CRT Dynamics

A report on the dynamical properties of CRT based visual displays

Introduction

In 2004 more LCD-monitors have been sold as computer monitors than CRT-based monitors. When LCD-monitors are used foe office work with a computer, there are quite some ergonomic advantages that make LCD-monitors more attractive than their heavyweight counterparts (e.g. contrast, flicker, reflections, etc.).

Since LCDs have started to replace the CRT in television sets as well, some people begin to realize, that at least the dynamic performance of CRT screens is somehow better than that of their flat replacements.

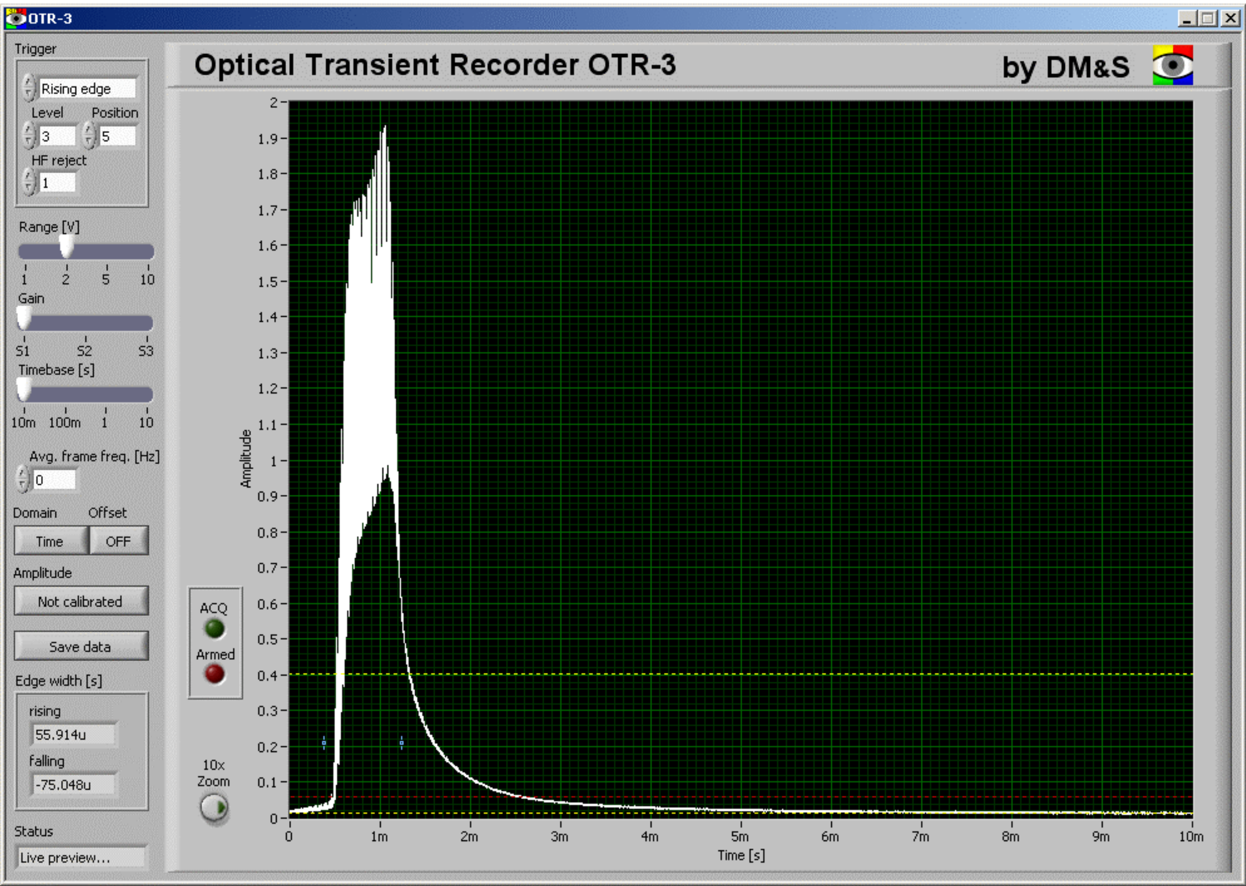
An effect that is usually distinctly visible is the blurring of the edges of moving objects. The faster these objects move the more the (initially well defined) edges become blurred.

