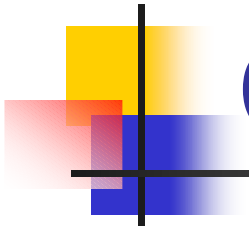
Digital Reconstruction of Analog NTSC Video

Eric Bradley

December 10, 2007



Objectives

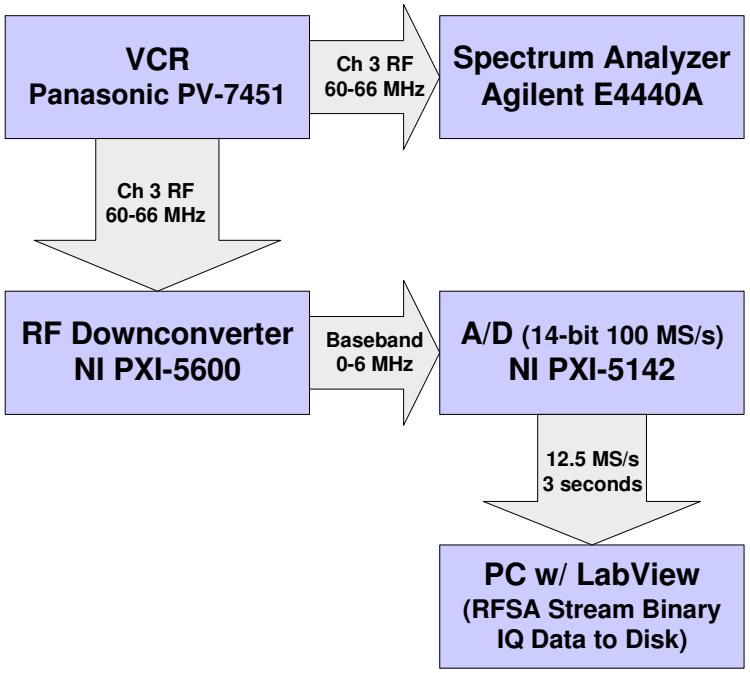
- Obtain RF Sampled NTSC Data
- Analyze the Data / Spectrum
- Reconstruct Audio and Luminance Data
- Compare to Original Data
- Analyze Color Signal

Data Capture

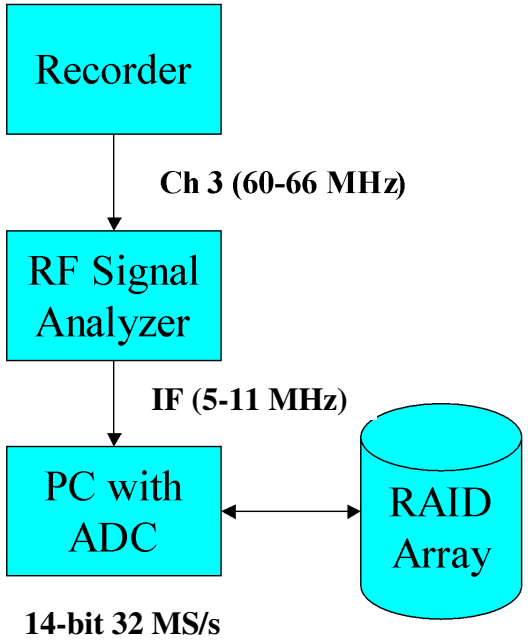
- 2 Independent Sources

	Data Collector	Sample Rate	Frequency Band	Video Content	Clip Length	Source Video Available	Relative Signal Quality
Dataset 1	Eric Bradley	12.5 MS/s	0-6 MHz	Aspen Ski Promo	2 seconds & 3 seconds	Yes	Good
Dataset 2	Dr. Nicholas Beser	32 MS/s	5-11 MHz	Al Jazeera Newscast	60 seconds	No	Poor

