IMAGE LEVEL SHIFTS WITH HLG

Summary

The HLG display function maps the full signal range to the brightness of the specific display, with a display gamma that is a function of the display brightness. This makes images displayed on monitors with different brightness levels inherently unmatched, thus altering creative intent.

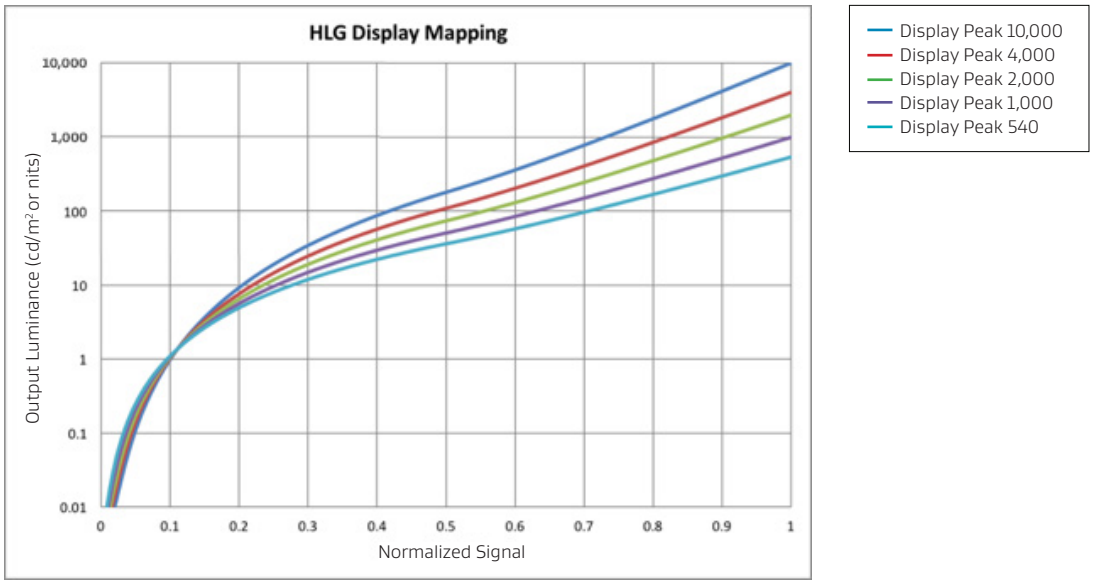
Details

Much has been claimed about HLG being a "display independent" signal, but this is not true. The image is typically altered via camera or other adjustments while being viewed on a specific display during program production, thus the production display does have an effect on the produced signal. If the signal is viewed on a display with different capabilities, the image will differ from the image that was seen in production. The important issue is whether "creative intent" is maintained.

The display mapping operation used by HLG is specified in Recommendation ITU-R BT.2100 as part of the HLG EOTF, and the display gamma is set by display brightness L_W according to this formula:

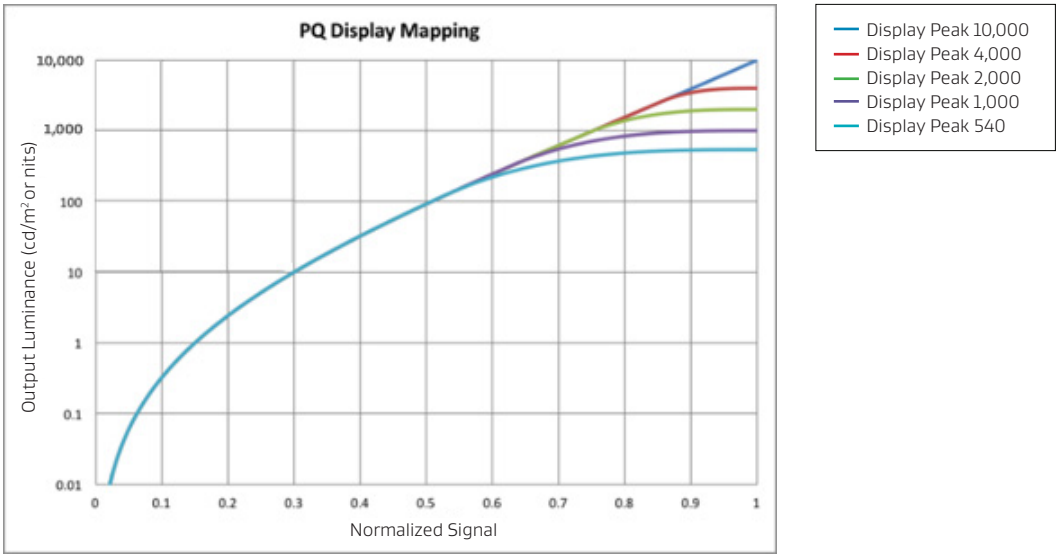
$$\gamma = 1.2 + 0.42 \mathrm{Log}_{10}(L_W/1000)$$

Basically, the HLG EOTF maps the signal to the full brightness range of the display being used, and then applies a system gamma adjustment. This plot illustrates the mapping on a selection of potential displays:



It is easy to see that significant changes in displayed image levels occur when displays of different peak brightness are used. As an example, if a producer could see a 4,000 cd/m² display next to a 1,000 cd/m² display in their production room, human faces and other common objects would appear brighter on the 4,000 cd/m² display. The producer would have to decide for which display they wish to optimize their HLG signal. If faces are set for the desired brightness on the 4,000 cd/m² display, then the faces on the 1,000 cd/m² display will appear too dark. Conversely, if faces are set to achieve their artistic intent on the 1,000 cd/m² display, then the faces on the 4,000 cd/m² display will appear too light.

PQ signals on the other hand represent actual brightness levels in the production environment. Since they cover a full 0-10,000 cd/m² range, they are never scaled up for brighter displays. For lower output displays, a soft clipping function (described in Report ITU-R BT.2390) is applied which mainly affects the highlight regions, leaving most of the signal range unaltered as shown on the next chart.



The result is that PQ images remain very consistent across all displays. A set of images (courtesy Robert Primes, ASC) follow to illustrate the differences which we would expect to see on PQ and HLG displays of different brightness levels. (Note that these images had to be tone mapped for viewing in this document.)

2,000 cd/m² PQ Display (reference)

2,000 cd/m² HLG Display

1,000 cd/m² PQ Display

1,000 cd/m² HLG Display

540 cd/m² PQ Display

540 cd/m² HLG Display