P.81: Image Sticking Cartography on PDP TV: A New Quantitative Measurement.

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Abstract

Image sticking phenomenon is currently one of the most serious problems of PDP for television applications. In this paper, we introduce a new automated solution to measure quantitatively the temporal image sticking on this type of display. The method is based on the use of a high quality and rapid 2D luminance meter that takes images of the PDP versus time. The panel is burned with a given test pattern during a fixed time and then switched to dark or bright state. The temporal evolution of the remaining image sticking level is followed in real time by the luminance meter. For quantitative cartography a chessboard is used as test pattern and the temporal evolution of each elemental pattern is deduced and adjusted with exponential decays. Quantitative information on the time constant and the amplitude of the effect are deduced on the entire surface of the panel. So the quality of each panel can be precisely determined which allows quality control at the end of the fabrication process and quantitative comparisons between different panels.

1. Introduction

Rapid growing of the PDP (Plasma Display Panel) market for digital high definition television is now just at its beginning. However, there are still some issues related to the image quality of this type of display. Among them, the most critical is the image sticking phenomenon. This phenomenon has been studied by different authors both for PDP [1-3] and LCD [4-5]. It causes a deterioration of the image due to the residual image pattern still remaining on the subsequent images. It occurs when the same image pattern is displayed repeatedly over a short time (around 5 minutes) and has been related to the activation of MgO surface or the degradation of phosphor layers during the strong sustained discharges [1-2]. Special driving methods to reduce this parasitic effect have been proposed [3]. Nevertheless, the effect is never completely suppressed and accurate measurement methods are needed to quantify the phenomenon. Since it is mainly due to charge trap inside the structure of the panel it is certainly process dependent and then not necessarily homogeneous on the surface of the panel.

A method to quantify imaging sticking on LCD panels has been proposed in 2002 [5]. It is based on the use of a 2D luminance meter and chessboard pattern generator. We have applied the same type of method – adding in addition the notion of temporal dependence - to PDP using our new accurate and rapid 2D luminance meter MURATest. An automated method to analyze the temporal dependence of the patterns and adjust exponentials decays models has been implemented.

2. Description of the Method

2.1 2D Luminance Meter Requirements

Image sticking phenomenon requires a high signal/noise ratio for the measurements even if the effect is quite strong on PDP displays. Indeed, the human eye sensibility is in many aspects very high and residual image pattern less than 1/10000 of the original level can be easily detected depending on the conditions. The second main requirement is the measurement speed to be able to follow the temporal dependence of the effect as closely as possible. ELDIM MURATest has proven through years its excellent capabilities for 2D luminance (and color) imaging, thanks to a cooled CCD sensor and a high quality optics. In the third generation of the product, we use a Kodak CCD sensor with a real 16bits A/D converter and dark current compensation that ensures very low noise and high dynamic range.

2.2 Description of the Measurements

The experiment is completely computer controlled at all its steps. A black screen is first applied to suppress any remaining image sticking of a previous experiment. The duration depends on display quality and on the previous experiments applied to the display. It can be as long as one hour for displays with very high image sticking. A specified pattern is then applied on the display during a given time (typically 5 to 15 minutes). The luminance of the panel is taken during this step and use as a reference for the temporal analysis. Afterwards the panel is switched to black or white state and real time luminance measurements of the entire surface of the panel are performed versus time. For white state switching the integration time of each measurement is fixed all along the experiment since the luminance of the panel is always high and around the same values. For black state switching the integration is adapted versus time for an optimize evaluation of the temporal dependence (as short as possible just after switching and as long as 30s at the end of the experiment).

As an example, figure 1 shows some luminance measurements taken on one PDP using a chessboard pattern. On figure 1.a the original chessboard pattern is reported and its remaining image after 100 seconds due to image sticking for dark and bright configurations are reported in figures 1.b and 1.c respectively. The remaining image of the chessboard pattern is easily detected in both cases. One can notice also that white cells of the chessboard remain brighter than the black ones when switching to dark background (dark image sticking) whereas they appear darker by switching to bright background (bright image sticking).

