QVC recently upgraded its Studio Park facility with the addition of more than 60 Canon HD studio and portable lenses. This live broadcast, with QVC host Patti Reilly (on the right) and fashion designer Marc Bouwer, featured the M by Marc Bouwer sportswear collection. Photo by Rick Gerrity.

Maximize your HD camera's performance

BY LARRY THORPE

Consumer HDTVs are becoming commonplace and continue to improve, with larger and brighter models featuring contrast ratios that are achieving impressive levels. Maximizing the image-creation performance of an HD camera combined with an HD lens must anticipate this unprecedented new HD picture performance yardstick now present in so many homes.

When speaking about HDTV picture quality, creative people often make use of such superlatives as high sharpness, crispness, high contrast, richness and vibrance. When videographers, cinematographers, directors and other creatives use such language, they are in fact expressing a psychophysical response to the multidimensional nature of HD pictures. The separate optimization of each of the contributing picture attributes — which include sharpness, tonal and color reproduction, and exposure latitude — is critical to high overall image performance of an HD lens-camera system.

The six stages of HDTV origination

HDTV origination is a six-stage process that starts with the lens performing the all-important initial act of image creation. This is followed by the camera imager's sampling of that optical image (both spatially and temporally) and its transformation to an analog representation. This, in turn, is followed by the image's conversion into a very high data rate digital representation and then digital processing of the three RGB video signals. (See Figure 1 on page XX.) All five of these processes imprint their own imaging characteristics onto the final HDTV video signal. In the case of the now ubiquitous HD camcorder, a sixth stage entails digital processing to lower the huge camera digital data rate before it is recorded to videotape or one of the numerous new tapeless media.

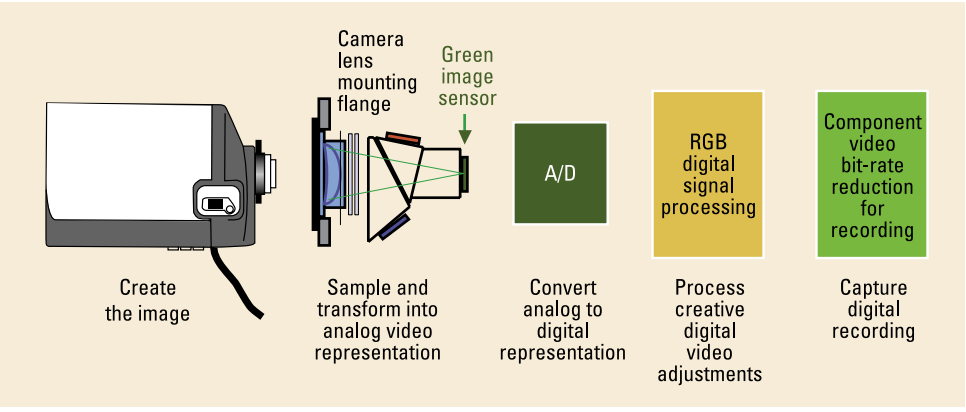

Figure 1. The origination and capture of an HDTV digital video signal is a six-stage process. Each stage imprints a performance footprint onto all of the separate attributes of picture quality.

Maximizing HD camera performance

Table 1 correlates the separate image-related parameters of HD lenses and HD cameras with those picture attributes that contribute directly to overall HD picture quality. All of these lens and most of the camera-imaging parameters are inherent in their respective technologies. In the case of the camera, there are additional variables in the form of video controls that manipulate some picture-performance attributes, which are shown in yellow in the table.

