Canon

WHITE PAPER

CINEMA EOS LENSES

PERSONALITY OF THE CANON CINEMA EOS LENS: *IMAGE SHARPNESS*

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CINEMA EOS

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The Personality of the Canon Cinema Lens – Session #2

Personality of the Cine Zoom Lens in Relation to Image Sharpness

In this chapter we will take a look at a particular aspect of the design criteria for the new Canon cine zoom lenses. Because these lenses were born squarely within the new era of digital cinematography the goal of endowing them with full 4k optical performance made sense for two reasons: one, such high resolution would significantly benefit high-end 2k/HD digital cine cameras, and second, it would anticipate the now escalating emergence of 4k digital cine cameras. Canon did also note the increasing use of cine zoom lenses in place of the traditional sets of cine primes. While this still remains a slow movement, it was felt worthy of support by specifically seeking a performance level in the new zoom lenses that would credibly support their use as "variable primes".

When a set of cine prime lenses are deployed on a given production the expectations are:

1. Constant Optical Speed between lenses (if possible)
2. Constant Color Reproduction (precise color matching)
3. Constant Sharpness (and higher sharpness than traditional zooms)
4. Minimum Flare and Ghosting

A very specific design goal for the Cinema EOS cine zoom lenses was to achieve an overall optical performance that would equate with the best of contemporary prime lenses and to maintain that performance over their respective focal lengths. Achieving these goals imparts an unusual element to the performance "personality" of these lenses.

This paper will discuss the design criteria established to seek optical image sharpness that would meet the expectations of those seeking to achieve a high performance variable prime lens.

Sharpness Criteria for a "Variable Prime" Cine Lens

Canon set three specific design targets for the new lenses:

1. Full 4k optical resolution
2. Maintaining that high resolution across the most important central zone of the image plane
3. Maintaining that high resolution over the entire focal range of the lenses

It is inherent to each and every element of a lens that its resolution is at a maximum at the optical center. The MTF will then progressively lower when moving from that center toward the extremities of the image plane. Optical designers always strive to curtail that falloff in MTF as much as possible within the important central zone of the lens. Each optical manufacturer sets its own specific criteria for defining such a zone. Figure 1 outlines Canon's definition of two critical image zones within the Super 35mm image format.1

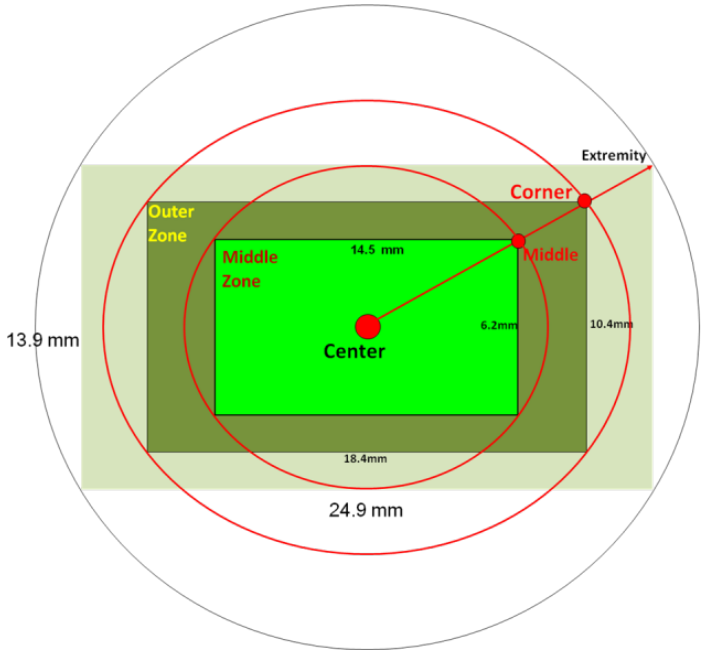

Figure 1 *Defining the boundaries of two image zones – a Middle Zone and an Outer Zone*

While the two zones are specified by the dimensions (in millimeters) of two rectangles, the very nature of lenses are circular, and accordingly, the Middle Zone is in fact a circle that encompasses the full height of the Super 35mm image format, while the Outer Zone is the larger circle shown in Figure 2. These two Zonal dimensions were decided upon based upon decades of dialog with cinematographers and videographers – and tempered by realities of what is optically possible (determined over many decades). The significance of the two zones to picture sharpness is best explained with some images.