Data Collection Systems

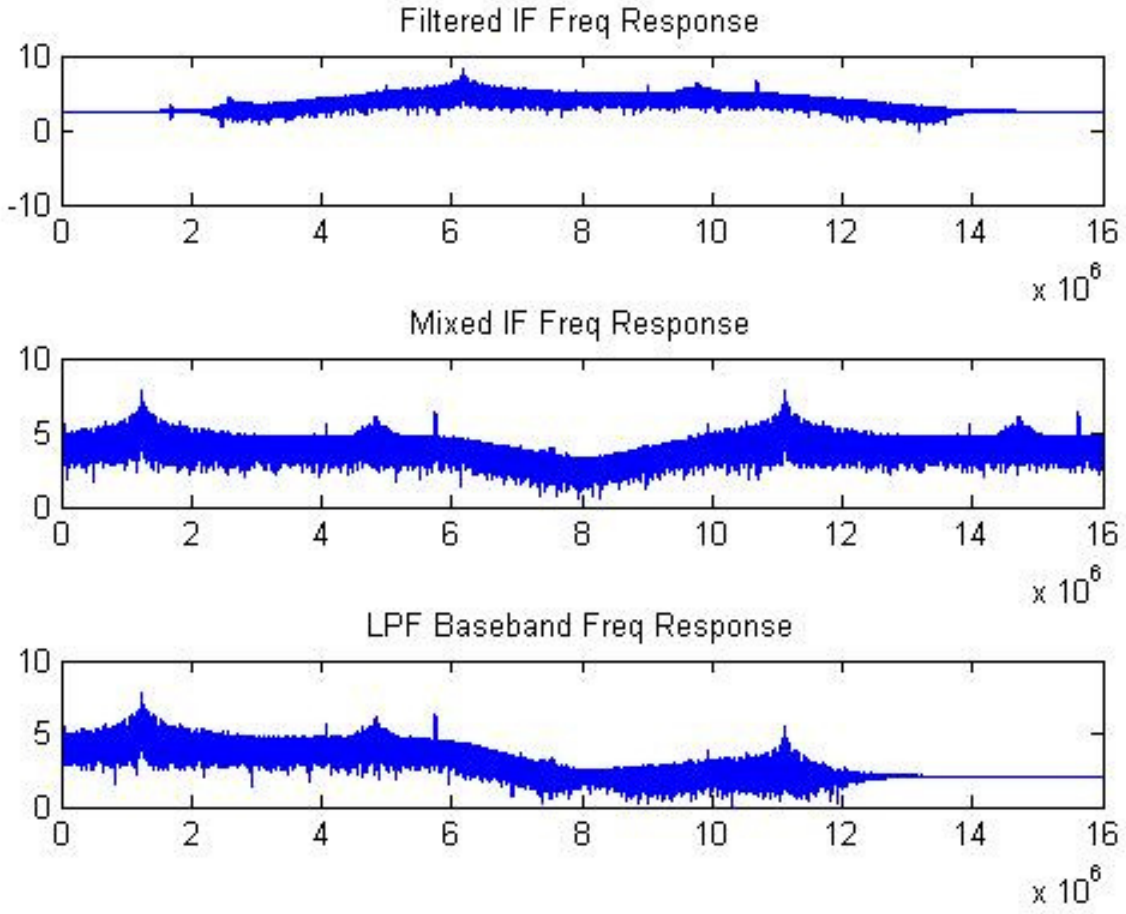


Dataset 1

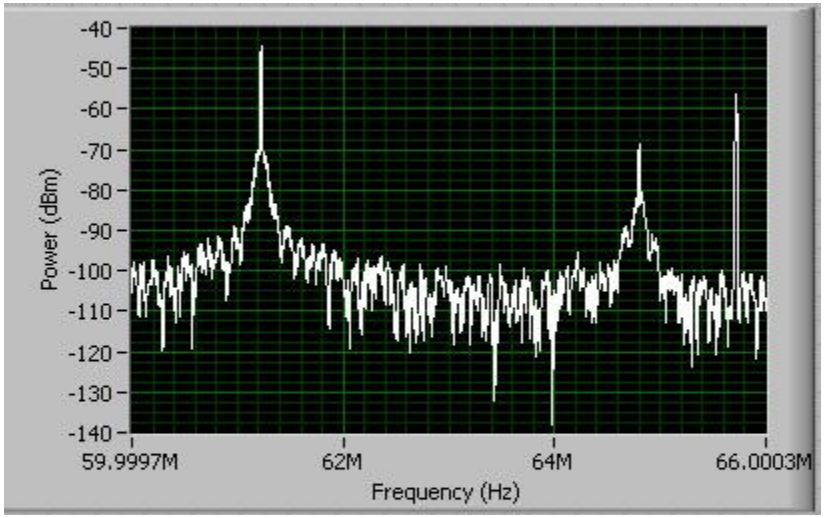


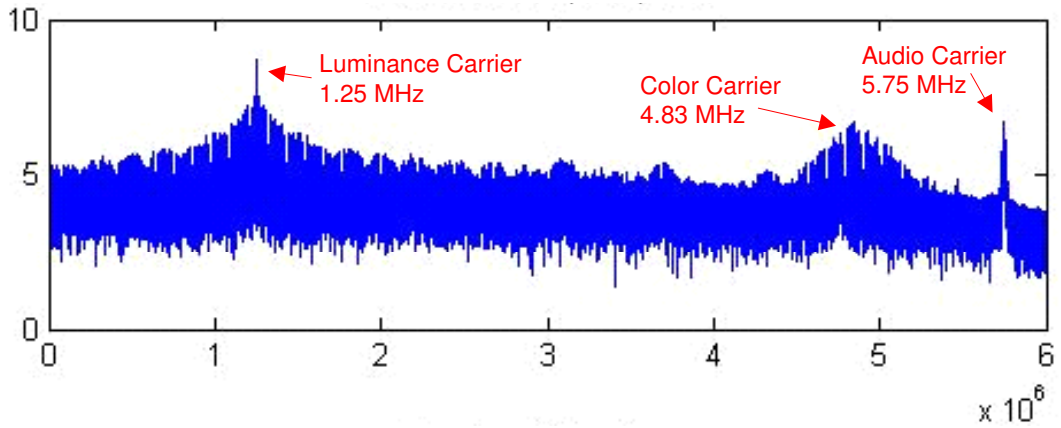
Dataset 2

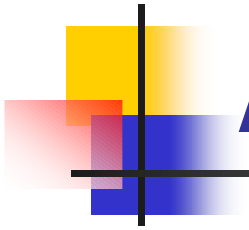
IF Filter and Downconvert



RF and Baseband Frequency Response



