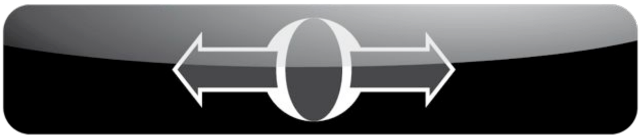
ALEXA Anamorphic De-squeeze

White Paper, July 7, 2011



Introduction

Starting with ALEXA Software Update Packet (SUP) 4.0, some new features can be added to ALEXA cameras through the purchase of a license. The first such feature is an anamorphic de-squeeze function. This paper describes the basics and history of the anamorphic process and how the de-squeeze function in ALEXA works. While the subject of the anamorphic process is fascinating and really deserves a longer treatise, it is meant here as a simple primer so the reasons for the ALEXA de-squeeze function can be better understood.

What is Anamorphic?

There are currently two types of lenses in use for professional productions: spherical and anamorphic lenses. While spherical lenses are easier to use, as they do not necessitate special viewing and post production considerations, anamorphic lenses bestow a unique look on the image.

Shooting with Spherical Lenses

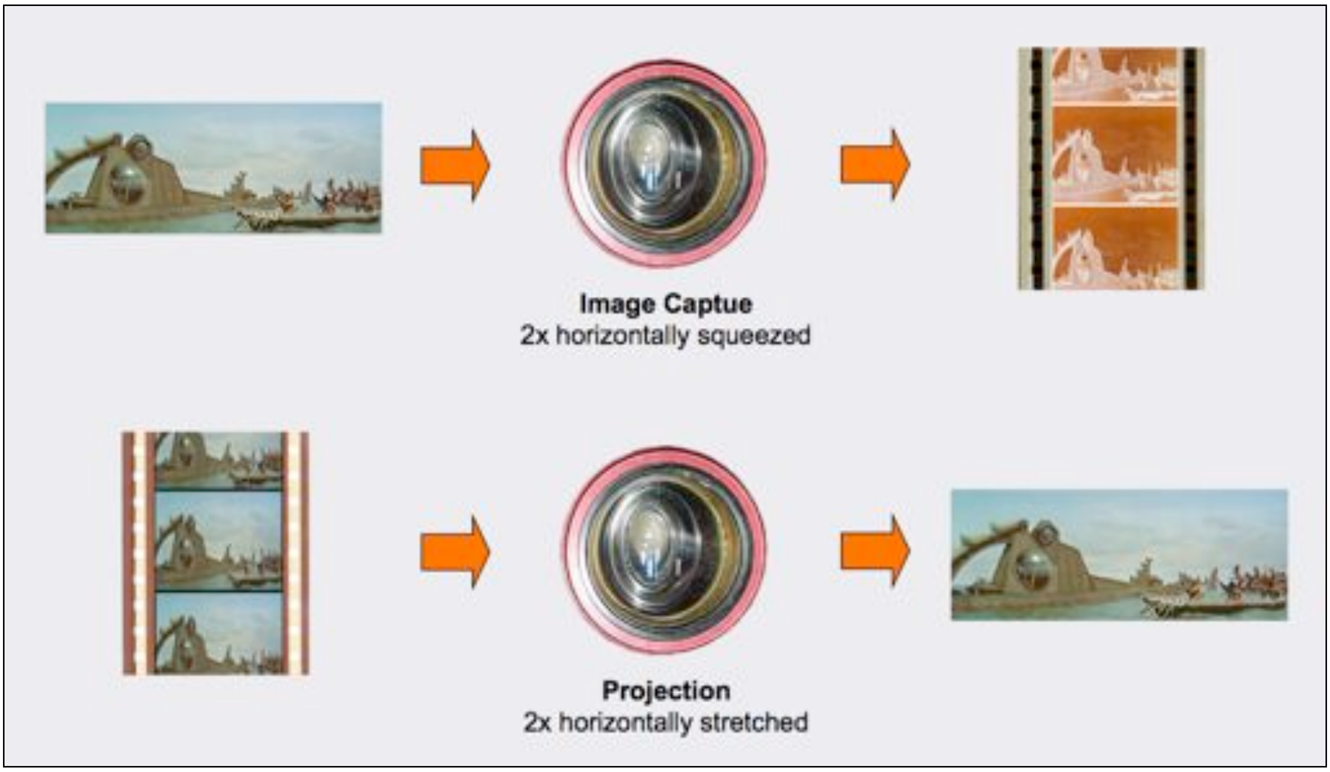
Spherical lenses project an image onto the sensor with the correct relationship of width to height (also called aspect ratio). A circle on the set in front of the lens remains a circle on the sensor. Most lenses used in photography and cinematography are spherical lenses.