This phenomenon is based on two effects:

- LCDs are hold-type displays, e.g. they display a constant visual information over one frame period while CRT screens flash the visual information for a small fraction of the frame period,
- the *smooth pursuit eye-tracking* of the human visual system that makes the eye follow a moving target.

This movement of the eye over an image that remains constant and fixed during one frame period causes the blurring of edges and other details.

In this report we present results of our measurements and evaluations of the dynamics of CRT-screens for comparison to data obtained from LCD-screens.



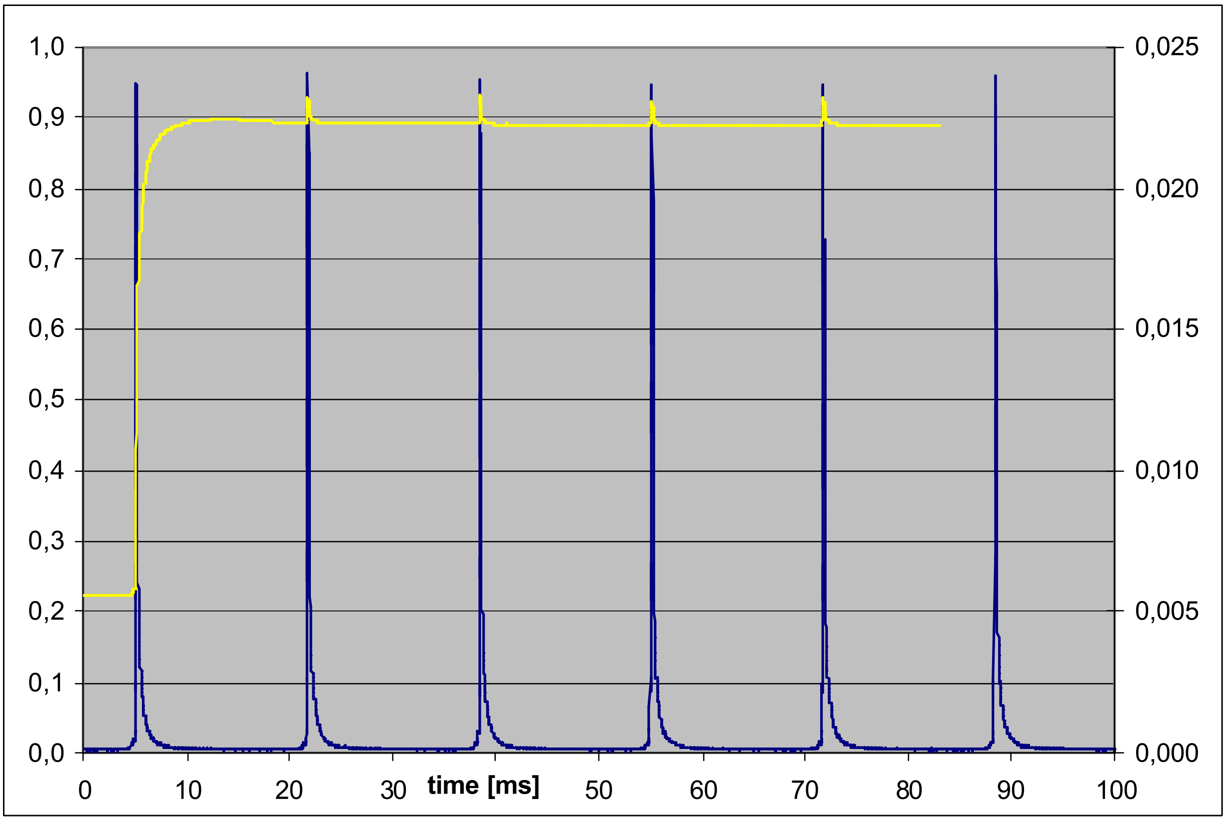


Fig. 1: Switching from dark to bright (0 → 255), pulses at a rate of 60 Hz (blue curve) and convolution of the pulses with a window of 1 frame-period width (16,667 ms, yellow curve).

