

White Paper

Automatic Phase Adjust for analog RGB inputs on LCD displays

What's inside?

- Image quality issues with LCD displays driven by analog generators
- How to overcome these issues

Jan Deraedt
Sales Support Engineer
Barco nv
Security & Monitoring Division
Jan.Deraedt@barco.com

Barco
Pres. Kennedypark 35
B-8500 Kortrijk, Belgium



Copyright © 2007
BARCO n.v., Kortrijk, Belgium

All rights reserved. No part of this publication may be reproduced in any form or by any means without written permission from Barco.

Jan Deraedt



Table of contents

1 Introduction **4**
2 What causes the phase shift anyway ? **6**
3 Somewhat more technical..... **7**
4 Conclusion **13**

1 INTRODUCTION

An important difference between CRT monitors and LCD panels is that the former require an analog signal to produce a picture and the latter require a digital signal. This is why the set-up of an LCD's clock and phase controls is critical to obtain the best possible display quality. It also creates difficulties for panels that do not possess automatic setup features and require these adjustments to be made manually.

The problem occurs when LCD panels are used with legacy graphics generators, which have analog outputs. In this situation the graphics signal is generated digitally inside the PC, converted by the graphics card to an analog signal, then fed to the LCD panel where it has to be converted back into a digital signal. For the whole process to work properly, the two converters must be adjusted so that their clocks are running at the same frequency and phase. This requires that the clock and phase for the converter in the LCD panel continuously be adjusted to match with the graphics card.

There is no issue with DVI outputs.

This is exactly what Barco's Automatic Phase Adjust (APA) functionality does: when the generator clock is drifting (this is a slow process), APA constantly adjusts the sample clock in the display to maintain a crisp image.



Fig 1a: Correctly sampled image



Fig 1b: Wrong sampling due to clock phase shift

As can be seen in the above picture, wrong sampling is especially noticeable with text, non-horizontal line segments, and checker board patterns.

2 WHAT CAUSES THE PHASE SHIFT ANYWAY ?

The phase shift can have several causes. First of all, it is different for every single generator, so switching between generators implies a readjustment of the display. For one given generator, changing the length of the cables can also cause a phase shift, again resulting in the need to readjust the display. These configurational changes probably do not happen that often, so the display sample delay adjustment could perhaps still be done manually.

However, the generator Horizontal Sync phase also dynamically drifts with temperature changes and aging. Especially the temperature changes are annoying to manually compensate for, since these happen quite frequently and rather fast: e.g. startup of the system (electronics warming up !), fans switching ON/OFF, airco system...

3 SOMEWHAT MORE TECHNICAL

In a CRT display, due to the nature of writing the image to the screen (horizontal & vertical deflection of the electron beam), both a horizontal and a vertical synchronization signal are generated by the graphics card and fed into the display. Since the CRT is an analog display device (analog addressing of pixels), there is no need to sample the video signal, and as such no need to have the pixel clock as a signal inside the display.

In a LCD display, the pixels are addressed in a discrete way (each pixel has its fixed position in the screen), and as such, the ideal video input to the display would be a serial data stream containing the video information, combined with a pixel clock for synchronization. There is no need for a horizontal and vertical synchronization signal, since there is no deflection. But with the millions of legacy graphics generators out there, these are exactly the signals that are fed to the LCD display, together with the analog RGB. The pixel clock, required to sample the analog RGB signal, is not fed from the generator into the display. Instead, it needs to be reconstructed at the display side using the HS & VS timing information, and the total number of pixels per line.

And this is where the problem comes in... the pixel clock (= display sampling clock) is derived from the horizontal sync (HS) signal from the generator, so the slightest phase shift of the HS signal implies a shift of the pixel clock with possible miss-sampling, and thus a noisy, "jittery" low-quality image !

As displays (and especially their native resolutions) grow larger and the margin of error on graphics boards and in the display becomes smaller, the importance of Automatic Phase Adjustment also increases.

Let's have a look at what exactly happens inside the graphics generator and the display, with respect to timing.

In the generator, an analog video signal is generated from digital data. Also the Horizontal and Vertical sync signals are created. There is a phase difference (= time delay) between the Pixel Clock (and hence the Video Data) and the Horizontal Sync: $\delta 1$.