Shooting with Anamorphic Lenses

Anamorphic lenses do not maintain the proper aspect ratio, but instead squeeze the image horizontally, so it becomes thinner on the sensor than in reality. A circle on the set in front of the lens will turn into an oval on the sensor. Most anamorphic lenses squeeze the image by a factor of 2, even though there are some that squeeze by a factor of 1.3.

Film Projection of Anamorphic Images

When projecting a film print, the image on the film is still squeezed. A special anamorphic projection lens de-squeezes the image, i.e. it restores it to the proper height to width ratio. The graphic below illustrates the basic workflow with a traditional 2x anamorphic lens for film capture and projection.

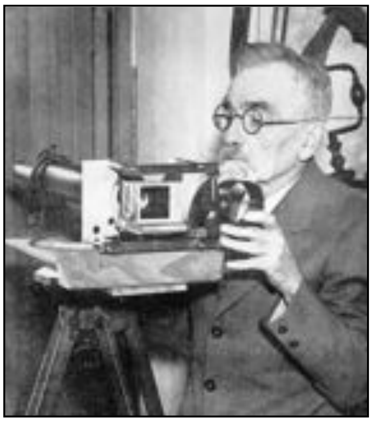


Digital Projection of Anamorphic Images

For a digital projection, the image is being de-squeezed in post production and a spherical image is projected by a spherical projection lens. The DCI specifications do not allow for transporting a squeezed image to the theatres.

A Brief History of the Anamorphic Process

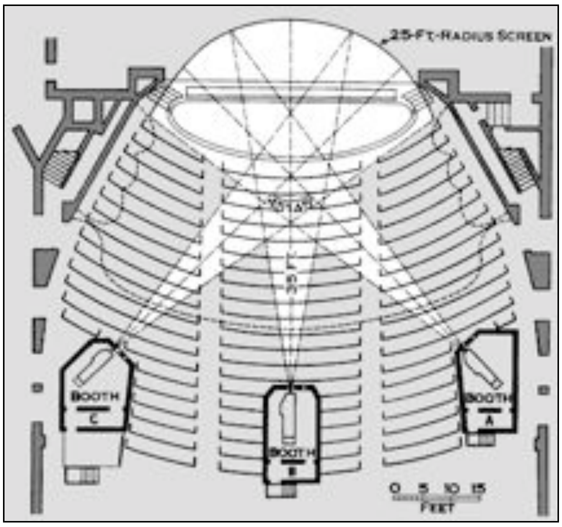
While the idea of anamorphic optical distortions can be found very early on in the history of optics, the first documented occurrence that leads to anamorphic lenses as we know them is a 1897 patent by P. Rudolph and E. Abbe. Ernst Abbe was a co-owner of The Carl Zeiss AG and one of the founders of modern optics. However, severe aberrations made anamorphic lenses impractical at that time.



After having used anamorphic lenses for creating a wide angle viewer for military tanks, French inventor Henry Chrétien filed his own patent in 1926 for producing a color film system. He proposed to use anamorphic lenses to optically squeeze the red, green and blue images side by side onto a 35 mm film strip. This never received any commercial success, and neither did his anamorphic system for printing the left and right eye of 3D images onto one strip of film. Then he saw Abel Gance's *Napoléon*, which consisted in the original of three side by side screens. While this technically was not a widescreen projection, as mostly different images were shown on the three screens, it convinced Mr. Chrétien of a bright future for widescreen cinema captured with his anamorphic lenses. He attempted to convince the European and US studios of the merit of this idea, but in 1927 he was decades ahead of his time. The prototypes of his *Hypergonar* anamorphic lenses were forgotten for the next 25 years.