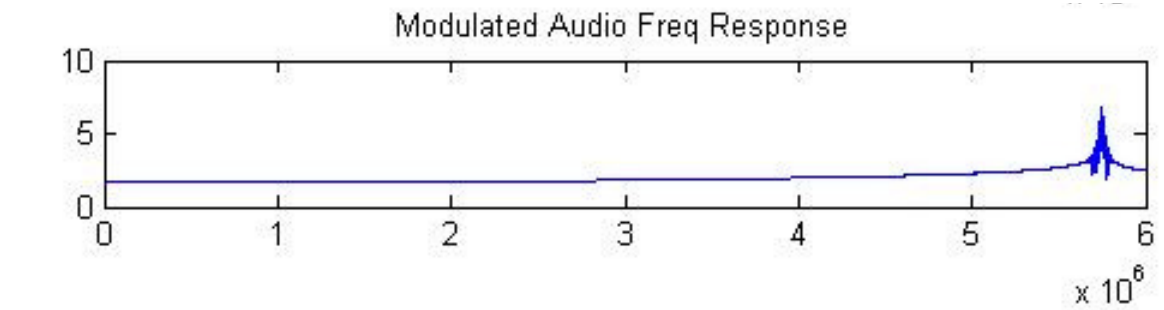


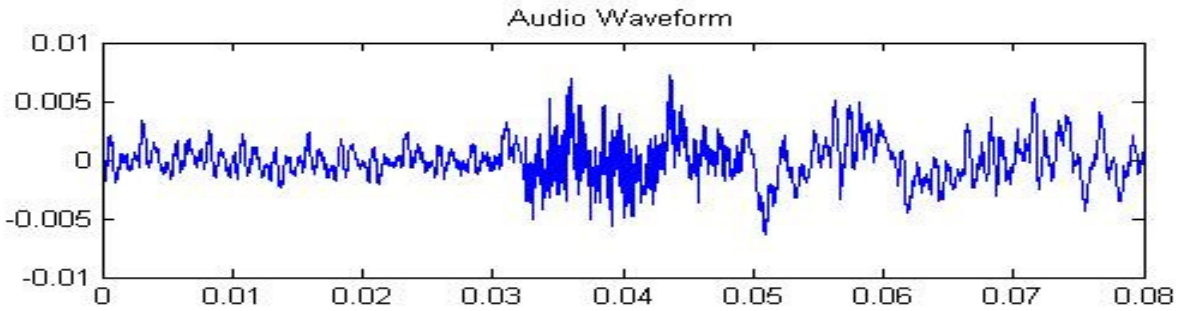


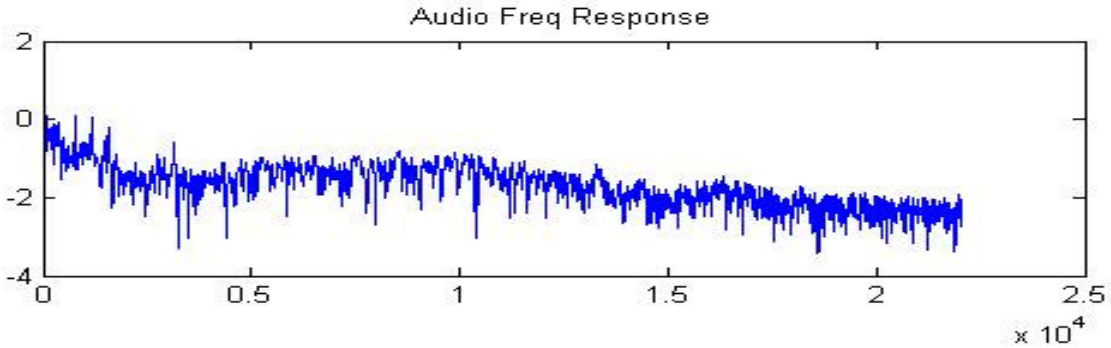
Audio Reconstruction

- FM Demodulation @ 4.5 MHz (above luminance)
- BPF +/- 15 KHz surrounding audio center
- Downsample to 44.1 KHz

