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Video Restoration Lab I - Fall 2011
Reformatting Project
Video A/D Comparison

Analog-to-digital Conversion

Data converters are seen as tools that bridge and translate “the world of tangible physics and the world of abstract digits.” From the early concepts of pulse code modulation to today's high level data processing, the back and forth conversion of analog signal and digital data has been utilized in a myriad of technologies, fields and applications.

During the 1970s analog to digital converters (ADC) were eventually introduced to video. In its early years video ADCs focused on digitizing video on tape to explore the possibilities of digital video such as escaping constraints of linearity. Today ADCs are vital tools in digital video production and distribution. And with the obsolescence of early videotapes and their playback machines, ADCs are now also key preservation tools.

The preservation of video stored on videotapes today centers on digitization. In videotapes, the analog video signal is in the physical form of metallic particles magnetically recorded onto the surface of the videotape. Given longevity issues such as media obsolescence, chemical deterioration, mechanical damage, equipment absence, mold, and poor handling among others leading to errors, changes and loss, videotapes are considered high risk materials preservation wise.

Digitization enables the extension of the lifecycles of videos stored in videotapes as it frees them from obsolescence of their original carriers and playback machines and opens them up to new preservation actions and strategies in the digital realm. Also, video quality in analog tapes degrades each time a copy is made. Digitization lessens this generational loss which is a key factor in preservation and access cycles.

At the core of digitization is the conversion of this analog signal to digital. Wherein the analog voltage or current is converted to representative data of zeros and ones proportional to the magnitude of the input. Analog signal as a linear continuous signal is then turned into discrete time digital representation.

To be able to accomplish this a circuit device in the form of an analog-to-digital converter, or ADC, is needed. The ADC takes the analog signal as an electric current and converts it to a digital binary format. The first generation ADCs for video in the 1970s were modular devices and were typically 8bit in resolution with $4f_{sc}$ sampling. By 1980s video ADCs usually were at 9/10-bit and by 1990s they were able to handle mixed-signal integration.

For video digitization today, ADCs come as video conversion boxes usually with analog signal conditioning and digital signal processing. Several of these products are available in the market and they vary in terms of input/output support, specifications, and features. Specification includes resolution, coding, sampling rate, linearity, and bandwidth among others.

This projects aims to compare two of these video ADCs as to identify quality and differences of outputs. On one hand is the ADVC3000, on the other, is the Blackmagic Decklink Studio.

Though there are ADC testing models developed through the years (static ADC testing, cross plot measurements, servo-loop code transition tests) very few has been written about their application for video ADCs. These tests however require field specific knowledge and understanding and involve particular equipments and tools not available for this study.

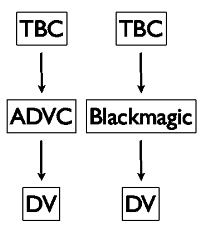
This study then looks into the converted video outputs analyzing visually and utilizing tools to compare and identify differences if there are any. Reviewing variables and leading to further hypothesis for future studies in video ADC tests.

Design and Findings

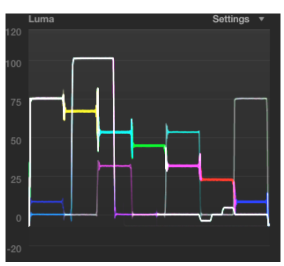
The following diagrams illustrate the different comparative variables that this project explored. The findings follow accordingly.

I. Colorbar test

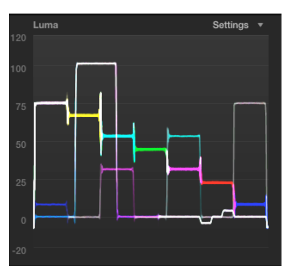
The idea is to set and compare reference points by capturing the colorbars from the TBC through both the ADVC and Blackmagic. A composite NTSC set-up is used capturing via firewire in Final Cut Pro using a Mac outputting to DV NTSC 48 kHz file format.



