CHACE
AUDIO FOR DVD, FILM AND BROADCAST
HEAR THE PASSION™

The Art and Craft of Optical Recording Made Easy

A Chace Productions Whitepaper

Foreword

Optical sound recording and reproduction techniques have been around for close to a century and its time honored craft has now been honed to a fine art. While newer digital processes and its associated media formats holds the promise of even higher audio dynamics, wider reproduction versatility with less distortion artifacts, the venerable film format, which has captured and preserved each filmmaker's visual and aural legacy on celluloid, has withstood the test of time throughout this evolution. Now however, celluloid's longevity, faces a crisis brought on by age, wear and mishandling. Moreover, digital technology threatens to make the art and craft of the optical sound engineer obsolete. This paper discusses how both mediums can co-exist and how the modern day re-recording engineer can move fluidly between optical and the newer digital formats to make sure that all re-recordings are pristine and are the mirror image of the original, preserving all the nuances that the filmmakers initially intended.

A Short Chronology of Optical Film Recording & Reproduction

In 1895, the visionary Lumière brothers, Auguste and Louis, showcased their first show of living pictures on the Boulevard des Capucines and forever changed the face of cinematography. This precursor to the present day cinematic experience ignited the imaginations of early pioneers who contemplated a world where picture and sound would one day be united. That dream became a reality fifteen years later when Eugene A. Lauste was granted a patent for a '*new and improved method of and means for simultaneously recording and reproducing movements and sounds*,' which first used a mechanical grate, then mirrors, and by late 1910, developed a light gate of a vibrating bronze silicon wire between two magnets to reproduce sound from an optical track.

By late 1926, the invention of electrical recording technology made sound pictures possible. This new breakthrough technology was incorporated into the recording and playback of film and in 1930, the motion picture soundtrack was standardized as a single-track (monaural) sound-on-film (optical) track on the edge of a 35mm film strip, thus creating the foundation and catalyst for continuous improvement of optical film playback well into the next millennium.

Another milestone was reached in 1937 when the film '*One Hundred Men and a Girl*' starring Deanna Durbin was released by Universal in standard monophonic sound. This was the first film soundtrack originally recorded by RCA in the '*Multiple Channel Recording*' process that had been developed by Bell Labs and RCA since 1932 at the Philadelphia Academy of Music. During the recording process, the songs of Durbin and the orchestra of Leopold Stokowski were recorded on 9 separate channels; each channel printed optically on a separate 35mm motion picture film. The 9 channels were then edited and mixed down into one channel for the optical soundtrack on the edge of the release prints.

It was not until November 13, 1940, with the premier of Walt Disney's '*Fantasia'* in New York's Broadway Theater that a multi-channel soundtrack produced by Leopold Stokowski was recorded on an optical track for each section of the orchestra, resulting in 9 separate soundtracks. This ground breaking cinematic event, which received countless accolades from the media and theater patrons alike, featured 4 master optical tracks played in synchronization on special equipment made by RCA for a multiple-loudspeaker theater installation called '*Fantasound'*.

Ever since this early adaptation of optical sound recording technology to bring the cinematic experience to life, the film industry, forecasting record sales at the box office, has been working hard to give the audience a more realistic audio experience. As the decades passed, the evolution of sound recording on optical film evolved, starting from a narrow monaural bandwidth track to a wide range two channel stereo analog track format. With the advent of digital formats first introduced in the late 1980s and early 1990s, filmmakers for the first time were able to lay down a 5.1 digital optical sound track along side the standard analog stereo track.

Ironically, despite the advances made in optical processing technologies for the past quarter century, optical soundtracks are still dependent on the technology of their original inception. This is especially poignant if we consider that even with the ever growing technology benefits that digital optical formats like SDDS (Sony Dynamic Digital Sound), SR-D (Dolby Stereo Digital) and DTS (Digital Theater Systems) offer, the film playback system defaults to the original analog soundtrack if there is any problem in retrieving the digital information printed on the film.

Truth-be-told, the only entertainment medium that has withstood the test of time and has been consistently heralded as the industry's ultimate preservation medium is the venerable film format, which has reigned supreme in image quality, interoperability, versatility and longevity…and now, the steadfast safeguard and backup for the optical soundtrack.

Despite film's inherent advantages, its supremacy may one day be overtaken by the progress made in digital recording, reproduction and distribution technologies as the industry moves cautiously toward the age of HDTV and digital cinema. No matter the outcome, the continuing evolvement in recording formats and its never ending proliferation of mandatory equipment purchases has galvanized the entertainment industry on safeguarding its most valued asset, the preservation of film and its irreplaceable visual and aural legacy.