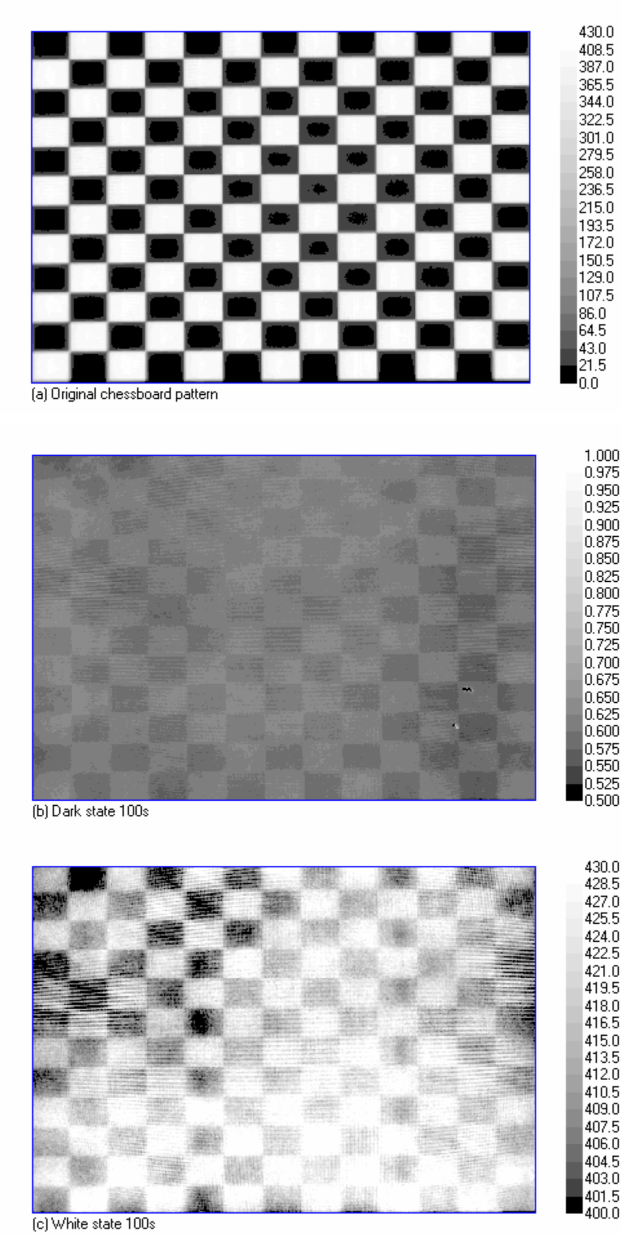


Figure 1: Original chessboard pattern (a), residual pattern after dark switching (b) and residual pattern after white state switching (c) both after 100s. Scale is directly the luminance of the panel (in Cd/m^2).

The mean luminance of specified areas can then deduced for each image versus time. When displaying chessboard pattern, specified areas are white cells in case of dark background and black cells in case of bright background. One example of such temporal dependence is reported in figure 2. The average luminance of the selected area is reported for a time scale depending on the assumed image sticking length (around 3 hours and 1 hour for dark and bright background respectively). We can notice that the time scale of the phenomenon is very different for dark and bright background cases. Main variation takes place during the first minutes for white state switching when it takes hours for dark state switching.

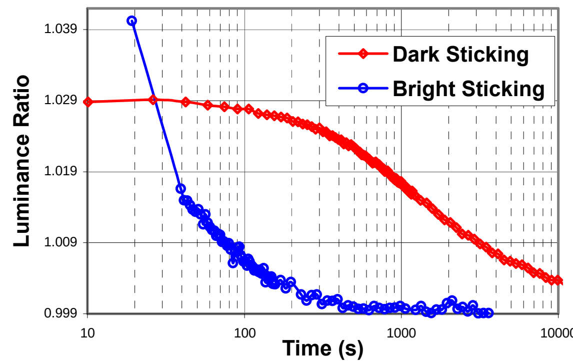


Figure 2: Temporal dependence of a chessboard cell for white and black state switching. Luminance is calibrated on white or black background without image sticking. Time Scale is logarithmic.

