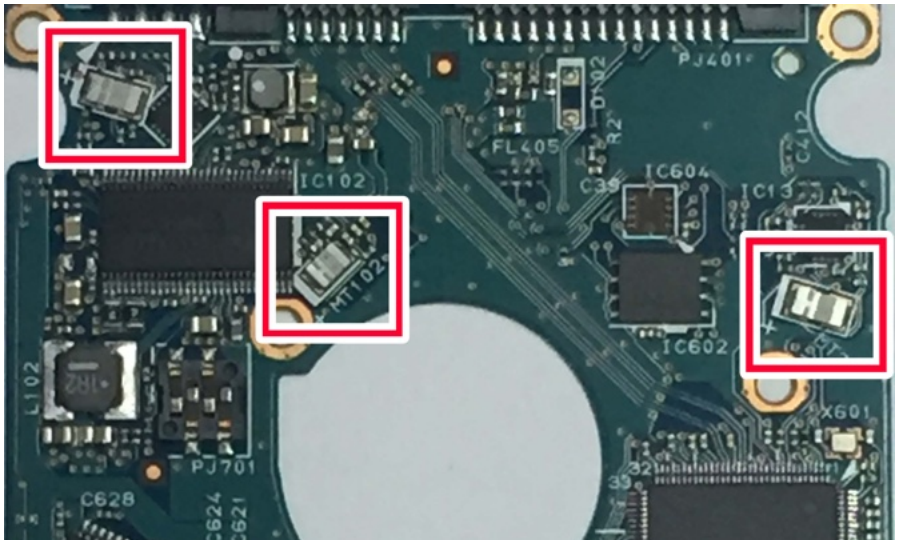
HDD: Seagate 7200.12 3.5”

Writes vs. Reads (audible)