We jump forward to 1950, a time when the Hollywood studios faced an alarming decline in cinema attendance. It is now assumed that this was caused by two main factors: a new post-war life style with varied recreational opportunities beyond the traditional visit to the cinema, combined with the ascendance of television. In their search for something to differentiate the cinema from television, the Hollywood studios experimented with a number of interesting presentation techniques, ranging from 3D and the misguided *Smell-O-Vision* to a visionary but premature attempt to build an electronic cinema projector (the fascinating and fatefully doomed *Eidophor* project).

While there had been experiments with wider aspect ratios and larger film gauges throughout the history of the cinema, a key moment occurred in 1952 when *This is Cinerama* was first projected. This first film in the Cinerama format was shot with a 27 mm lens (approximating the human field of view) and a camera using three strips of 35 mm film. It was presented by simultaneously projecting images from three synchronized 35 mm projectors at 26 fps onto a huge, deeply-curved screen, again trying to emulate the human field of view. The projected image usually had an aspect ratio of 2.65:1, and was accompanied by a seven channel stereo sound system. Equally loved by the public and reviewers, Cinerama was attractive for qualities that the small, 4:3 televisions with their tinny sound system simply could not match: a physically large screen with a wide aspect ratio image and a high fidelity audio system.



Unfortunately, simultaneously shooting three strips of film was cumbersome and expensive, and the analog film technology at the time never managed to precisely match the colors of all three projected images. Furthermore, converting existing movie theatres to Cinerama would have been prohibitively expensive or impossible. In their search for a more economical way to duplicate the appeal of widescreen cinema, the studios remembered Monsieur Chrétien. Twentieth Century Fox were the first to reach him in Paris. They bought his Hypergonar prototypes, trademarked the whole process as 'CinemaScope' and proceeded to change the shooting of a sword and sandals epic, *The Robe* (1953), which was to become the first film shot in CinemaScope.

By squeezing a widescreen image onto a standard piece of 35 mm film, the anamorphic process allows for the continued use of existing cameras, post production processes and projectors. Only the taking and projection lenses had to be changed from spherical to anamorphic. Also, converting a movie theatre to CinemaScope was less expensive than a conversion to Cinerama would have been. This gave the studios what they wanted: widescreen at a lower cost. Since then, many movies have been shot using anamorphic lenses, including *How to Marry a Millionaire* (1953), *20,000 Leagues under the Sea* (1954), *Apocalypse Now* (1979), *Blade Runner* (1982), *Chinatown* (1974), *Dances with Wolves* (1990), *Die Hard* (1988), *Indiana Jones* (1984, 1989, 2008), *Jaws* (1975), *Mission Impossible* (1996, 2000), *James Bond* (various), *The Last Samurai* (2003), *The Omen* (1976), *Scarface* (1983), *Star Wars 1, 4, 5, 6* (1977 - 1999), *The Prestige* (2006) and *Star Trek* (2009), just to name a few.

CinemaScope

Since patents for the anamorphic process had already run out by 1952, Twentieth Century Fox trademarked the term ‘CinemaScope’. In the beginning, they were also the only ones in possession of anamorphic lenses. The use of their lenses and the CinemaScope trademark, which in the public eye became synonymous with widescreen movies, was linked to licensing fees. This led to the development of other anamorphic lenses and a number of competing widescreen processes, some anamorphic and some spherical, some using 35 mm film and some larger gauges. These competing processes were given more or less creative names like Scanoscope, SuperScope, Techniscope, Arnoldscope (no relations), Vistarama or Thrillarama.

So technically CinemaScope is a Fox trademark rather than a description for the anamorphic process, even though they are often used interchangeably. Sometimes simply the shortened term ‘Scope’ is used.