To quantify precisely the temporal behavior we have adjusted an exponential decay with two time constants on the experimental data following:

$$I(t) = 1 + \alpha\, e^{-t/\tau} + \gamma\, e^{-t/\mu} \qquad (1)$$

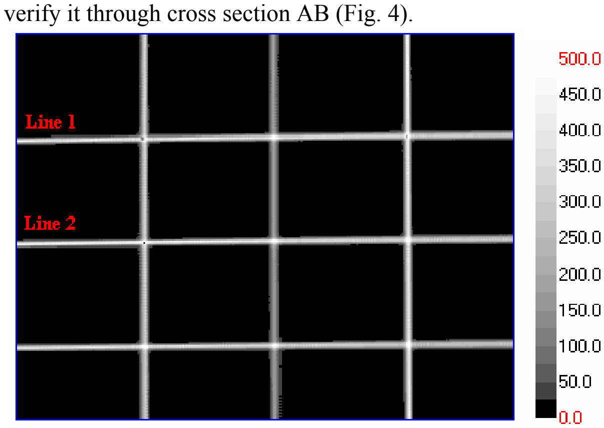
The sum $\alpha + \gamma$ corresponds to the amplitude of the phenomenon at the beginning of the measures, τ and μ are the "short term" and "long term" constants respectively and the result $\alpha.\tau + \gamma.\mu$ (Integral of $I(t) - 1$) can be linked to "quantity of ions" stored in the cells (or "trapped" in case of image sticking effect) and can be used to quantify the "amount" of image sticking.

3. Experimental Results

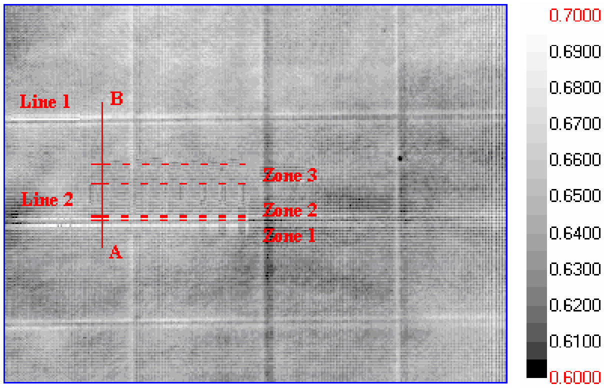
We focused our study on two different analyses. We first looked to the pixel and line analysis to demonstrate the sensitivity of our method. A second part of the study is devoted the uniformity measurements on different panels using the chessboard method.

3.1 Pixel and Line Image Sticking Analysis

Any pattern can be used to study the sticking effect. The use of hatch pattern with only one pixel width lines is useful to understand image sticking phenomenon on these lines and on their neighboring lines (Fig. 3). As can be seen on figure 3.b, a dark line surrounded by bright ones appears where the white lines were displayed (more visible on horizontal lines). We can verify it through cross section AB (Fig. 4).



(a) Original Pattern



(b) Dark Image Sticking

Figure 3: Original lines pattern (a) and residual pattern on dark background (b) after 100s. Scales are directly the luminance of the panel (in Cd/m^2).

In order to measure precisely the different time evolution, the software allows defining different zones in the panel. In this example we have defined three zones of study (cf. Fig. 3.b and Fig. 4). Zone 1 represents the pixel row of the PDP originally lighted during the burning. Zone 2 collect the pixel row of the PDP just above and Zone 3 is located in a region far from the lines. The average of the intensity ratio on these zones is reported in figure 6 and confirms our observations: the area in the direct neighborhood of borders is more sensitive to image sticking phenomenon than the border itself.

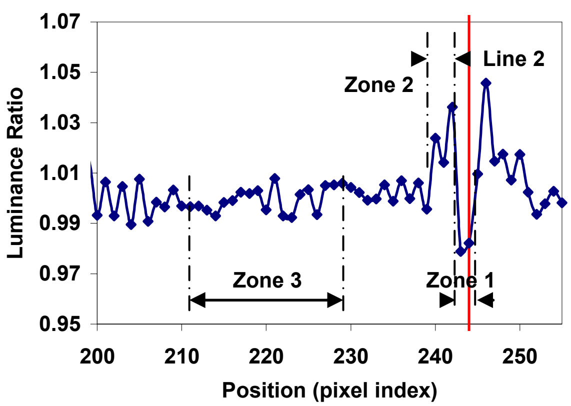


Figure 4: Cross section AB of Figure 3.b. Luminance is calibrated on dark background without image sticking.