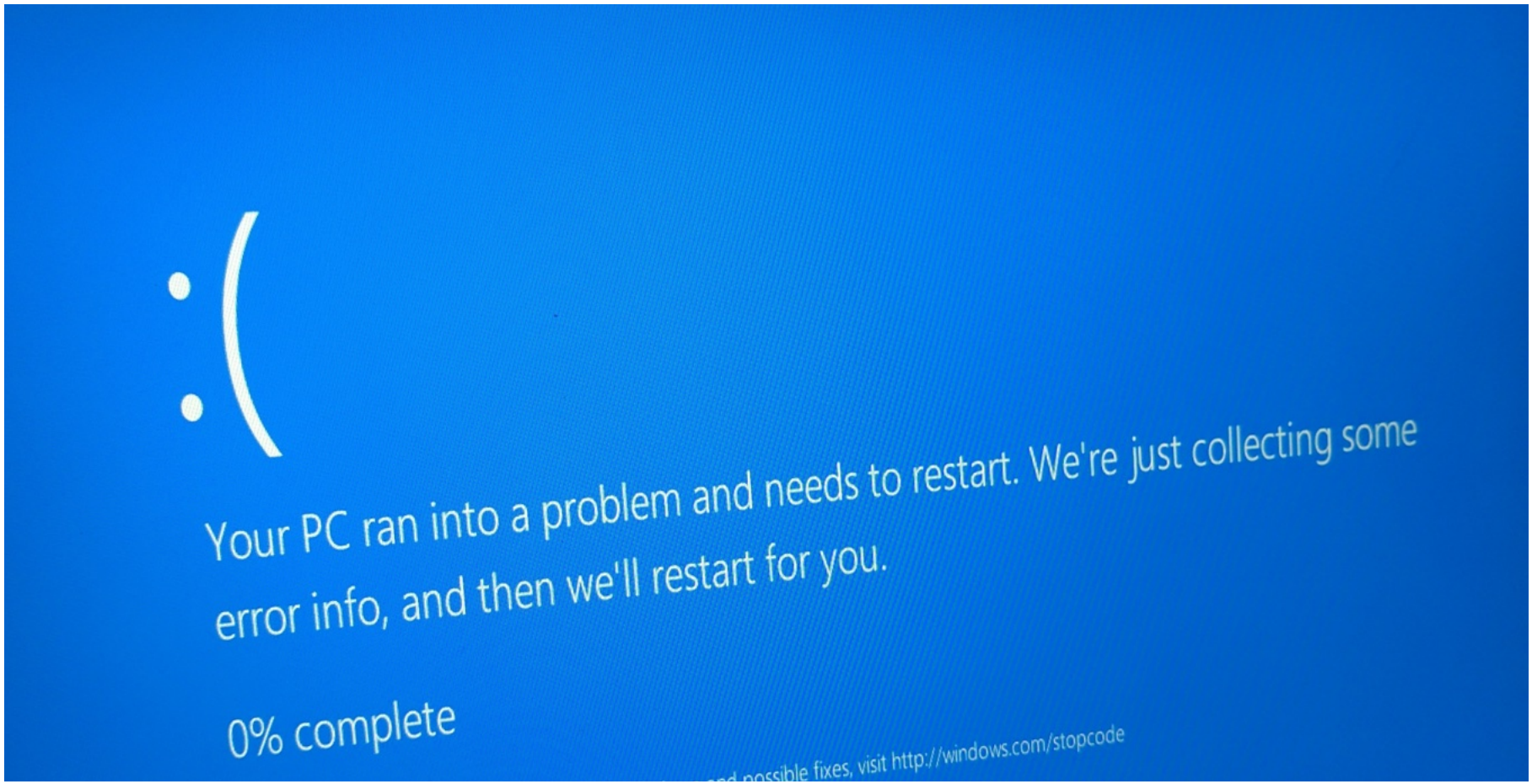


HDD: Seagate 7200.12 3.5”