Audio Reconstruction







Dataset 1

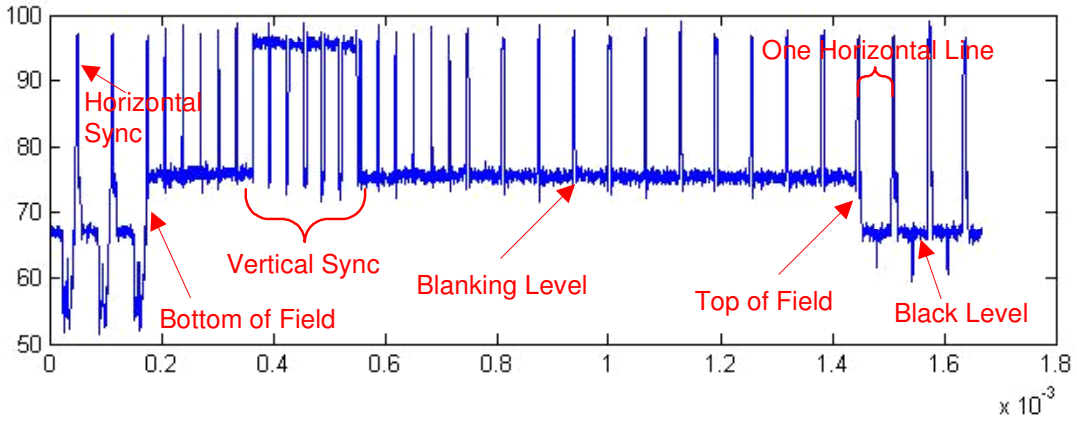
Dataset 2

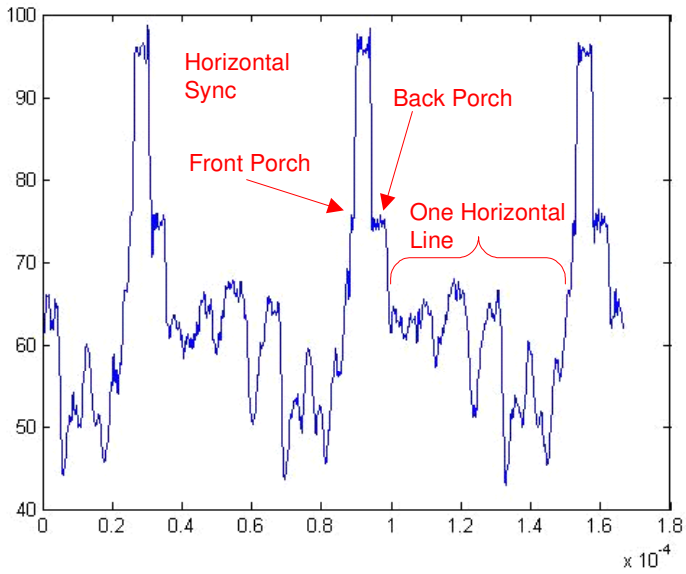
Luminance Reconstruction

- VSB Demodulation @ 1.25 MHz
- LPF to 4.2 MHz
  - Comb or Trap Filter would be better to remove Color Harmonics
- Normalize to 0-100