3.2 Image Sticking Cartography

We applied a chessboard pattern to study the global image sticking behavior on all the surface of different PDPs. As shown in Fig. 6, the amplitude of the phenomenon taken on one cell varies drastically depending on the panel: it is very low (2%) for panel 2 whereas it is quite important (18%) for panel 1. This difference is certainly due to the technology of the panel and in particular to the driving methods. Special methods have already been developed to reduce image sticking [3]. With our measurement method the difference can be quantitatively determined.

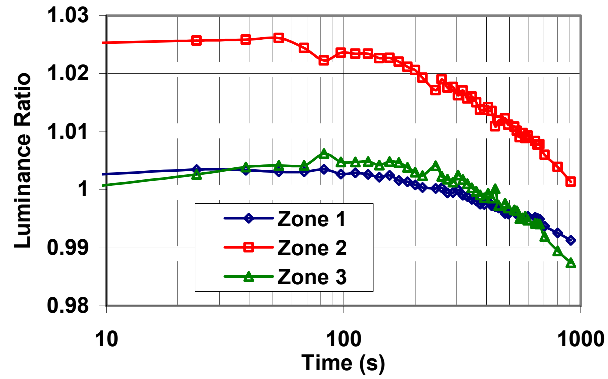


Figure 5: Temporal dependence of zones 1, 2 and 3 for dark background. Luminance is calibrated on dark background without image sticking.

The experimental curves of figure 6 are adjusted closely with the formula (1). The extracted parameters are summarized in Table I. In this way, the difference between the two panels can be quantitatively evaluated. These parameters are evaluated for all cells/areas on each panel. Their intensity reported in a map is a precise picture of the homogeneity of the panel for the image sticking phenomenon.

Sample	Panel 1	Panel 2
amplitude α	0.091	0.000906
time constant τ (s)	323.8078	493.2085
amplitude γ	0.087506	0.012416
time constant μ (s)	2163.364	1529.142
$\alpha.\tau + \gamma.\mu$	218.7733	19.43252

Table I: Fitted parameters for a specified area of two different PDP after dark state switching

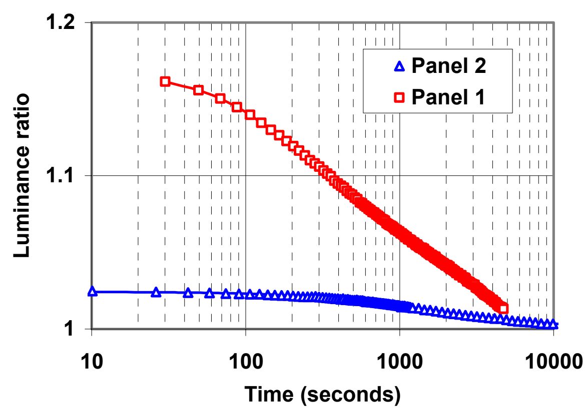


Figure 6: Exponential fitted temporal dependence of a specified area of two different PDP after dark state switching. Solid curves are the best adjustments using the formula (1).

On figure 7, for example the time constant μ is reported for panel 1 and one can see immediately that the behavior of the panel is not homogeneous versus time. The top of the panel exhibit time constants about two times lower than the bottom of it. This type of effect can be noticed directly by eyes but a quantitative measurement is especially useful and allows precise comparisons betweens different panels. The repeatability of the measurement has been checked. An example including three consecutive measurements is reported in figure 8. The different measurements are closely correlated (Variance = 0.8%). The little discrepancies can be attributed to the difficulty to get the panel completely free of remaining image sticking before starting a new experiment.

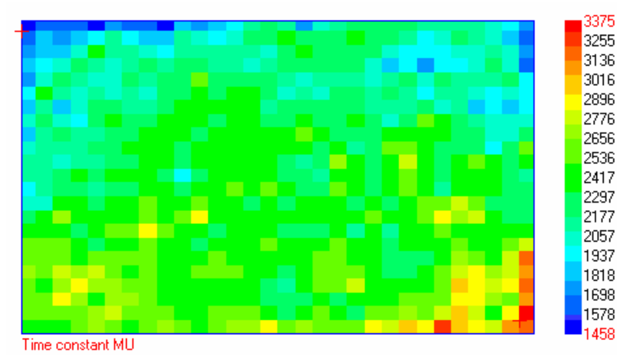


Figure 7: Cartography of the time constant μ for panel 1. The scale is directly in seconds.