Key picture attributes	Lens	Camera	Final picture performance
Sensitivity	• Maximum relative aperture	• Electronic sensitivity (imager plus drive circuits) • Video gain	• Operational sensitivity (and SNR spec) • Minimum illumination
Sharpness	• Diffraction • Defocus aberrations • Surface quality of lens elements • Dynamic behavior of MTF with actuation of zoom, focus and iris	• Optical prefilter • Sensor count • Sensor fill factor • Electrical post filter • Digital image enhancement • Skin tone detail	• Sharpness at picture center • Sharpness at picture extremities • Sharpness changes as lens controls are operationally manipulated
Tonal reproduction	• Black reproduction (flare and veiling glare) • Highlight reproduction (point spread function and protection against reflections) • relative light distribution	• Black level controls • White shading correction • Gamma • Black gamma • A/D converter	• Reproduction of detail in deep shadows • Reproduction of color details in deep shadows
Exposure latitude	• Contrast ratio • Reflections and ghosting	• Imager dynamic range • A/D converter bit depth • Nonlinear calculations bit depth • Nonlinear strategies (knee etc.)	• Handling of strong highlights • Preservation of detail in highlights

Color reproduction	• Spectral response
	• Element coatings
		• Spectral response of:
		  • IR filter
		  • Beam splitter
		  • Imager
		• Linear matrix
		• Secondary color corrections
			• Extent of the color gamut that can be accurately reproduced

Figure 2. A correlation of the image-related parameters of HD lenses and cameras and the picture attributes that contribute directly to overall HD picture quality

Clearly, the lens has a definitive first say in the quality of the HDTV picture. The imaging parameters for the HDTV lens listed in Table 1 will be significantly different between a large studio box lens and a compact portable ENG lens. This bears directly on the quality of the HD image sought for a specific program genre.

For the purpose of this article, two extremes of HD television production will be profiled. First, high-end studio production seeks the best HD imagery using the highest performance HD lens and HD camera available. Second, field acquisition for HD news seeks the best HD imagery possible with a low-cost tapeless HD camcorder and HD lens.

Maximizing HD studio lens-camera performance

Following competitive evaluation, the selection of a contemporary HD studio camera conforming to the highest HDTV production standard of 1920 x 1080 at 60P is assumed. Maximizing the HD picture from that camera requires an equally careful choice of a high-end HD studio box lens.

Beautiful HD studio origination entails an overall pleasing sharpness across the entire image allied with superb tonal and color reproduction. Picture edge sharpness (accurate reproduction of all outlines and transitions, with no artificial edge contouring) combines with high contrast and faithful reproduction of all textures within the scene. Studio origination requires optimized imagery across the entire 16:9 image plane as the principal talent in news interviews and talk shows are often framed at the picture extremities. (See Figure 2.)

Figure 2. A close-up shot includes important outlines and transitions that should be sharp and devoid of artificial edge contours, as well as subtle textural detail in human faces and clothing, which is a key imaging attribute that distinguishes HDTV from SDTV.

Key concepts to keep in mind when selecting a studio camera and lens, include:

- Carefully evaluate the lens parameters listed in Table 1, including sharpness, and tonal and color reproduction.
- The camera must not usurp the role of the lens. It should be understood that the camera is not the primary determinant of picture sharpness, contrast ratio or color gamut. Rather, its digital video controls are applied to the creative optimization of each.
- The HD lens is master in creating subtle textures, closely allied with the creative skills of the lighting director, makeup artist and camera video operator.
- Studio sets can embody large defined horizontal and vertical edges. On wide-angle shots, these will test the geometric distortion performance of an HDTV lens. Such specifications are not published, and only careful subjective testing of HD lenses will uncover the degree of optimization of this distortion achieved by each.

Further steps need to be taken for optimization. Engineering and production should work as a collaborative team and view the final HD images on a large (60in or more) precisely calibrated high-performance HDTV monitor. Hiring a professional actor or model is a good investment for the initial tests and adjustments. A new camera will benefit from the involvement of the manufacturer's technical specialist. At the outset, adjust the camera for accurate reproduction of the studio scene, that is, a faithful representation of the object image projected by the lens. Do not apply digital image enhancement or color correction at this stage. Set lighting levels and lens aperture to achieve the desired facial illumination and depth of focus between the news anchors at their desk and the background studio set.