Luminance Reconstruction

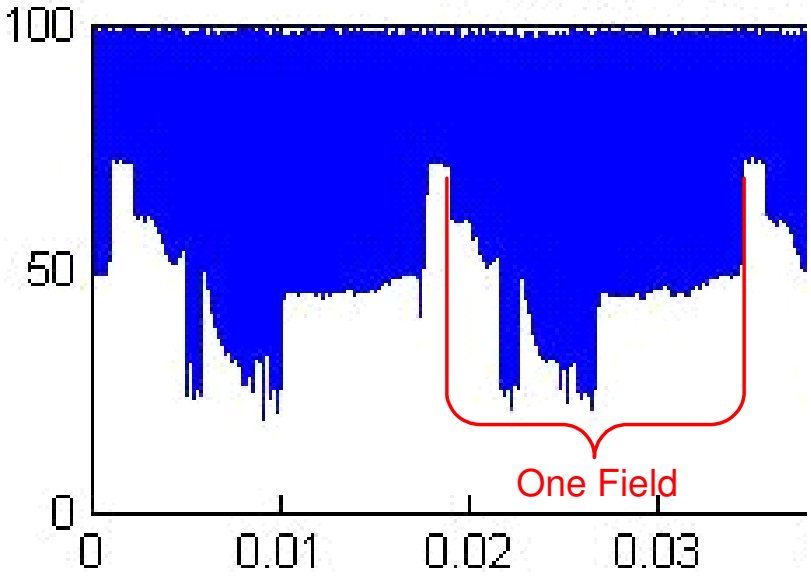
- Field Rate: 59.94 Hz
- 262.5 lines per field
- 700 pixels per line
- 2 fields per frame