Anamorphic Aspect Ratios

Up until 1952, cinema formats were easy to understand as all mainstream movies and television were shot and projected in the aspect ratio of 4:3 (1.33:1). When anamorphic shooting became popular after 1952, a number of aspect ratios were experimented with for anamorphic productions, including 2.66:1 and 2.55:1 (the need for reducing costs even further subsequently spawned the spherical widescreen formats of 1.85:1 and 1.66:1). A SMPTE specification for anamorphic projection from 1957 (PH22.106-1957) finally standardized the aperture to 2.35:1. An update in 1970 (PH22.106-1971) changed the aspect ratio to 2.39:1 in order to make splices less noticeable. This aspect ratio of 2.39:1 was confirmed by the most recent revision from August 1993 (SMPTE 195-1993).

Unfortunately, everyone was so used to calling anamorphic films 2.35:1, that many still use that aspect ratio erroneously, even when talking about films shot after 1970. Similarly, 2.40:1 is an incorrect, unfortunate and unnecessary rounding up; a proper rounding up would be 2.4:1. The correct aspect ratio for anamorphic films shot after 1970 is 2.39:1.

The Anamorphic Look

The reasons for shooting with anamorphic lenses have changed over the decades. In the beginning, the grain structure of film negatives was simply not fine enough to shoot widescreen movies with spherical lenses. Using a spherical lens to capture a 2.39:1 image would have used only half of the available negative area resulting in grainy pictures. An anamorphic lens, by comparison, squeezes the widescreen image onto the existing 4:3 film frame, thus using almost the whole negative area.

However, since anamorphic lenses are significantly more difficult to build than spherical lenses, they exhibit a number of unique optical characteristics, some not found at all in spherical lenses, some much reduced. These characteristics include a vertical stretch of all out of focus parts of the image (leading to the unique anamorphic bokeh and the tell-tale oval out of focus specular highlights), reduced depth of field, extreme geometric distortion for wide angle lenses, strong and frequent oval flares, ghosting, severe breathing, poor close focus performance, poor field illumination, strong chromatic aberrations and the famous horizontal blue line that occurs when a light shines into the lens.

Interestingly, the early CinemaScope films do not show any of these characteristics, and if so, only mildly and briefly, which could lead one to conclude that the cinematographers back then considered them optical faults to be avoided at all costs. So in the beginning the reason for shooting with anamorphic lenses was simply to reduce the grain in widescreen movies, and that was most likely the only characteristic desired: a high quality widescreen image.

This changed as directors hit the scene in the 80s and 90s who were looking for new ways to express their artistic vision on film. They intentionally used the unique characteristics of anamorphic lenses as very effective story telling tools, as can be seen in most anamorphic films up until today. The painterly, impressionistic bokeh now clearly distinguishes anamorphic films from spherical ones, depth of field is shallow, oval flares and highlights are markers for the protagonist's mental health and right before something scary happens, someone invariably will shines a flashlight directly into the lens to create blue horizontal lines. For a little entertaining stroll through the development of anamorphic image characteristics we recommend the following films: *How to Marry a Millionaire* (1953), *Apocalypse Now* (1979), *Alien* (1979), *Bringing out the Dead* (1979), *The Prestige* (2006) and the over-the-top flare and aberration fireworks in *Star Trek* (2009).

The story, however, is not over. The recent trend to the increased use of digital cameras has generated a new interest in anamorphic lenses. Grain is not an issue anymore, but some are considering images created with digital cameras too clean, effectively lacking the organic quality of film grain. To add a bit of 'organic character', the use of anamorphic lenses has again gained in popularity.

ALEXA De-squeeze Overview

Anamorphic de-squeeze shows a properly de-squeezed image (with or without surround view) on the EVF-1 and/or MON OUT when working with 2x or 1.3x anamorphic lenses. Requirements: ALEXA or ALEXA Plus with Software Update Packet 4.0. Anamorphic de-squeeze includes four different modes:

- De-squeeze off
- De-squeeze 2x
- De-squeeze 2x & magnify
- De-squeeze 1.3x

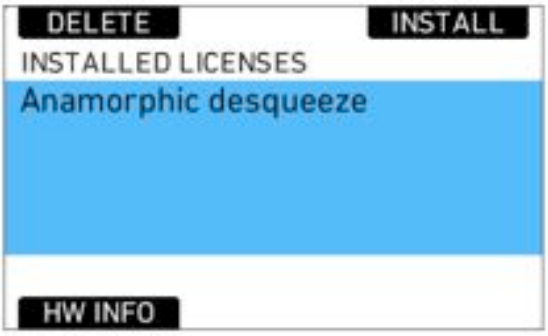
Purchasing a License

- Contact service@arri.de to purchase an anamorphic de-squeeze license.