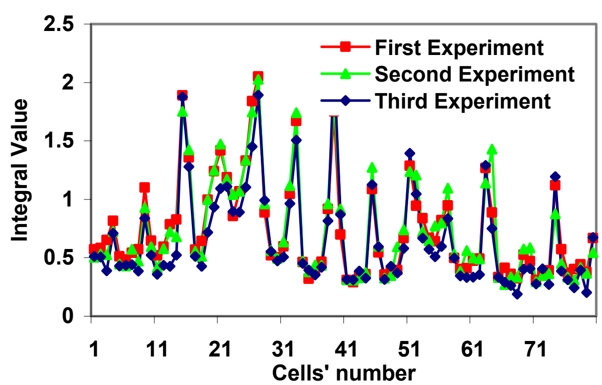
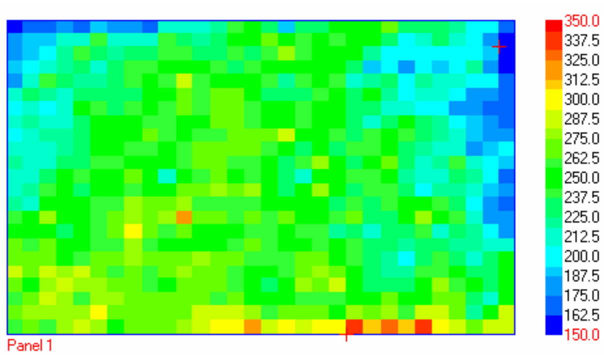


Figure 8: Comparison of image sticking phenomenon in 80 different cells/areas for 3 consecutive experiments.

On figures 9.a and 9.b we have reported the cartography of the "amount" of the image sticking for the two panels. Here also the effect is clearly non homogeneous with variations of more than 100% from one area to the other on the same panel. There is no real symmetry or special shape in these diagrams and the two panels are completely different.



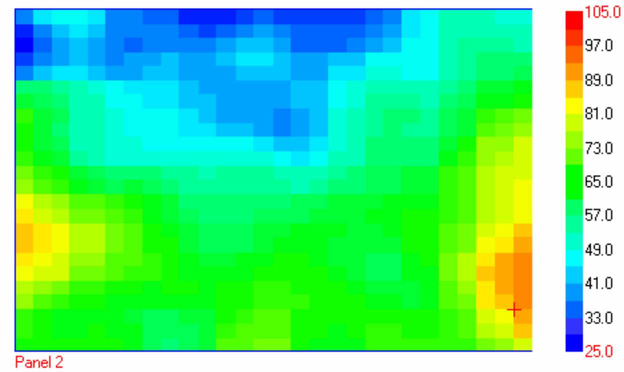


Figure 9: Cartography of the"amount"of image sticking $\alpha.\tau + \gamma.\mu$ for the two PDPs. The chessboard resolution is different for two panels.

Nevertheless, this information can be, without doubt, related to one or different steps of the fabrication process of the panels. Moreover, panel 1 is much less efficient in term of image sticking correction than panel 2 (values around 250 for panel 1 against values around 50 for panel 2 for $\alpha.\tau + \gamma.\mu$). Due to its repeatability, we think that this type of information can be extremely useful to control the manufacturing process and especially the deposition step of the MgO and phosphor layers.

4. Conclusion

We have presented a new method to measure accurately the image sticking phenomenon. This method used a 2D luminance meter and a precise temporal analysis of the effect. Through this process we define amplitude, time constants and "quantity" to characterize image sticking phenomenon for any position on the surface of the panels under test. These measurement are repeatable and absolute in the sense that their can be compared from panel to panel. We have shown for the first time that the image sticking effect is not homogeneous on the surface of the panels. This characterization of the phenomenon can be useful to understand more closely this effect and to improve the manufacturing process, especially MgO and phosphor layers deposition.

5. References

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