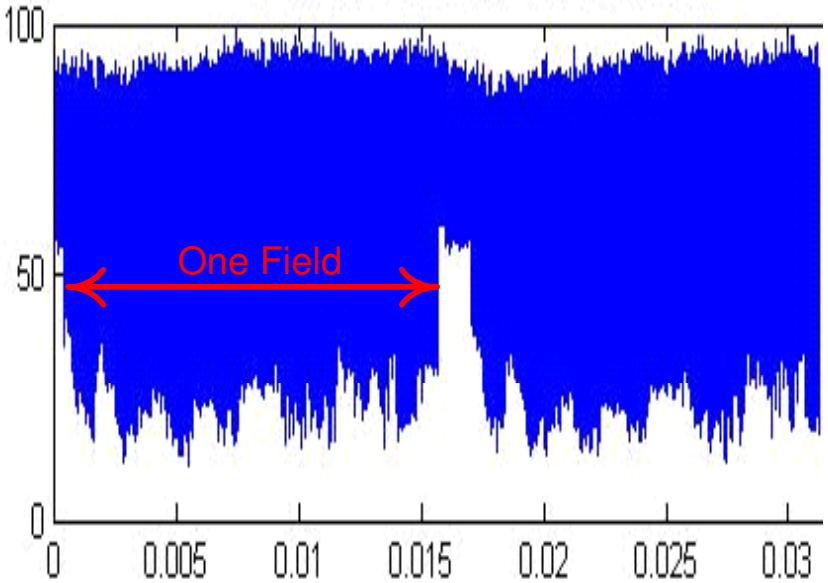


Vertical Sync Pulses

- Algorithm not tolerant to significant noise



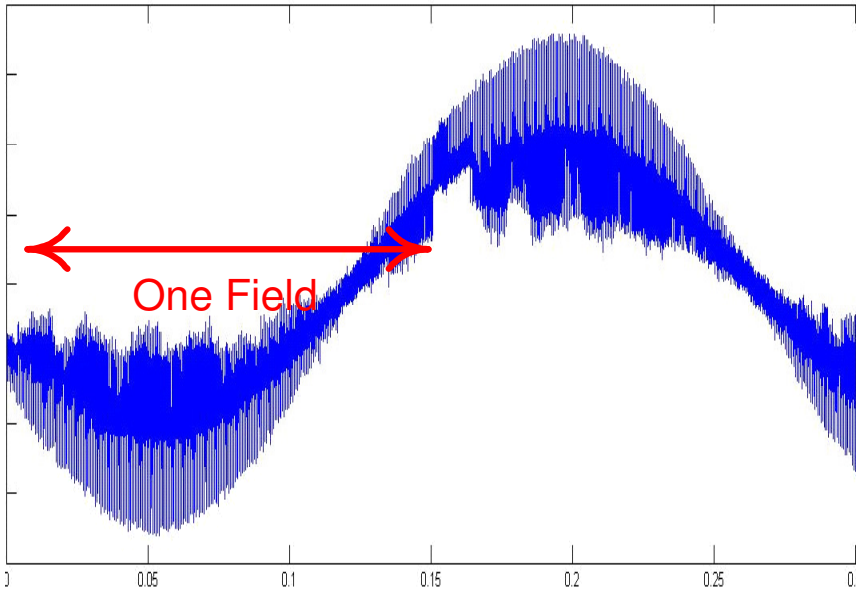
Dataset 1



Dataset 2

Variable Luminance Carrier Frequency in Dataset 2

- Demodulation with frequency slightly wrong (10s of Hz) results in unreadable signal



Luminance Reconstruction Results Dataset 1

Original
(captured with commercial frame capture hardware)

Reconstruction

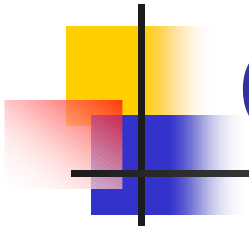
Luminance Reconstruction Results Dataset 1

Original
(captured with commercial frame capture hardware)

Reconstruction

Luminance Reconstruction Results Dataset 2

Example Frame
(not typical)

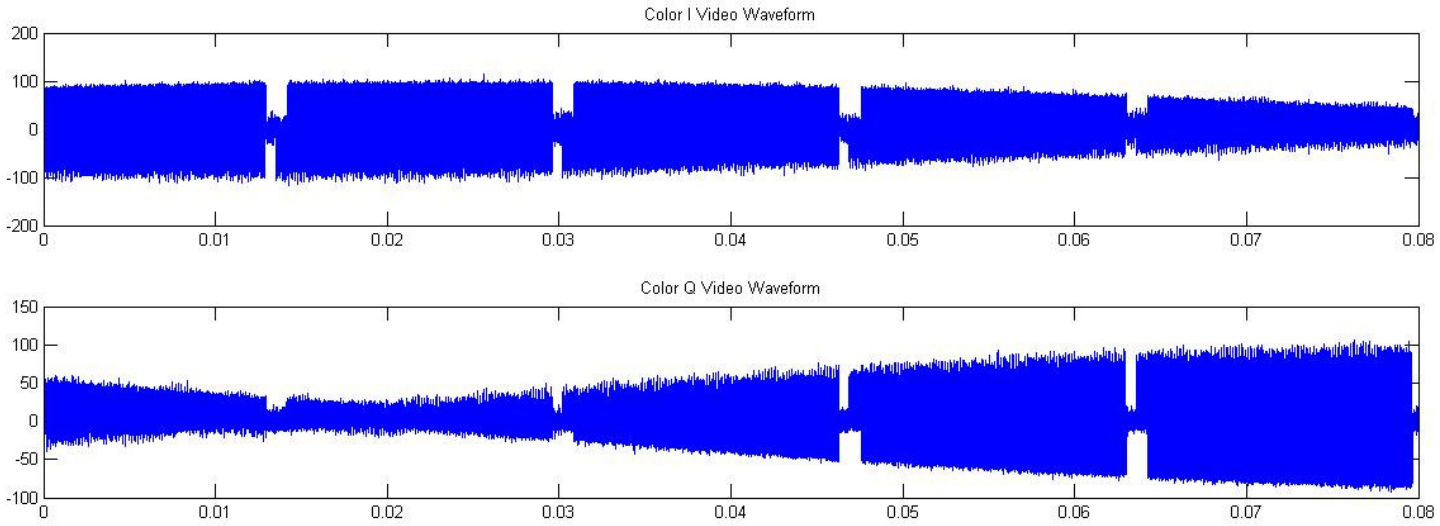


Color Video Reconstruction

- Chrominance I (orange/cyan)
- Chrominance Q (green/purple)
- BPF 2.1 – 4.1 MHz
- QAM Demodulation @ 3.58 MHz
- LPF 1.5 MHz (I), 0.5 MHz (Q)
- YIQ -> RGB