Installing a License

- The customer copies the purchased license file from their computer to an SD card.
- Once this SD card is inserted into the camera, the license can be installed in MENU button > SYSTEM > LICENSED FEATURES > INSTALL.
- At that point the license is installed and will be present in the camera even when the SD card is removed. In fact, we recommend that the license owner now remove the SD card containing the license to avoid an unwanted copying of then license by others. The SD card should be stored in a safe and secure place.
- The license can be removed from the camera at any time in MENU button > SYSTEM > LICENSED FEATURES > DELETE.

• A list of all installed licenses is available in MENU button > SYSTEM > LICENSED FEATURES



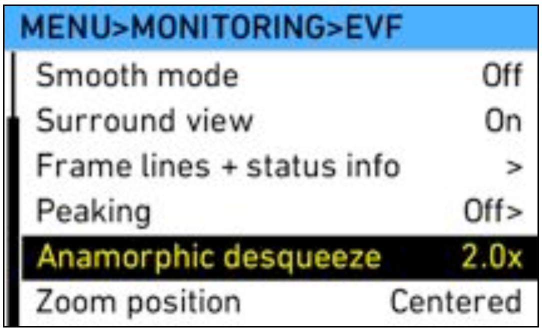
• Installed licenses will remain present when the camera is updated to a Software Update Packet higher than 4.0. Installed licenses will also remain in the camera when the camera is downgraded to a Software Update Packet below 4.0. It will then be visible again when that camera is updated to a packet of 4.0 or later.

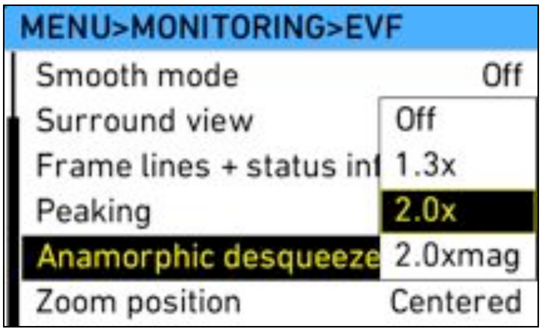
Turning De-squeeze On

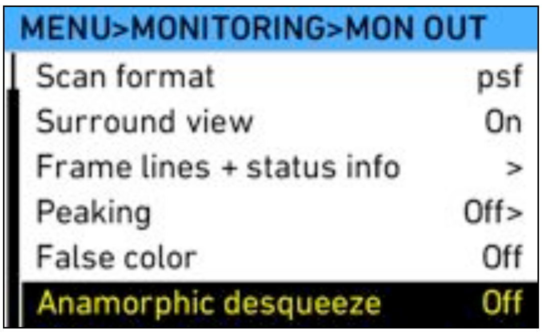
De-squeezing can be enabled in the following menus:

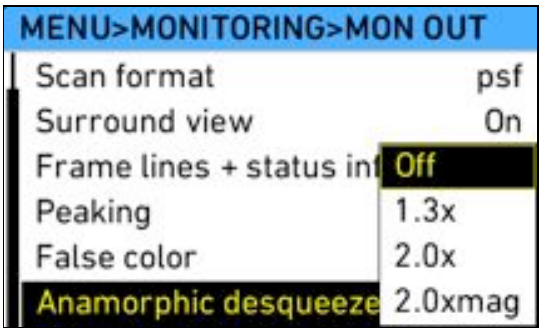
MENU button > MONITORING > ELECTRONIC VIEWFINDER > ANAMORPHIC DESQUEEZE