Ultrasonic Frequencies:
Shock Sensor Spoofing



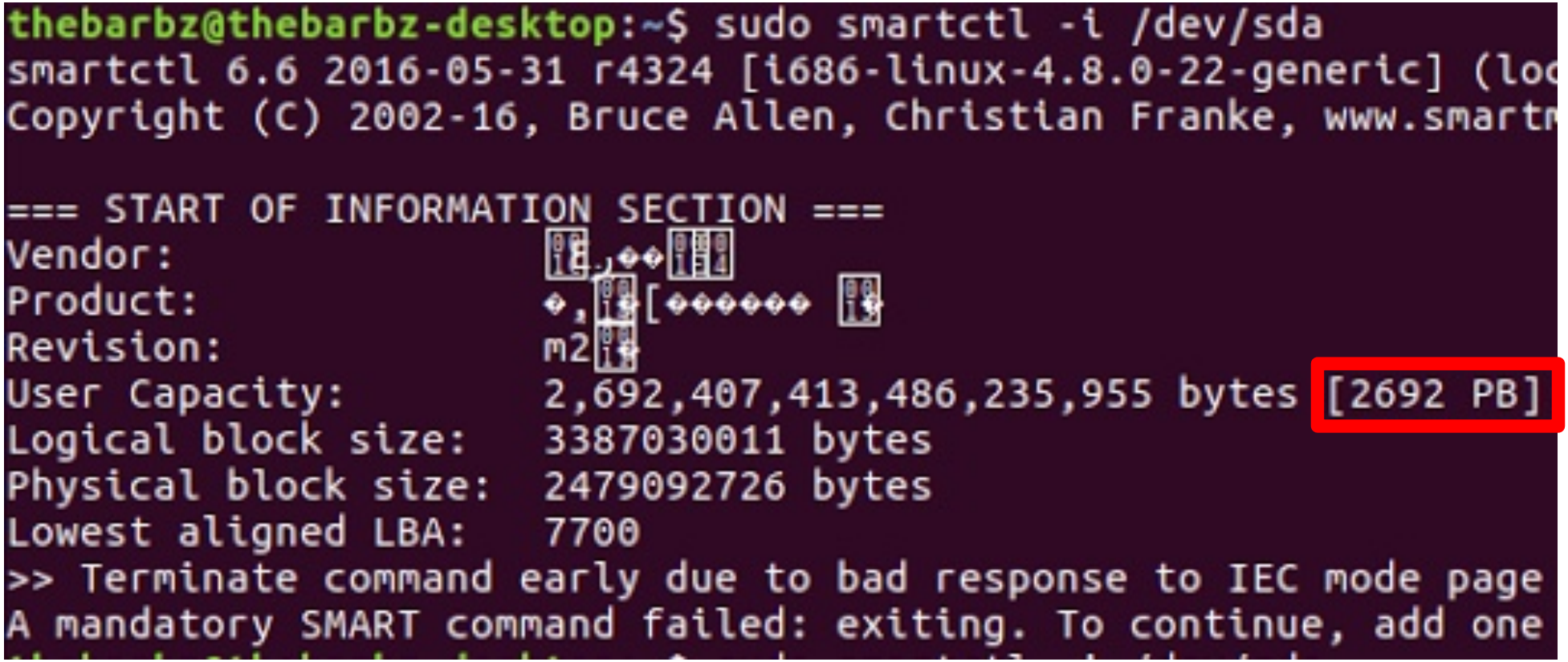
System Consequences



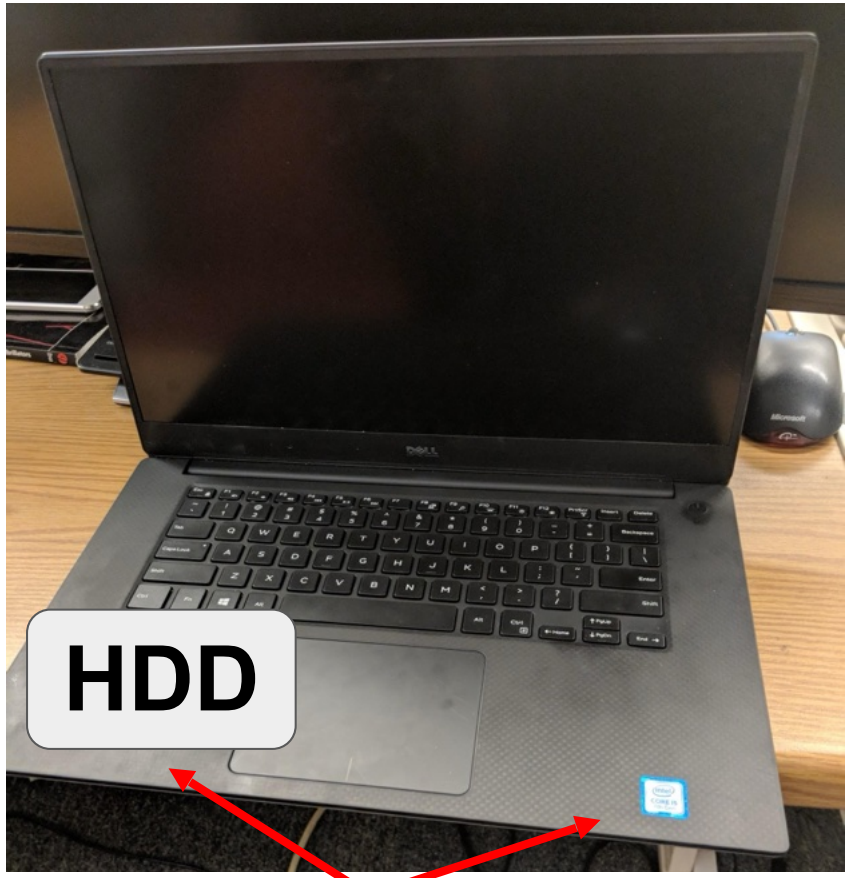
Disabling Video Surveillance DVR

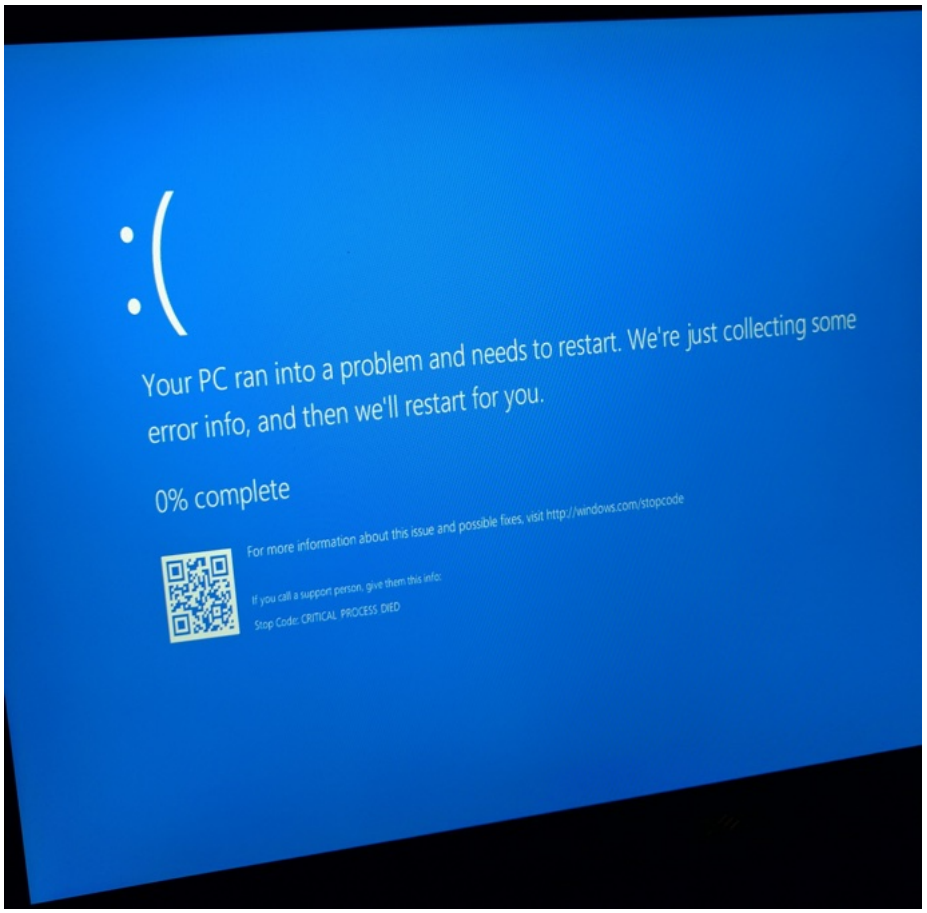
Surveillance:
Pics or It Didn't Happen