Color Burst

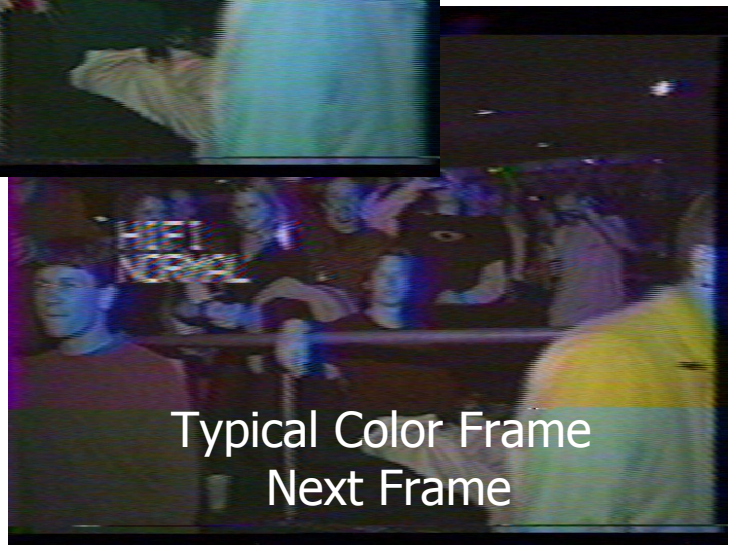
- 3.58 MHz Color Burst on Luminance to Synchronize Phase is Critical
- Not Found in Datasets - Try it Anyways!