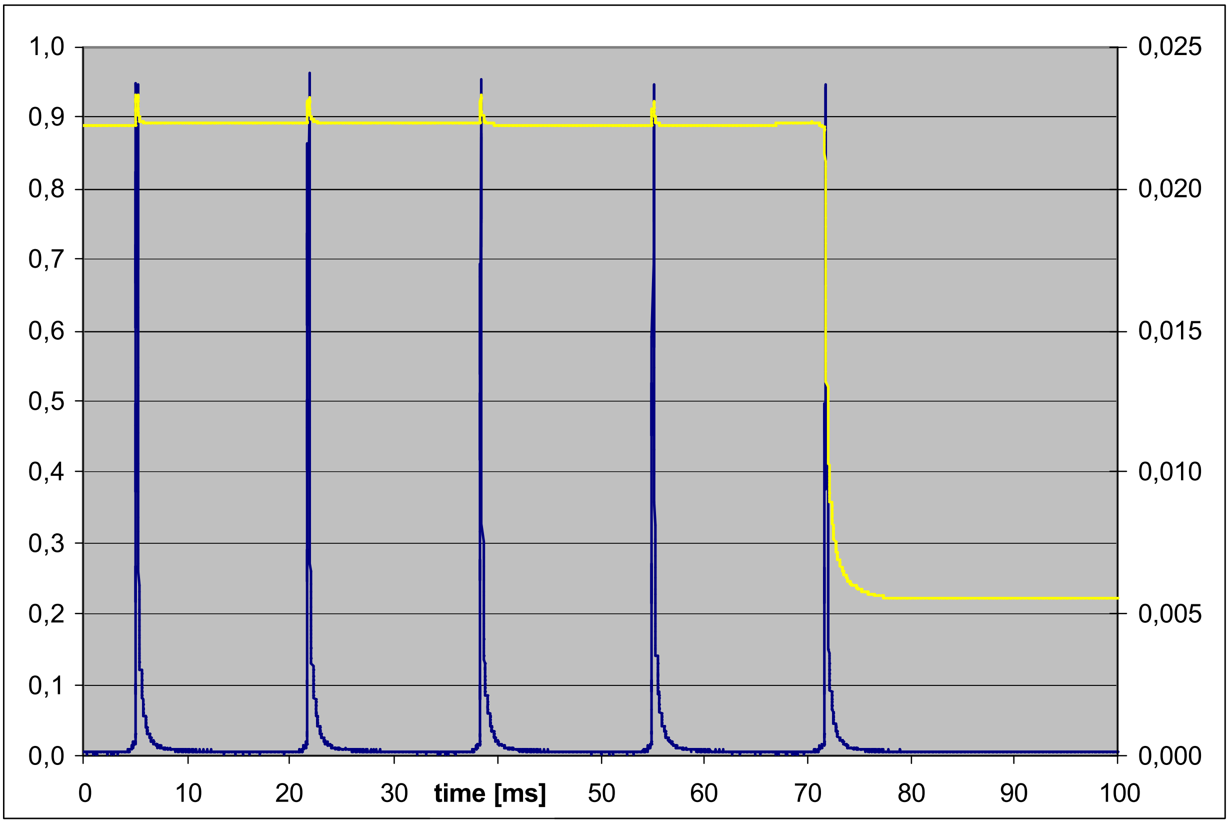


Fig. 2: Switching from bright to dark (255 → 0), pulses at a rate of 60 Hz (blue curve) and convolution of the pulses with a window of 1 frame-period width (16,667 ms, yellow curve).