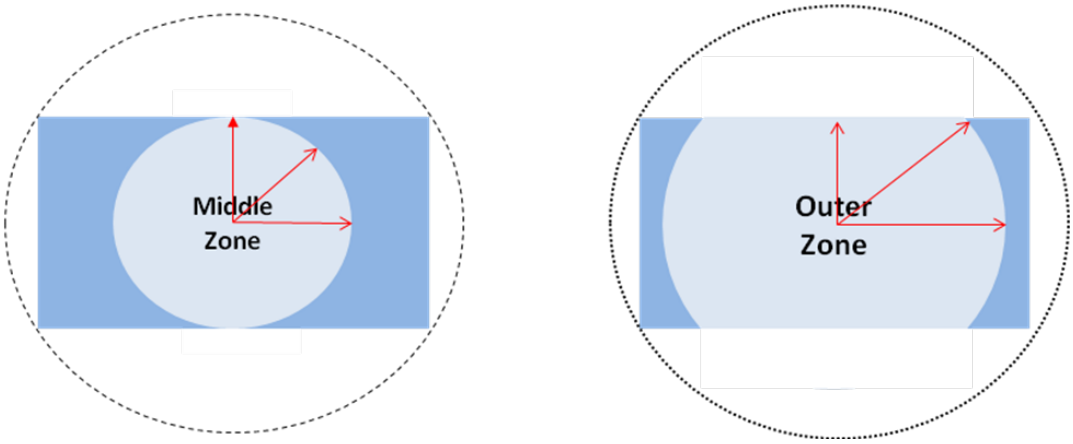

Figure 2 *Showing the two circular zones across the Super 35mm image plane that are determined by the specified dimensions of the rectangles in Figure 1*

The Middle Zone has an area that is particularly favorable to reproduction of a facial close-up as suggested in Figure 3.

Figure 3 *Showing how the Middle Zone encompasses a singular facial close-up and a medium close-up of two principal actors*

It was Canon's goal to develop a lens that would ensure constant subjective sharpness within that Middle Zone to the degree possible and to further protect that sharpness over the entire focal range of the lens. This was deemed important to achieve the performance expected of a variable prime lens. Outside of this Middle Zone, the designers sought to control the inevitable falloff in optical MTF to a slow and graceful degree that would be subjectively imperceptible. This Outer Zone embraces more than 80% of the total image area, and accordingly, would do justice to wide angle images that contain a great deal of image detail.

Figure 4 *Showing the Outer Zone and how its area covers the greater portion of the total Super 35mm image format.*

A few years ago, Canon had responded to a request from the NHK Technical Research Lab to develop a 10:1 zoom lens to support their ongoing R&D into Ultra-HDTV (or Super HiVision as it is termed in Japan). This 8k lens design stipulated an optical resolution performance that is sixteen times greater than today's 1080-line HDTV. From this work was born an optical design platform on which the new 4k cine zooms are based.

Personality of Image Sharpness Characteristics of the Top End Cine Zoom Lenses

The optical designers spent a great deal of time using powerful computer simulation techniques to support a quest to maximize the cine zoom lens MTF according to the principles described. For the wide-angle CN-E14.5 –60mm T2.6 lens the final simulation showed that a quite tight control of lens MTF could be maintained from picture center to the limits of the Middle Zone. Further, this could also be tightly controlled over the full 4.1x zoom range of the lens. The simulation results are shown below in Figure 4. It was also shown that even out to the extremities of the secondary Outer Zone the falloff in MTF would be benign.

