What is ENF?

- **Electric Network Frequency** – nominally 60Hz in North America and 50Hz mostly elsewhere.
- ENF can be captured by audio/video recordings, due to electromagnetic influences.
- ENF fluctuates around nominal value due load changes in the grid.
- Changing instantaneous ENF values over time form the ENF signal.

ENF for Multimedia Synchronization

- ENF embedded in video signals is aliased due to low frame rate of cameras (ranges between 24-60fps).
  - Overcome aliasing problem for CMOS imaging sensors by exploiting **rolling shutter**, where lines are read in sequentially as opposed to all at once as with **global shutter**.

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Temporal Alignment of Historical Recordings

- Two ENFs can appear in digitized historical recordings:
  - ENF from initial recording time and
  - ENF at digitization time.
- Envision to assemble a historical ENF database to help timestamp old recordings of interest.

Speed Restoration of Digitized Audio

- Speed offset may occur in digitized audio recordings.
  - Due to inconsistency of tape rolling speed in analog devices.
  - Lead to severe perceptual distortions of the audio.
- ENF signal serves as a reference for speed restoration

Example of rolling shutter effect from Wikipedia.

Frame 1
Frame N
Concatenate Row Averages Frame After Frame
Row Illumination Variation Signal

Before Restoration
After Restoration

Digitized Apollo 11 Recording

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URL: www.mast.umd.edu/index.php/enf-menu