It should be understood that the camera is not the primary determinant of picture sharpness, contrast ratio or color gamut.

Adjust the various camera RGB controls (using appropriate grayscale and color test charts) to achieve superb tonal reproduction between capped

black and reference white. Follow with an optimized reproduction of overexposed studio highlights and details in deeply shadowed areas using all of the contemporary nonlinear tools in the camera. (See Figure 3.)

The all-important treatment of anchors and prominent talent will require final adjustments to lighting and makeup while framing a close-up within the studio set. Makeup should be subtle and uniformly applied. Seek reproduction of a natural-looking sharpness with pleasing texture on the large HD studio monitor. Follow this with a medium-angle shot of three subjects (preferably with different skin and hair coloring) sitting across the news desk and framed to span the 16:9 image plane. Sharpness, contrast and color should be subjectively equal for all three. Production should now make the final creative decision on application (or not) of a small amount of digital image enhancement for a subjectively optimized image of the three anchors on the large viewing monitor. Carefully recheck this on a close-up of a single anchor. Choose a best compromise between the two settings (amplitude of optical image detail is altering with lens focal length as shown in Figure 4).

Finally, examine a wide selection of colored materials (both high saturation and pastel) on the HD monitor, including the clothing favored by anchors. This will aid final decisions on the degree of secondary color correction that might be required in the HD camera.

Figure 3. In medium wide-angle shots, edge sharpness is more prevalent and textural information has increased in spatial frequency. The nature of this picture requires all image attributes be optimized over the entire image plane.

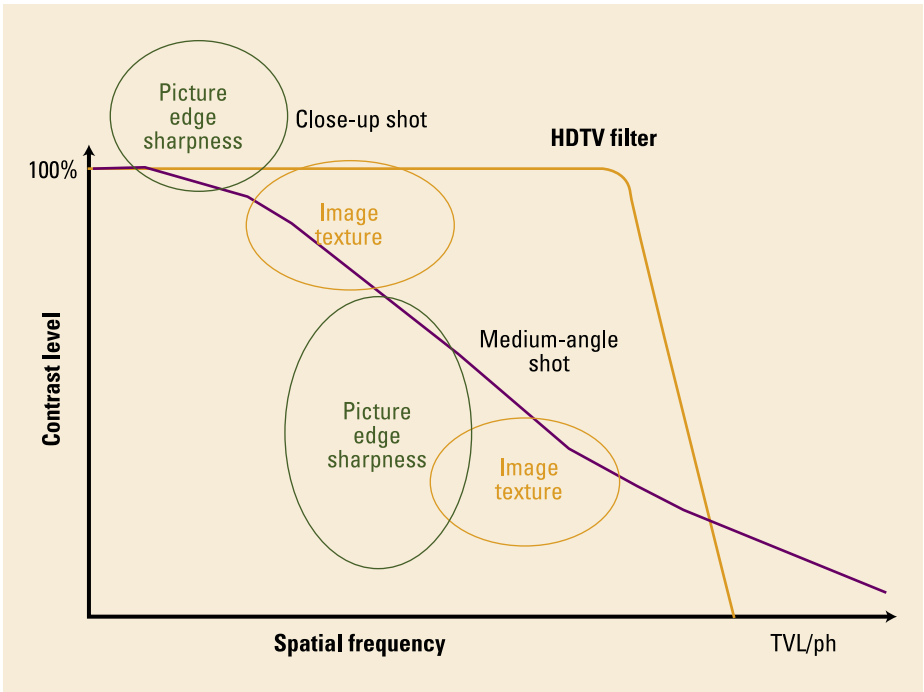

Figure 4. MTF for a typical 2/3in HDTV lens-camera. Lens focal length changes cause edge sharpness and textural spatial frequencies to ride the HD lens-camera curve, thus posing a challenge to a single optimized setting of camera digital image enhancement.