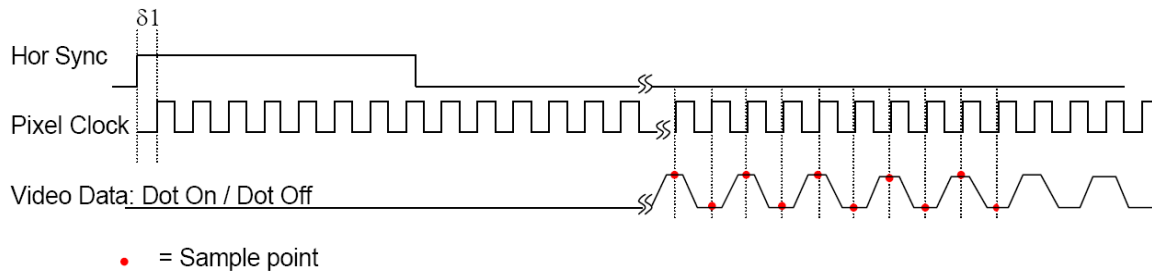


Fig 2a: Generator signal waveforms

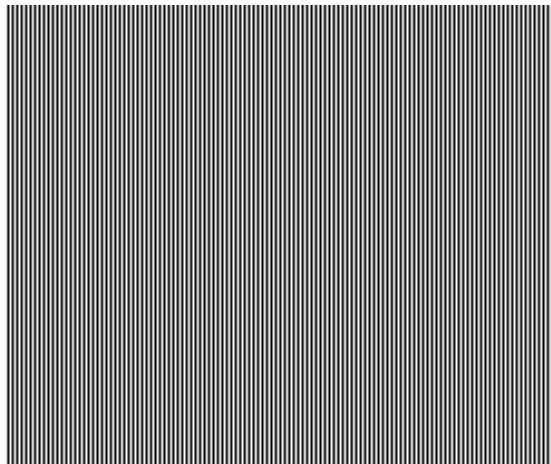


Fig 2b: Generated image as per generator video data in Fig 2a.

At the display side, the Pixel Clock (that is used to sample the video data) is created by multiplying the line frequency with the total number of pixels per line.

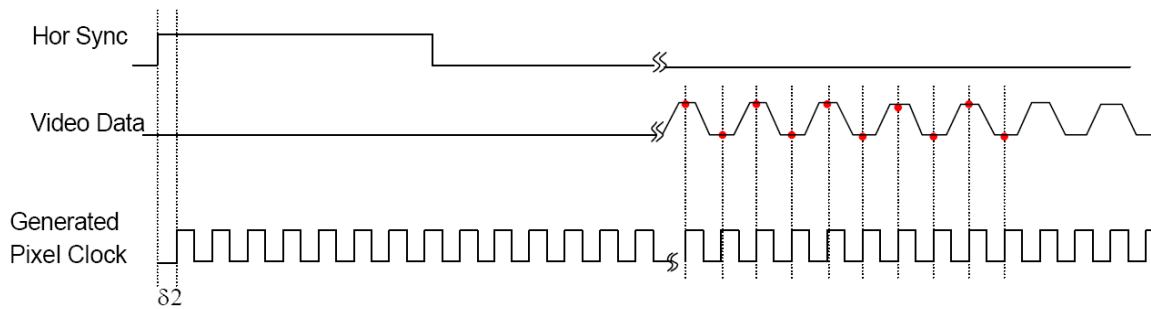


Fig 3a: Display signal waveforms

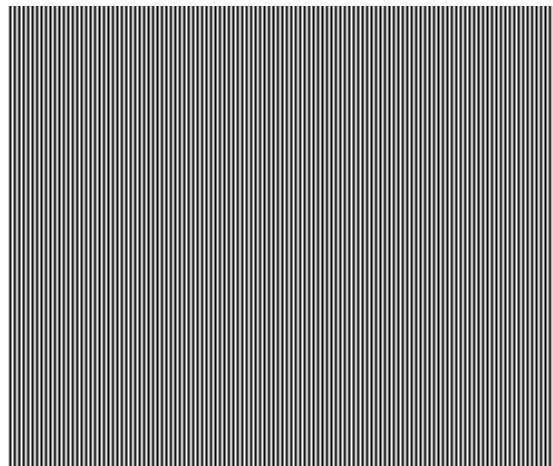


Fig 3b: Displayed image with generated Video Data as in Fig 1a, and correct display sampling phase, as shown in Fig 3a.

By adjusting $\delta 2$ on the display (= Sample Delay), we make sure that the video data is sampled at the correct moment, and a crisp image is shown on the screen.

Now what about APA? Timing parameters in electronics are slightly temperature dependent, causing $\delta 1$ to vary with temperature changes (startup of a PC, fans switching on or off, ...) These changes are small, but enough to affect the image quality.

APA automatically compensates for changes of $\delta 1$. As the native resolutions are becoming higher, so is the pixel clock frequency. Therefore a small drift in $\delta 1$ (only nanoseconds!) already can have an enormous impact. The higher the clock frequency (\sim resolution), the bigger the need for Automatic Phase Adjustment.