Unsynchronized I & Q for 6 Solid Color Fields

Color Video Reconstruction

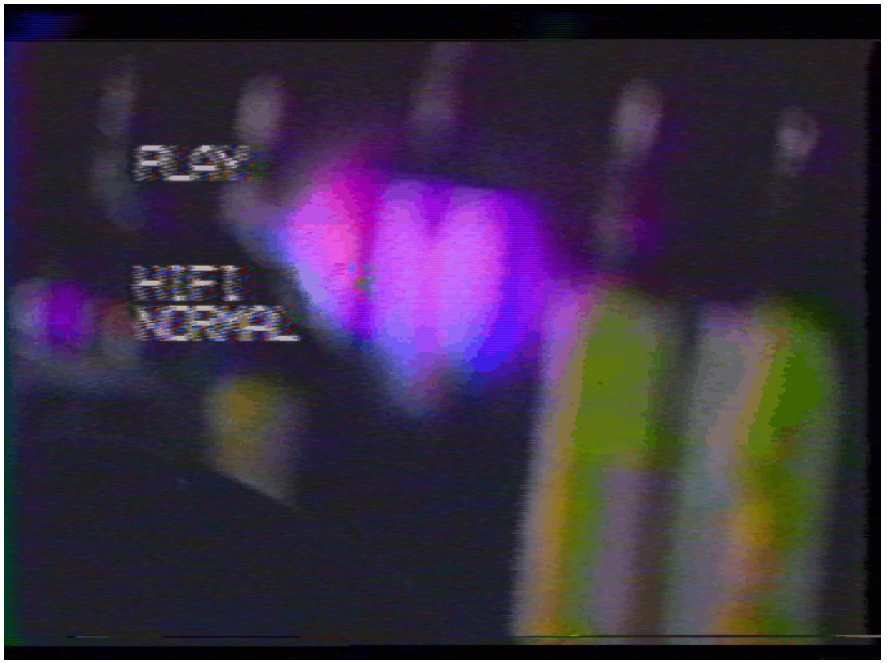
Original



Reconstruction

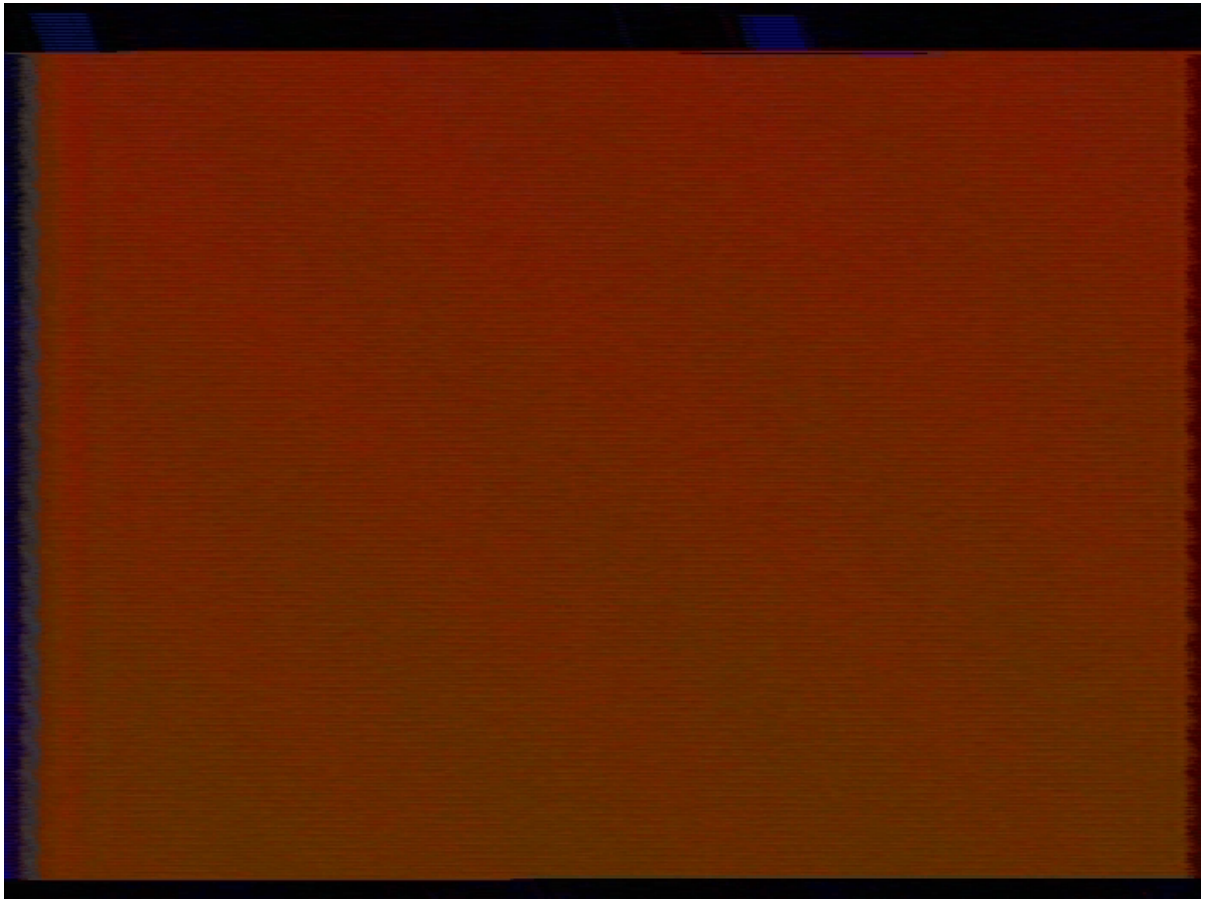
Color Video Reconstruction

Original



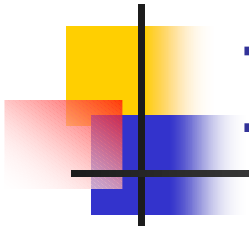
Reconstruction

Color Video Reconstruction

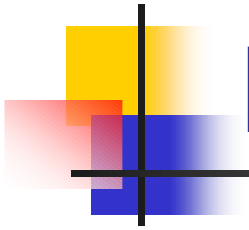


Solid Blue Background Video

Possible Algorithm Improvements

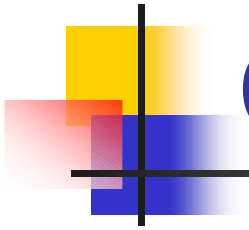


- Color Burst
- Additional Filtering – Comb or Trap
- More Robust Vertical Sync Detector and/or Normalizer
- Manually or Automatically Adjust Modulation Frequency as it Drifts for Dataset 2



Performance

- Dataset 1 – 3 seconds of audio/video
  - 60 minutes of CPU time
  - ~50 MB RAM
- Dataset 2 – 60 seconds of audio/video
  - No vertical syncs
  - 285 minutes of CPU time
  - 100s MB RAM



Conclusion

- NTSC Luminance and Audio can be Reconstructed Digitally
- Clean Data is Relatively Easy
- Noise Corrupts Syncs
- Color Synchronization is Harder
- Frequency Drift is Harder
- Questions