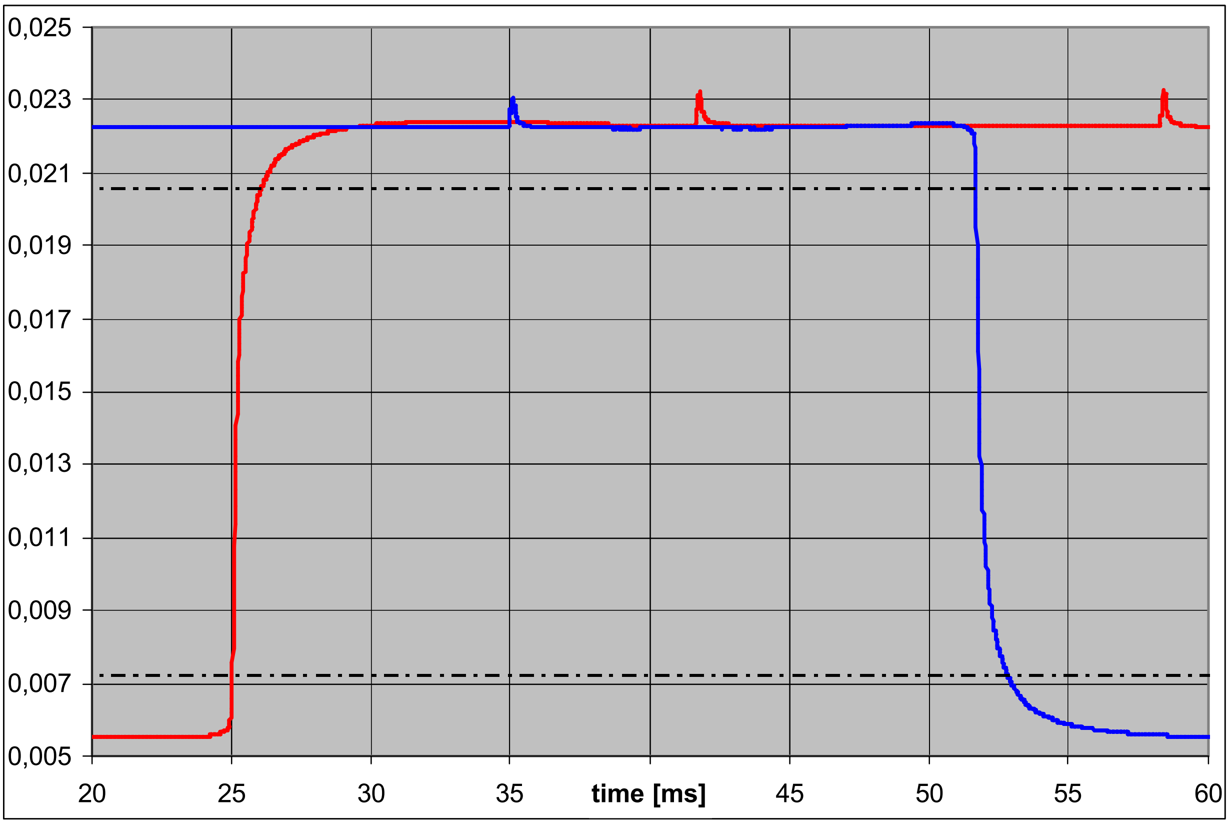


Fig. 3: Transitions between dark and bright state obtained from the pulses of figs. 1 and 2 by convolution with a window of 1 frame-period width.

The slope of the transitions is characterized by the time that elapses between a change from 10% to 90% of the stationary states (plateau values).

	rising	falling
$(t_{90} - t_{10})$ [ms]	1,04	1,12
blurred edge	0,062	0,067

The ***normalized blurred edge*** is characterized here by the blurred edge time (time that elapses between a change from 10% to 90% of the stationary states) divided by the frame-period. The normalized blurred edge is thus dimensionless. When multiplied with the advancement per frame, the ***blurred edge width*** is obtained, when multiplied with the frame period the blurred edge time is obtained.

While 80% of the transition (i.e. between the 10% and the 90% level) happens in a short period of time, the final 10% take 2 – 5 times as long as the transition from 10% to 90%.