What is the result of a drift of $\delta 1$?

If we look at the diagram below, we can see that when $\delta 1$ changes (to $\delta 1'$), that the pixel clock and the generated video also shift with respect to the Horizontal Sync signal. So far no problem.

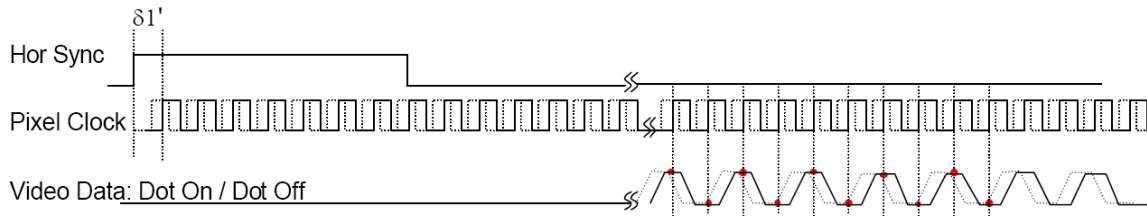


Fig 4: Generator signal waveforms, with phase shift

On the display side, we previously adjusted Sample Delay $\delta 2$ to match $\delta 1$. As $\delta 1$ has now changed to $\delta 1'$, there is no match anymore:

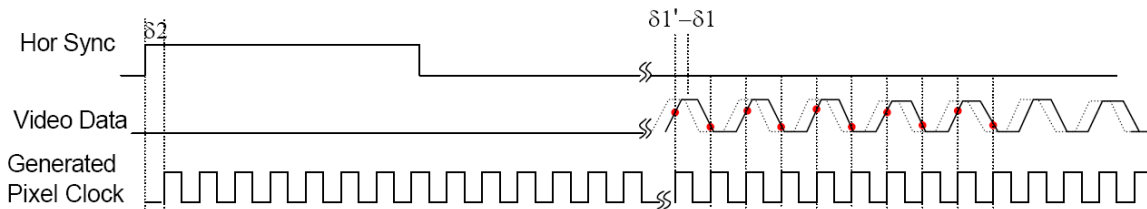


Fig 5a: Display signal waveforms, with phase shift

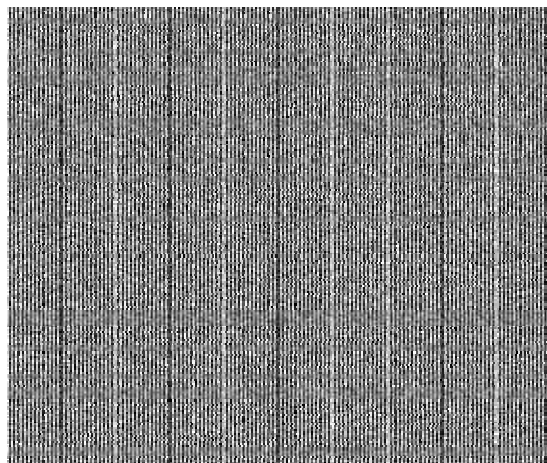


Fig 5b: Displayed image with generated Video Data as in Fig 1a, and phase shift in the display sampling clock, as shown in Fig 5a.

The sampling point shifted so far that we do not get the correct data anymore, resulting in a noisy, "jittery" picture and possible loss of data. So what does APA really do ? It keeps $\delta 2$ locked to $\delta 1$, which is subject to drifting.

This is done, using Barco's proprietary algorithm, keeping the sampling phase automatically correct at all times.

4 BARCO LCD DISPLAYS FOR COMMAND & CONTROL

With APA on its LCD displays, Barco offers the highest quality solution to support the legacy market (analog RGB generators), with easy upgrade paths to the newer digital graphics generators, by providing a modular display input approach.

APA is standard implemented in all Barco LCD displays for Command & Control (e.g. RFD 251 series, MRFD series, ISIS, FD-471, TL family ...).

5 CONCLUSION

APA is relevant to analog video inputs only, digital video signals (DVI) do not suffer from phase shifting, as the pixel clock is one of the signals fed directly from the graphics generator into the display (so the conversion clocks are running at the same frequency and phase all the time).

Since an LCD panel is a purely digital device, it makes much more sense to feed it with digital data directly via a DVI interface. It seems wasteful to use a RAMDAC in a graphics card to convert the digital signal to analog, send the analog signal to the LCD panel, and then convert it back to digital inside the panel.

For simulations showing the effects of sampling clock shifting on image quality, visit the Barco website at <http://www.barco.com/defense/en/Technology/apa.asp>.

For more information, please contact your Barco sales representative or visit www.barcodefense.com.