No significant difference has been noted on the captured colobars from the two different TBCs. Using FCP's video scopes, both output can be seen to have similar measurements. The waveform readings below is one example.



TBC_ADVC / Waveform, Luma



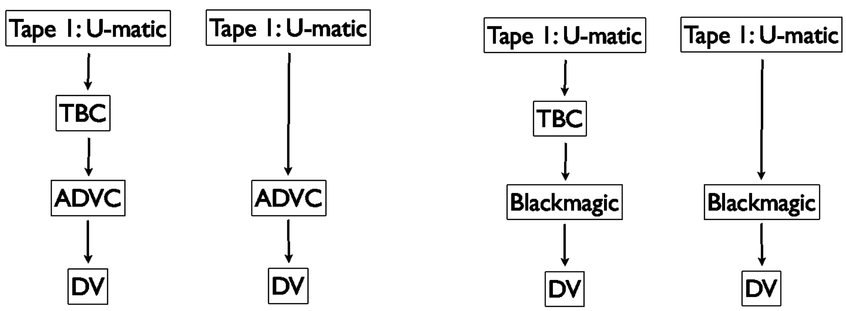
TBC_Blackmagic / Waveform, Luma

Both serve as good reference points for the rest of the tests.

II. TBC test

This test looks into the difference, if any, between capturing patching through and without TBC. The idea is to identify if there is still a need for a TBC to reduce errors caused by instabilities before sending the signal to an ADC. Will the TBC significantly aid in syncing signals between and throughout devices? Or can these ADCs handle unbuffered video signals accordingly and correct things without an intermediary TBC. Findings from this test will set the role of the TBC in the succeeding test designs.

A composite NTSC set-up is used capturing a minute worth of footage on a U-matic tape played on a U-matic deck. Via firewire connection it is captured in Final Cut Pro using a Mac outputting to DV NTSC 48 kHz file format.



For the ADVC, there is difference between the TBC patched output and the non-TBC patched one. The TBC patched one has better registrations and more stable colors compared to the non- patched one that displays some color bleeding seen in the high yellow/orange hue and intensity. The vectorscope readings reflect this color difference.


ADVC w/o TBC


ADVC w/ TBC

The Blackmagic also tend to be more stable and has less errors if it is patched through a TBC. Without the TBC, the image lines (loss) and colors (bleeding) are distorted and at times, images drop and do no register at all leading to quick flashes to blank/black screens.

Blackmagic w/o TBC Blackmagic w/ TBC

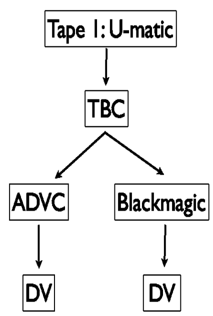
ADVC did not suffer such sync problems and signal loss. It seems that ADVC can handle more instability when it comes to sync and signals. This can perhaps be attributed to ADVC's image-enhancement technology wherein the converter box already includes an integrated line time base correction to stabilize image. So while Blackmagic might need the TBC to buffer the signal steady, ADVC no longer needs it. Nonetheless, the TBC patched ADVC yielded better color quality in terms of saturation among others.

The TBC then is seen as an integral intermediary tool in buffering and stabilizing the video signal for syncing, timing and reception prior to actual conversion via the ADCs.

As such, the succeeding test designs use and place the TBC as an intermediary device for stability and consistency.

III. Output Test

The main objective of the project is to compare the outputs between the ADVC and Blackmagic given all other variables as constants. With a composite NTSC set-up the same input (U-matic) is patched through the TBC and converted through ADVC and Blackmagic targeting the same file DV NTSC 48 kHz output. Via firewire connection it



is captured in Final Cut Pro using a Mac.

ADVC

Blackmagic

Both ADVC and Blackmagic were successful in converting the material. Regrettably the researcher does not have access to the original video for thorough objective or subjective comparison. A comparative calculation of the signal-to-noise ratio between the original video signal and the converted video signals could have been done. Or even a subjective review analysis by watching the original and comparing it to the converted ones.