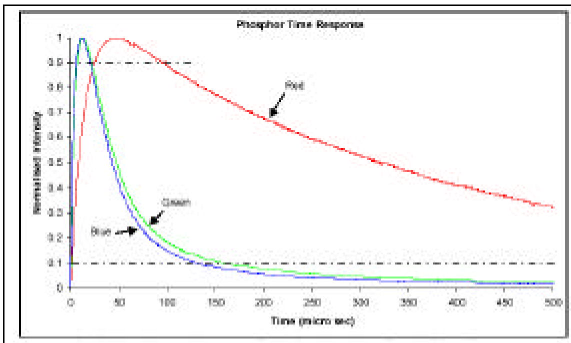


Fig. 4: Dynamics of typical CRT phosphors. The red phosphor is considerable slower than the blue and green phosphor.

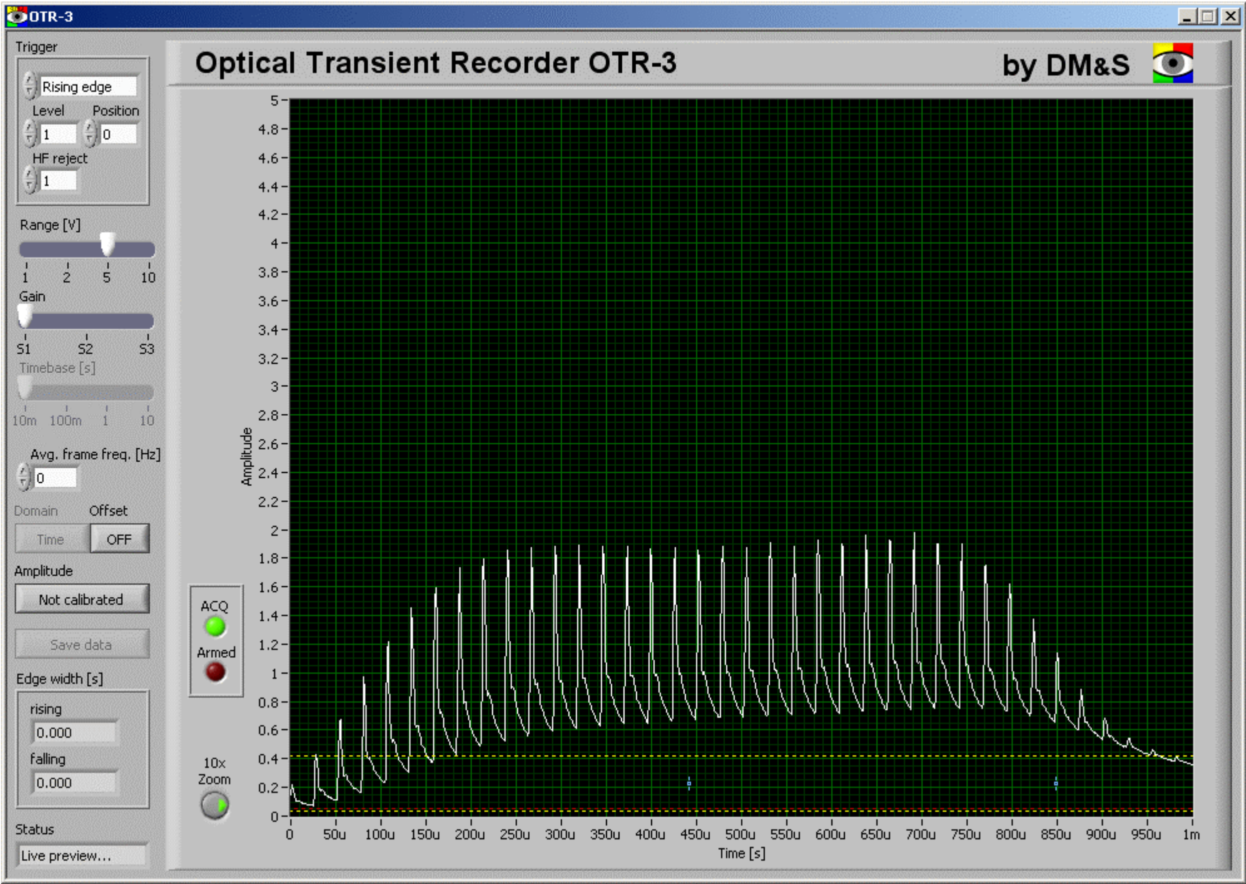


Fig. 4: Sequence of pulses corresponding to the lines that are written one after the other across the area of the field of measurement (15mm diameter).