Communication Errors & Corruption



Built-In Speaker: Crash Windows 10





Defenses:
Passive Noise Canceling

Shortcomings of Passive Noise Canceling

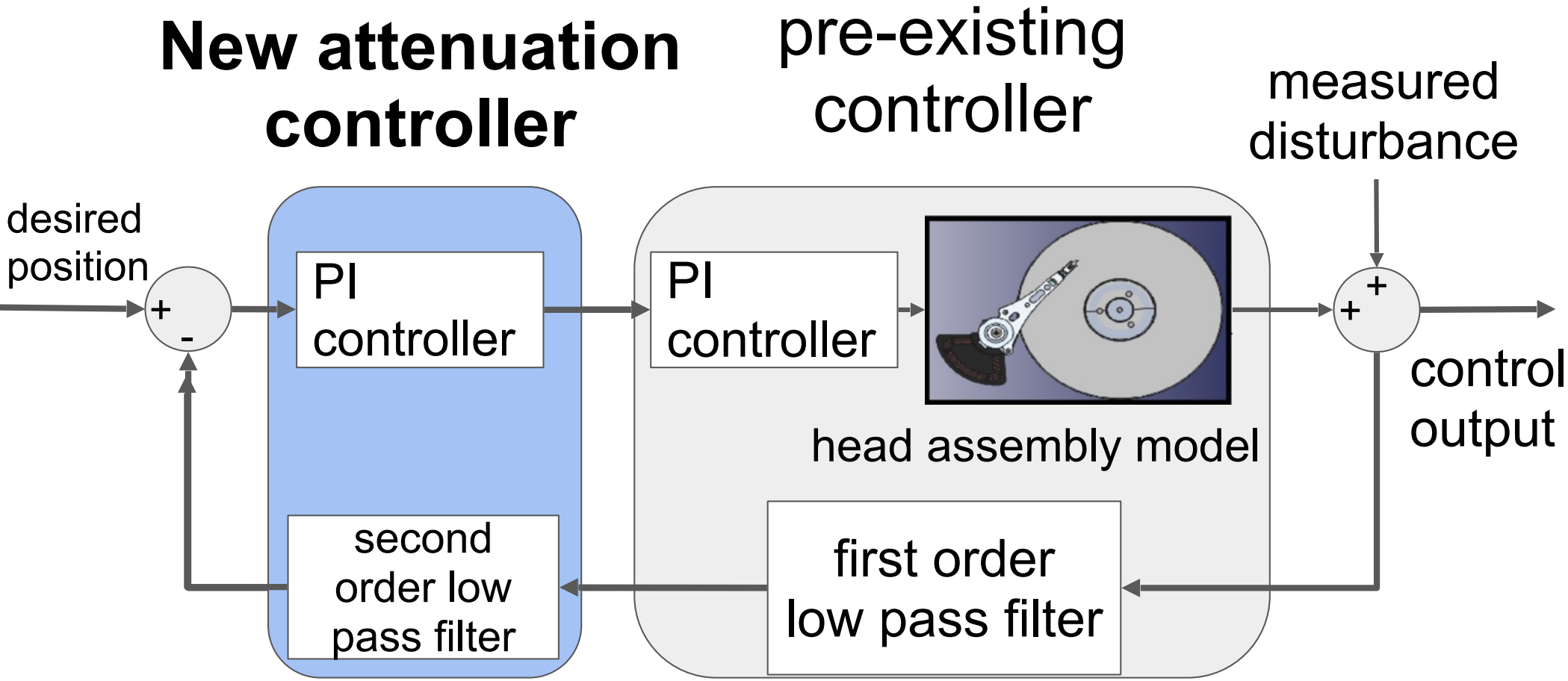
- Low frequencies "bend" around foam
- Foam traps heat!