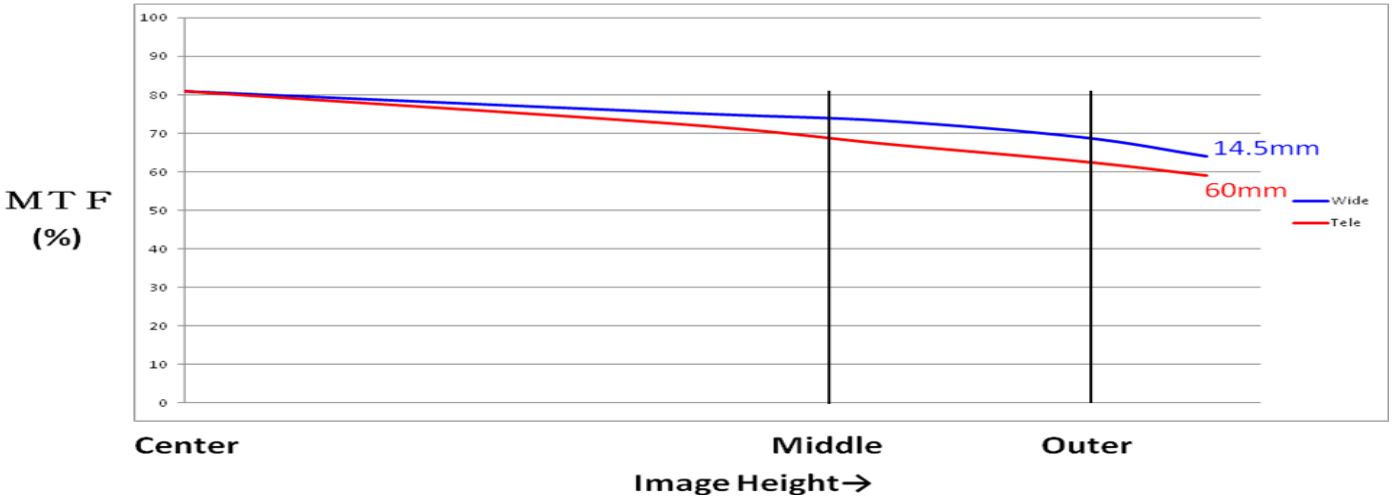

Figure 4 *Showing computer simulation results for the wide-angle cine zoom lens (at 40LP/mm)*

In the case of the more challenging lens – the new 10x telephoto CN-E30–300mm T2.95 – the computer simulation finally produced an optimized performance shown in Figure 5 – a truly exemplary promise.

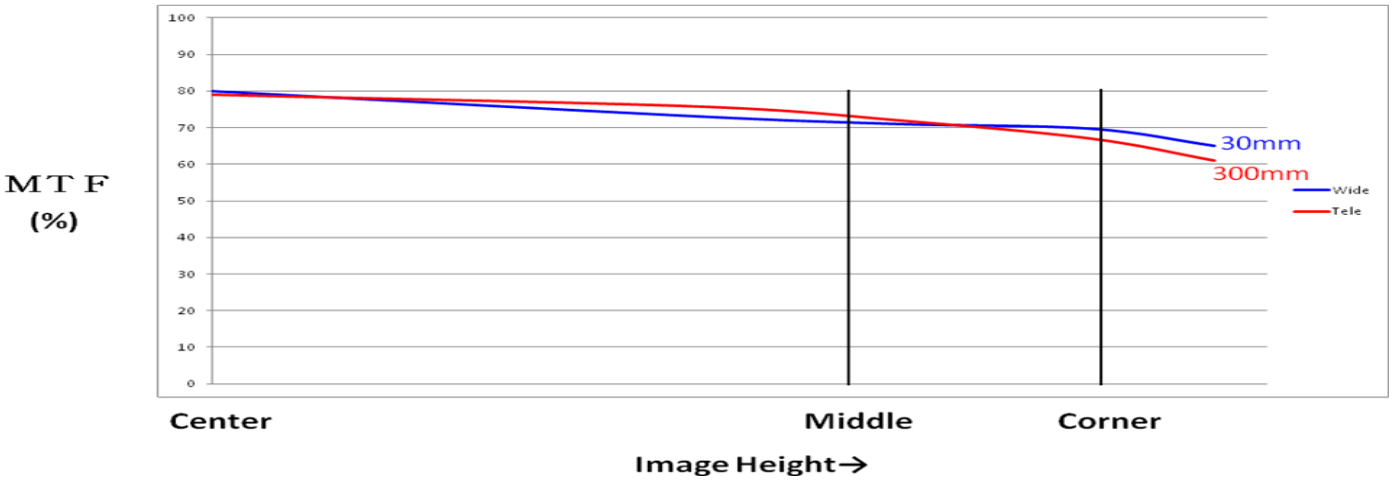

Figure 5 *Showing computer simulation results for the 10:1 telephoto cine zoom lens (at 40 LP/mm)*

Comments on the Subjective Results

The curves shown in Figures 4 and 5 yield the anticipated MTF characteristics at one specific spatial frequency – namely, 40 line pairs per millimeter (LP/mm). Given that the optical Nyquist frequency for a 4K lens is twice that – at 80 LP/mm – the question might be asked: why look at half that defining boundary spatial frequency? Many years of accumulated experiences in cinematography have shown that the most important region of an MTF curve lies in its central region. Having as high an MTF as possible in this region ensures both clean sharp edge transitions (think buildings and windows in a wide-angle cityscape) as well as clean and clear textural reproduction (think facial and clothing textures). It is also noteworthy that a high MTF at this 40 LP/mm region is the boundary of a 2K camera and thus such a lens will ensure excellent sharpness when mounted to a 2K camera (or an HD camera).