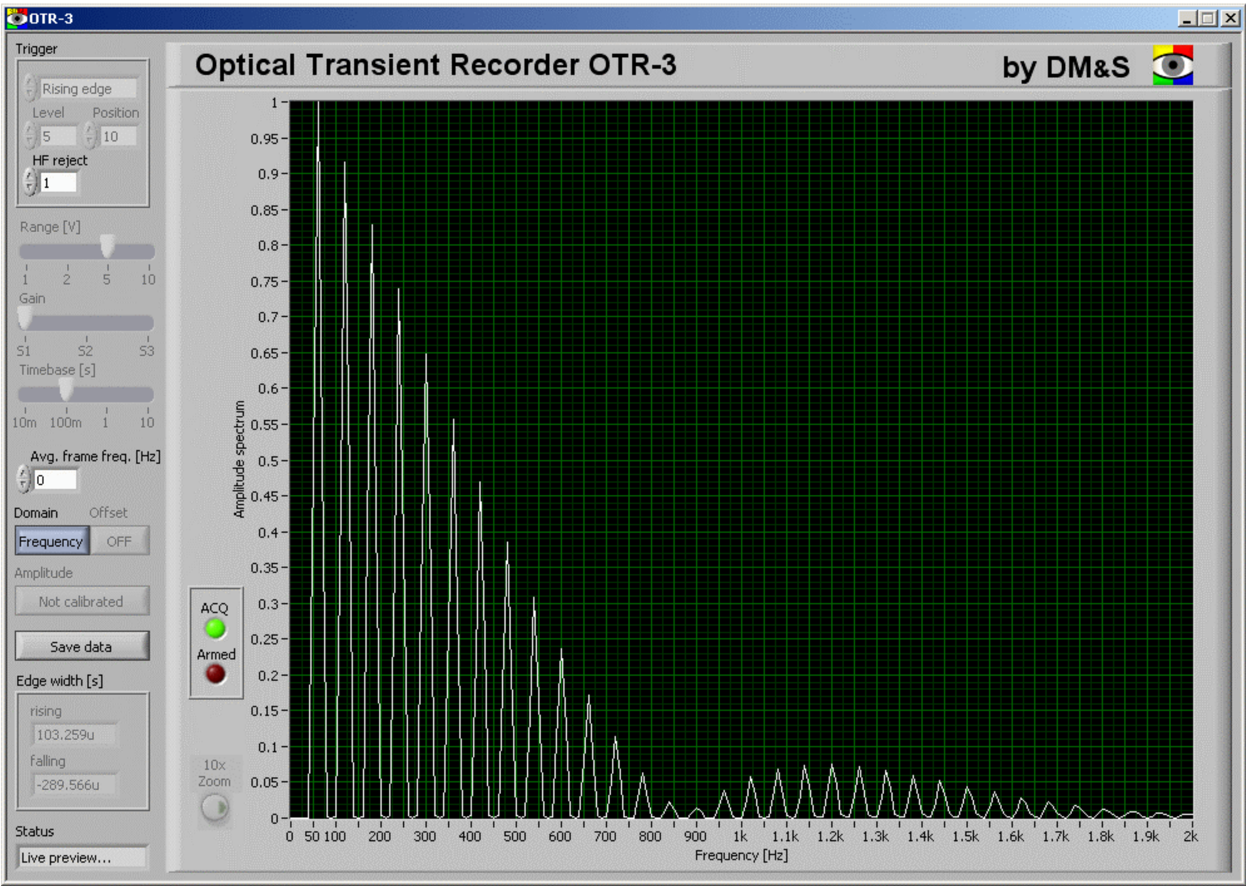


Fig. 5: Frequency spectrum (amplitude) of the pulses of figs. 1 and 2.