Defenses: Attenuation Controller

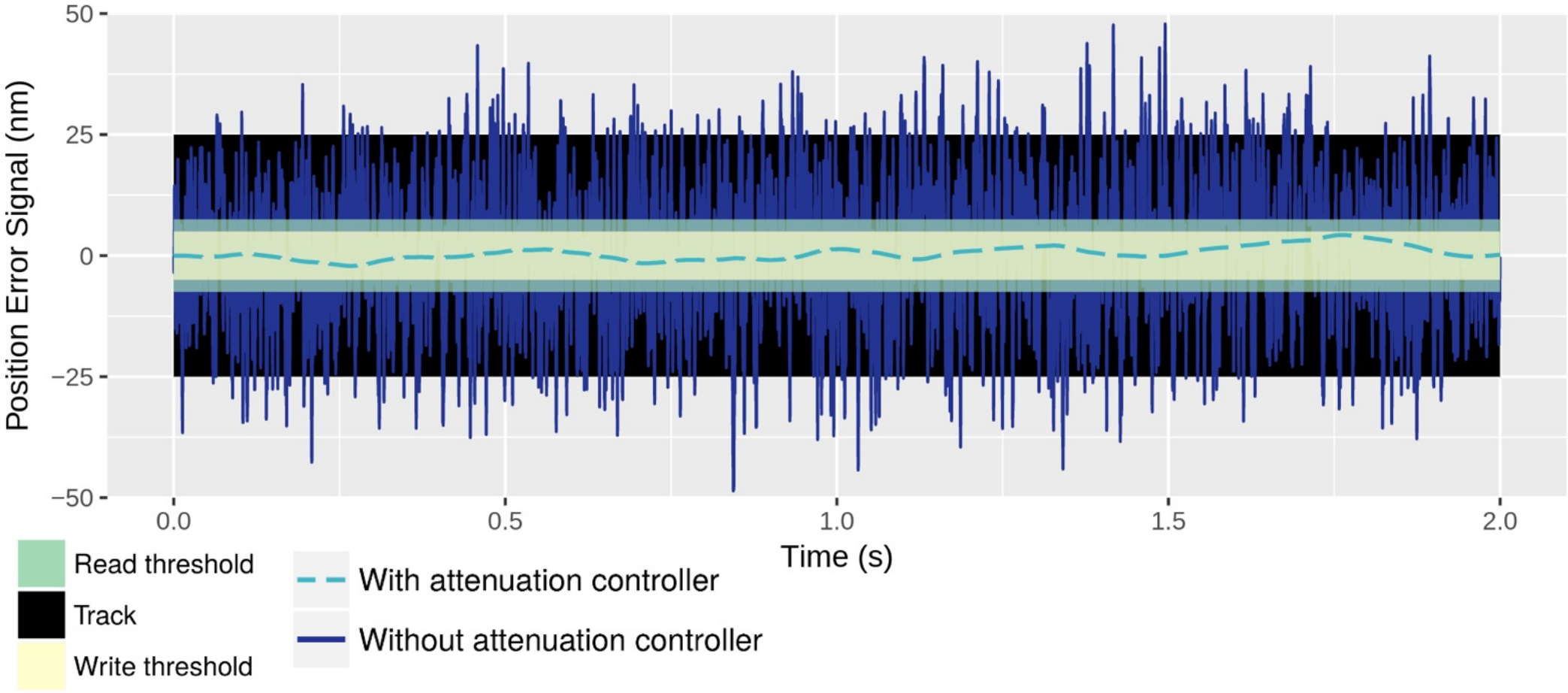
Plate Spinning Disaster at the Acrobat Show