MENU button > MONITORING > MON OUT > ANAMORPHIC DESQUEEZE







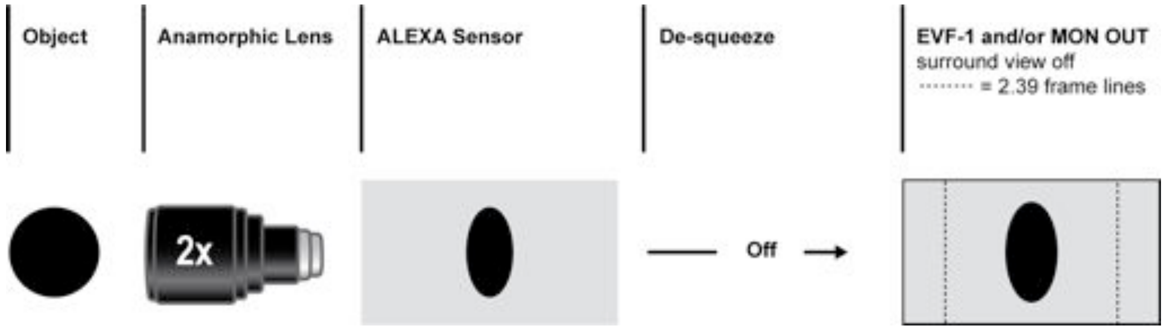


ALEXA De-squeeze for 2x Anamorphic Lenses

2x anamorphic lenses are the classic anamorphic lenses that squeeze the image by a factor of 2. A circle on the set in front of the lens will look like an oval on the sensor. For simplicity's sake only the resulting images with surround view off are shown below. However, surround view can also be switched on.

De-squeeze off

When De-squeeze is off you will see the full sensor in the viewfinder and/or on the MON OUT output with everything squeezed by a factor of 2. The dotted lines indicate the frame lines that will result in a 2.39:1 image once the image is de-squeezed. These frame lines are 1.195:1 (2.39 divided by two = 1.195).



De-squeeze 2x

When 'De-squeeze 2x' is enabled you see the full sensor, but this time properly de-squeezed so a circle is a proper circle again. The dotted lines show the 2.39:1 aspect ratio, and you can see that you will record some extra image to the left and to the right, which can be used in post for repositioning.

De-squeeze 2x & magnify

If the 'De-squeeze 2x' setting makes the image too small for you, you can switch to 'De-squeeze 2x & magnify'. In this case the image is enlarged in the viewfinder. The 2.39:1 frame lines now almost fill the horizontally available space. You see a little to the left and to the right of the 2.39:1 frame, but you do not see the full sensor image that you will be recording; you are recording more image content to the left and right that is not visible.

Please note that this mode is available in Standby and Record, but not in Playback mode. If 'De-squeeze 2x & magnify' is set for the viewfinder and/or MON OUT and an image is played back from the SxS PRO card, playback will be "De-squeeze 2x" instead.

ALEXA De-squeeze for 1.3x Anamorphic Lenses

Specifically developed for 16:9 sensors, 1.3x anamorphic lenses do not squeeze the image by a factor or 2, but rather by a factor of 1.3. That makes a 2.39:1 image fit almost perfectly onto a 1.78:1 (16:9) sensor. For simplicity's sake only the resulting images with surround view off are been shown below. However, surround view can also be switched on.

<u>De-squeeze off</u>

In the case of 'De-squeeze off' you will see the full sensor in the viewfinder with everything squeezed by a factor of 1.3. The dotted lines indicate the frame lines that will result in a 2.39:1 image once the image is de-squeezed. These frame lines are 1.838:1 (2.39 divided by 1.3 = 1.838), which is of course very close to the 1.78:1 aspect ratio of the availbale pixels on the ALEXA sensor.

<u>De-squeeze 1.3x</u>

In the case of 'De-squeeze 1.3x' you see the full sensor, but this time properly de-squeezed so a circle is a proper circle again. The dotted lines show you the 2.39:1 aspect ratio, and you can see that you will record just a little bit more image on top and bottom.

ALEXA De-squeeze Graphic Overview