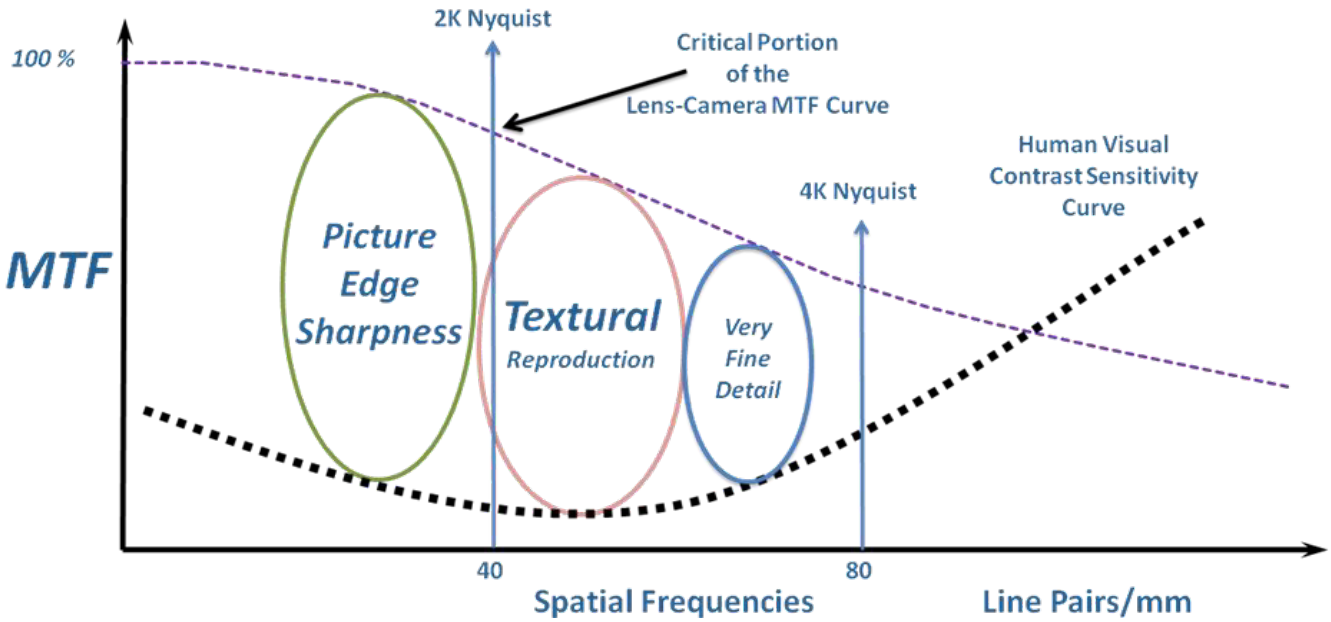

Figure 6 *Perceived picture sharpness is represented between the boundaries of the lens MTF characteristic and the human visual system's contrast sensitivity characteristic.*

The curves shown in Figures 4 and 5 are the final computer simulated results prior to the lenses actually being built. Canon does not publish actual MTF curves for its high-end professional lenses (a universal practice among all major optical manufacturers). However, it can be said that the actual results achieved in both the CN-E14.5–60mm and the CN-E30–300mm slightly exceed the computer predictions. This has been verified in a number of recent technical evaluations made in the U.S., Europe, and in Japan [1], [2], [3], [4].

Cine Lens Personality in the Form of its Image Sharpness

Cinematographers will speak enthusiastically about the imaging characteristics of lenses to which they have developed a loyalty – indeed, in many cases, an affection. In describing all that they might like in a given lens one might hear adjectives that include: "Vivid, razor sharp, brilliant, contrasty, creamy".

These are non-technical descriptors of the identified “personality” of a specific lens in terms of how it reproduces imagery. While that personality can be bound up in numerous optical attributes it can generally be assumed that image sharpness is one central element.

Canon set out to shape an MTF characteristic for these new cine zoom lenses that would ensure a high and even sharpness on a facial close-up (the Middle Zone) – and largely sustain that sharpness when zooming out to capture a wider-angle image with increasing detail content. In so doing we believe these lenses to possess an image sharpness personality that will justify their deployment as an alternative to a set of Super 35mm prime lenses (having approximately the same focal range). At the same time, that high sharpness was tempered in the manner described in our first session (Pro Dealer Insider Sep 2013) to impart a more cinematic characteristic. An excellent assessment and discussion on the behavior of picture sharpness of these lenses is contained in references [1] and [2].

But, lens personality also includes other core imaging attributes – notably those earlier listed on Page 1. In our next section we will look at the behavior of the maximum relative aperture with focal length as this is critical to the behavior of the zoom lens as a variable prime. We will also describe the specific design steps taken to realize a specific color reproduction characteristic for these cine zoom lenses.

REFERENCES

[1] http://alfonsoparra.com/en/press/cat/research/234/Canon-CN-E-14-5-60mm-T2_6-

[2] http://alfonsoparra.com/en/press/cat/research/237/Canon-CN-E-30-300mm-T2_95-3_7-

[3} Otto Nementz Not published (but may be willing to share on a private basis)

[4] Per Böhler Not published (but may be willing to share on a private basis)

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