Credit: https://www.youtube.com/watch?reload=9&v=tzkLq2cgXL8

Feedback Controller: Adding Resilience



Attenuation Controller Effectiveness



HDD model based off Seagate 7200.12 3.5”

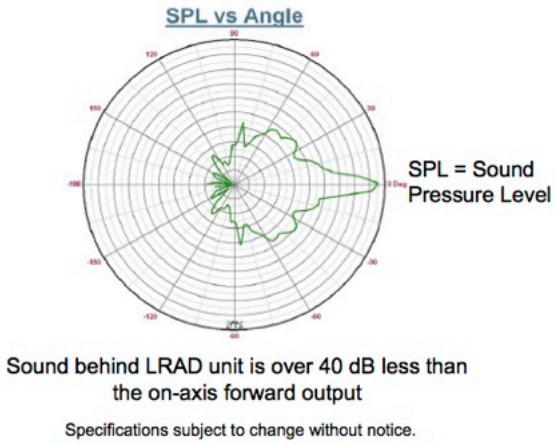
Problem: Distance a Red Herring

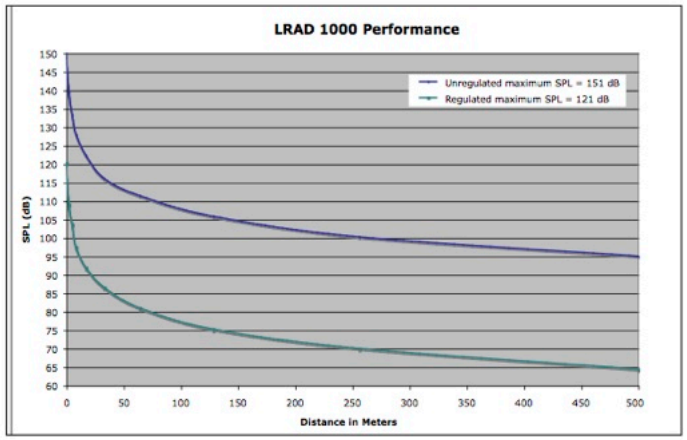
2km range

151 dB SPL at close range

100 dB SPL at 300 meters

Airbags, traction control, O2 sensor...





LRADs

LRADs

Summary

- How sound causes HDD DoS
  - Audible: Vibrate head and disks
  - Ultrasonic: Shock sensor spoofing
- Risks: OS crash & undef behavior
  - Built-in speakers & autoplay
  - Covert ultrasonic transducers
- HDD firmware update to protect against vibration of R/W head

Blue poop credit: https://weheartit.com/entry/204114571
Speaker credit: https://www.newegg.com/Product/Product.aspx?Item=0J9-0005-00061

Northeastern University
EECE 5698 Fall 2025
Design Project:
Protecting the Security of Voice-Controlled Systems from Laser Injection Attacks

Instructor: Prof. Kevin Fu
TAs: Hui Zhuang, Nuntipat Narkthong
Last updated: 10/02/2025, 3 PM

Project Title Deadline: **During lecture on Thu, Oct 9**
Oral Proposal Deadline: **During lecture on Mon, Oct 20**
Written Proposal Deadline: **Thu, Oct 30 11:45 AM**
Milestone Presentation Deadline: **During lecture on Thu, Nov 20**
Project Demo: **In open lab hours Nov 24 - 28.** Timeslot will be posted later.
Tournament Deadline: **During the lecture on Thu, Dec 4**
Final Report Deadline: **Mon, Dec 8 11:45 AM**

Homework and Next

- Homework
  - ✓ Lab #2: Done.
  - ➡ Design Project: Title due Thursday, October 9
  - ➡ Pre-lab #3: Due Thursday, October 16
  - ➡ Oral presentations of proposals in class Monday, October 20
- Next
  - Thursday: Oleg Yusim joins us from from Illumina on Cryptography and TPMs
  - Monday: Holiday; Thursday: Lab #3 time in class