Maximizing HD field lens-camcorder performance

The new generation of tapeless HD camcorders leverages multiple technologies to lower cost, size, weight and power. Camera sections include a range of image format sizes, choices of CCD and CMOS imager technologies (with an attendant broad range of sensor counts in these imagers), different bit depths in A/D conversion, and different DSP bit depths for digital nonlinear RGB video calculations. Lens manufacturers have introduced a second tier of portable HD lenses specifically designed to complement the cost and performance of these new tapeless camcorders.

Separately, the recording sections of these HD camcorders resort to a range of aggressive bit-rate reduction strategies to meet the specified recording times of disparate media,

which include tape, optical and hard disk drive, and solid-state memory cards. These strategies include component video color recoding, digital filtering and bit-depth reduction, and finally, advanced compression algorithms employed (many with quite aggressive compression ratios). There are subtle imaging footprints associated with all of these expediencies.

Figure 5. The HD ENG picture should seek optimization of imagery in the central zone of the picture (where primary subjects are generally framed) and accept any inherent modest shortfalls at picture extremities.

Maximizing HD ENG picture performance entails different criteria than those used in HD studio cameras, the imperative being the best possible imagery within the technical constraints listed. Engineering must collaborate closely with production and news photographers in this quest. Optimization of the central zone of the image plane in terms of sharpness, contrast, color and exposure latitude is a priority. Superb picture edge sharpness off the recording media should be the primary concern for ENG. Everything that the HD ENG lens can possibly deliver to the camera over that lower and midband spatial frequency range is precious contrast detail that comes with no additional penalty in noise, aliasing or compression artifacts.

The unpredictable scene illumination (day and nighttime) encountered in ENG shooting places a special priority on reconciling optimization of camera dynamic range with the bit depth of the recording system.

Key concepts to keep in mind when selecting an HD lens and camera for ENG, include:

- At picture extremities, the HD ENG lens sharpness will be compromised relative to that of the high-end studio lens. The contrast will likewise be impaired at picture extremities (relative light distribution characteristic). Optical aberrations will also be higher.
- Minimizing digital image enhancement has a special importance in ENG in that the filtering and compression of the recording system can exacerbate associated aliasing and noise as well as alter edge transitions created by that enhancement.
- Patient and iterative testing and adjustment is required to maximize the playback performance of any of the new low-cost tapeless lens-camcorder systems.

Further steps need to be taken for optimization. Start with the camera (initially ignoring the recording section) using the direct HD-SDI feed available on most HD camcorders. Optimized tonal reproduction of high contrast scenes will require particular care in the setting of the overall nonlinear transfer characteristic (black levels, white shading, gamma, black gamma and knee controls).

Record a range of carefully selected test pictures (reflective of news acquisition in daytime and nighttime) in the camcorder, and play back the pictures onto a large accurately aligned HD monitor (preferably in the region of 60in diagonal). Compared to the raw camera images, the imaging footprint of the recording will be apparent. For example, some scene color detail may fall victim to color component coding strategies (such as 4:2:0 and 4:1:1) together with associated digital filtering.

Textural detail may be somewhat compromised by digital recording bit-rate reduction strategies. Compensating for these may require iterative adjustments to camera image enhancement controls (recording and playing back each time) to optimize sharpness of the central zone of a medium-angle shot. (See Figure 5.)

Eventually, an optimized set of adjustments will be identified that provide the cleanest, sharpest high-contrast imagery in the central region of the picture. Any attendant imaging shortfalls at the extremities should simply be accepted. Most HD camcorders allow storage of these special ENG settings on a memory card.

Summary

HD studio cameras outfitted with studio-style HD box lenses provide maximum HD performance, delivering the best possible image across the entire image plane. Only the studio box lens embodies all of the required performance attributes. HD ENG camcorders outfitted with portable HD lenses don't offer the same performance as their studio cousins, but are essential for news. HD image performance is nevertheless impressive, as these camcorders exploit powerful contemporary digital-camera controls that optimize the look of the playback HD. BE

Larry Thorpe is the national marketing executive of the Canon Broadcast and Communications Division.