Optical Recording Engineers – An Evolving Breed

Instant gratification is one of the negative connotations associated with the 21st century. In today's fast paced society, the younger generation has the near-instantaneous ability to get what they want, when they want it and taking years to learn a trade like optical recording, is fast becoming an oxymoron. Compared to digital formats and their ease of use, optical recording methods seem archaic and the long tutelage period needed to learn the trade of becoming a certified optical sound recording engineer is even more remote for young apprentices. Who can blame them in an industry where you only have one chance to turn out a pristine optical soundtrack and whose mantra is '*you have to be 100% right 100% of the time'*.

Optical recording, unlike other sound recording formats, does not offer the optical recording engineer the luxury of being able to re-record over a mistake or anomaly in the track. Quite the opposite, the objective of the optical engineer is to give a mirror image of what is presented to them – first time, every time. This flies up in the face of the throw-away technology that we've become accustomed to within the last 30 years, due in part to the manufacturers' need to consistently generate revenue.

In retrospect, nothing was thrown away and everything was used and reused in the old days of the film industry. Old optical soundtracks were striped with magnetic oxide to be used as magnetic stock, or old stock would be used as a leader, just to mention a few ways people maximized the expenses of film.

Further, the optical soundtrack has its own particular constraints concerning low and high frequency response and overall level. There is also the concern of how loud you can make a track without butting heads with the age-old enemy of distortion. Quite the opposite, digital formats have a broader bandwidth with unbelievable head room.

The dichotomy of analog versus digital has given rise to a new class of sound re-recording mixer - an individual who is able to mix one sound track for analog optical and another for the digital format. The modern day optical recording engineer has to keep constant vigilance on the continuing evolvement in recording formats and their associated idiosyncrasies because of the constantly changing technological environment. As a side note, in retrospect, the adage of not fixing things if they are not broken comes into mind, noting that the original analog format has remained the most robust and easiest to retrieve of all the optical sound formats with an estimated shelf storage life of well over 200 years in the proper environment.

The Art of the Transfer – Filmmaker Tips for Optimal Audio Dynamics

Newer digital video recording formats like DVCam or DVCPro offer the budget minded filmmaker a very cost effective alternative to recording on film. Digital video recording formats not only allow filmmakers to shoot endless takes, but preserve both the video and audio at first generation quality. Heeding the following tips will minimize any headaches when it's time to transfer to optical.

The first step is to log all the video and audio information onto a computer for the editing process. After the editing process, the film should be broken into reel lengths of approximately 20 minutes per reel. The soundtrack can then be manipulated separately from the picture in order for the filmmaker to perform additional sound editing or layering tracks.

If the product is to be released in theaters, it is likely that the finished sound track will be transferred to an optical negative at the end of the production process. If a 5.1 mix is to be put to optical, the three digital formats (DTS, SDDS, SR-D) have specific technical requirements which they make available to filmmakers as part of the licensing process. For SDDS or SR-D the analog and digital sound is transferred to the 35mm optical film simultaneously. For DTS, a time-code track is recorded alongside the analog soundtrack to provide synchronization for the DTS disc.

It is important for the filmmaker, on completion of the soundtrack, to make sure all audio is properly synced to the picture. Since many of us are not endowed with a photographic memory (and the use of the *Vulcan Mind Meld* only works if you're a sentient being from a fictitious planet), careful records should be kept of important decision points like fade-outs, fade-ins, editing and reel lengths. Also, it is vital that a sync pop be included at the head of the audio which corresponds with the three foot frame on the academy countdown leader at the head of the picture. In addition, reels should not be longer than 20 minutes in length. Last, in order to create the 35mm optical sound track negative, the audio can be recorded onto any of the following formats:

Audio Formats For Analog Optical Soundtracks

35mm or 16mm magnetic film; Time Code DAT; DA-88, 98, 98HR;
Audio tape with 60 Hz or time code; A variety of hard drive formats
(Pro-tools, Broadcast Wave, etc.)

Keep in mind at least for the time being that recording formats and their subsequent technologies are constantly changing but the sound will always end up on optical film if it is to be projected in a theater.

Optical Recording Tips

The difference between a good mix and a bad one is significant, breathing life to a cinematic experience on one hand and completely destroying it on the other. Therefore, it’s important to understand the audio dynamics of the particular recording medium that is being used such as the limits of recording to a 35mm mono or 2 channel stereo analog optical sound track negative. Here are some quick points to remember:

1. An analog optical sound track negative does not have the head room or the dynamic range of a digital sound track.

2. Low frequencies are rolled off at 31 Hz, while high frequencies are limited to 12.5 to 14.5 KHz. This is not dictated by what the optical recorder is able to handle in the way of high frequencies, but what projectors are able to play back in the theater environment.