Nonetheless, the converted outputs can be compared against each other. The Blackmagic output had a few signal noise and poorer registration and focus. While the ADVC output also had a bit of better registration with sharper edges than that of Blackmagic. This is prominent during the black & white parts of the outputs, wherein Blackmagic lost some contrast with greys. The luma level, as read in the waveform, is higher with the ADVC than the Blackmagic.

Besides from the aforementioned integrated LTBC, ADVC has the Canopus DV codec technology said to yield better DV outputs. This capability may explain ADVC's slight better output than that of Blackmagic.

IV. Tape Format Input, Signal Format Process and File Format Output

Analog-to-digital video converters deal with analog video inputs and yield digital video file outputs. In evaluating ADC technologies and systems one needs to look into their input and output capabilities.

Both ADVC and Blackmagic, given the right connectors and the availability of playback machines, are able to take various videotape formats. A TBC will assist in better playback reliability and signal transfer amidst format differences. Though the set of tests in this study worked on composite signal format, both ADCs are capable of managing other signal formats.

On the other hand, ADVC is only able to yield DV file formats compared to Blackmagic that has an array of file format output capabilities. This enables Blackmagic to more efficiently provide options for preservation and access strategies.

Simple funtionality tests were done to check these input, signal format, and output capabilities. Both ADCs showed and confirmed the aforementioned capabilities.

Summary of Findings and Recommendations

Both the ADVC and Blackmagic were successful in converting analog signals to digital files. Their inherent technical specifications though draws the differences between their capabilities consequently affecting their outputs.

Differences can be seen in the output of these two ADCs. ADVC seem to yield better images that are more stable, sharp and with better registration than that of Blackmagic. This can be attributed to the high-quality image-enhancement technology that ADVC claims to have integrated in their conversion box. Indeed, it shows.

Though whether these inherent image-enhancements aid in the faithful reproduction of the original is unknown. Though the ADVC outputs seen in this study has comparatively better quality than that of Blackmagic, it does not necessarily equate to being the more faithful one. It is therefore recommended that comparisons be made between the original and the converted outpurs. Objective tests such as signal-to-noise comparisons and other computational metrics will help point this out, together with subjective viewing analysis.

It is then recommended that further study be done in analyzing deeper the quality of outputs. Given the composite setups in this test, it would be of value to look at changes in chrominance and luminance signals. Measuring and analyzing differential gain and differential phase will likely explain the changes in color hues and intensities discovered in the tests done.

One interesting finding is ADVC's capability to better handle unstable signals compared to Blackmagic. Blackmagic tends to have signal loss and errors most specially if the signal is not patched through an external TBC to stabilize it. Back-to-back static ADC tests among others will yield explanations regarding these sync, delays, and timing issues and measure the effectiveness of TBCs as an intermediary stabilizing device.

Other tools developed by engineers such as frequency domain testing should be looked further into and applied accordingly to video ADCs. This also includes measuring quantization errors, sampling limitations and coding capabilities. It might be of value to look into digital-to-analog video conversion and measure and analyze signal changes and image quality from the orginal to ADC and then to DAC.

Digitization frees video content on videotapes from the limitations of an obsolete media and opens it up to an extended lifecycle with a myriad of possible preservation activities and strategies. Analog-to-digital converters is at the heart of this digitization process and as such one should analyze and look at available choices closely.

Videos on videotapes are known for their generational loss in quality. When it comes to digitization, an ADC that delivers the closest to the original quality that is best know to be, should be the aim. The tests done in this study has preliminarily showed that different ADCs yield different outputs with varying qualities. And that different designs and workflows, with varying equipments and variables, will also yield different results. It is then a sound preservation practice to test various equipments, systems, and architecture specially in dealing with digitization with the objective of being faithful and saving the original content from obsolescence.