3. Not all listening environments are created the same. Head room depends upon the optical recorder and the playback. +10 to +12 dB is considered an optical operating standard range.

4. It is important that the optical recorder being used is tested weekly to determine that the electronics are aligned properly, that the modulator can record frequencies without distorting, and that the lamp is balanced to reduce the chance of out of phase information being recorded. Cross X-Mod tests should be performed to determine the lamp current and proper negative density aim in order to ensure a distortion-free sound track.

To reiterate, the job of the optical recording engineer is to give a mirror image of what is presented to him. The sound track that he or she produces should not have low or high frequencies beyond that of the Print Master given to him. The optical recording engineer should know the dynamics and limitations of his recorder and should be willing to work hand–in-hand with a mixer to create an optical from the Print Master being passed on to him.

Avoiding "Gotchas"

It has often been said that, “…the devil’s in the details.” And nowhere is that more true than in preparing your finished soundtrack for optical recording. Pay attention to these details and there’ll be no “gotchas” in your final print.

1. Sync pops at heads and tails.

   In order for the optical soundtrack to be lined up with your picture for release printing you must record a sync pop (generally 1000Hz – one frame long) that corresponds to the three foot (3’ O fr) frame on the

standard Academy leader. This “pop” provides a visual reference for the negative assembler at the laboratory to line-up the sound and picture. The optical recordist cannot do this when making the optical, you must record the “pop” as part of the sound mix. A tail sync pop is recorded 48 film frames (60 video frames or 2 seconds) after the last frame of picture (LFOP) at the end of the reel. The tail pop has two very important functions. First, it lets the optical recordist know the reel is over and second if there is a problem with sync with-in the reel the tail pop provides a second sync reference to check that the reel was printed correctly. Tail pops are also great to help identify the LFOP when a reel fades to black at the end.
(Note: when using time-coded material reels usually start at 1:00:00, sync pop at 1:06:00 and first-frame-of picture (FFOP) at 1:08:00)

2. Check for proper levels and frequency content as noted earlier.

   Modern analog stereo opticals do not have the dynamic range of digital tracks. Peak levels should not exceed +12db. Remember that digital 0 equals +20db, so 0db for your optical track should correspond to the –20 setting on a digital meter LED. And note the frequency limitation of 31Hz on the low end and 12.5kHz to 14.5kHz for high frequencies. Be sure your mix has been made with these limitations in mind.

3. Maintain sample rates and time code references.

   The digital acquisition of images, HD cam, DVCam etc. are great tools for storytelling. They offer low cost and high quality. And the computer editing systems are literally “studios in a box.” But when it comes time to output your digital video to film and make the optical soundtrack or finish the sound separately from the picture insurmountable and often uncorrectable problems can occur if timecodes and/or sample rates get changed without maintaining the proper sync reference. This is probably the most common single mistake and unfortunately the most complex area. If the final result is going to be a film print be certain that you or the technical manager understand, BEFORE YOU EVER START, how the film elements will be made. Then document each and every step of picture and sound acquisition and transfer so that there is a clear “technical” road-map. If a problem occurs with sync, this road-map will be the information that will help in figuring out where the problem occurred and more importantly how to fix it.

4. QC the final mix for quality issues.

   The post-production process is often a race to the finish line with both time and money running out. But there is nothing worse than watching your finished print and hearing a glaring error in the mix – a missing sound effect, out-of-sync dialog, static or noise – that was missed during the mixing process. Save a few hours in the mixing budget to playback the entire track to make important fixes if they are required.

5. QC the final mix for sync with the film picture.

   This step is not always possible again due to time and/or budget but when it's done, it's a 100% guarantee that the new optical soundtrack will match the picture. Since the first answer print is usually made for timing purposes; that is to check color balance and exposure, it is almost always a silent print (MOS-without sound). This first answer print can be compared either electronically – by making a standard video reference copy – or in a projection room prior to having the optical made. For a feature length film this session will cost from $500 to $1000. But it's cheap insurance when compared to the cost of the optical soundtrack negative ($3,500 – $5,000) and an answer print with sound ($3,500 – $6,000). This step is particularly effective at uncovering any sync issues for projects that were not originally produced on film.

6. Don't be afraid to ask questions.

   There is only one bad question and that's the one you were afraid to ask. All reputable facilities have specialists available to answer questions and help you through the process. So when you are not sure, pick-up the phone or send an e-mail. No one wants an unsatisfactory result or unhappy client. So be sure to get the information you need before you become a "gotcha".

Deleted: s