Method and Apparatus for Digital Auto Convergence of Projection Video Display

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Abstract

This thesis provides a new digital convergence method and apparatus which uses area photo sensor and new analog to digital algorithmic to identify the correct digital pattern position factor of the projection system. This method and apparatus can be applied to the convergence correction in a TV receiver with a display that comprises a display screen with photo sensors positioned adjacent to screen edges. It also can be applied to the manufacture process detection of the projection system to adjust the associative convergence parameter. In this paper, demonstrate how this convergence detecting algorithmic was implemented with four area photo sensors of special designed pattern to the rear projection CRT TV.

1. Introduction

Increasing demand for large screen TV is giving rise to an expanding market for projection TV suitable for use in the home. Desirable features of a large screen TV include high brightness, a large viewing angle, sharp picture definition and low geometrical distortion. Two of the most important factors which determine good performance in these respects are the convergence and focus characteristic.[1] Figure 1 shows the resulting geometrical distortion of the projected image for each color in the rear CRT projection system. In a digital convergence system convergence values are determined for each display color and applied at an array of points located at intersections of an alignment grid super-imposed on a black background. In a manual digital convergence system, a user may manually adjust deflection parameter at the grid intersections, in either or both horizontal and vertical scan directions, to superimpose individual colored lines to form a white grid on the black background. In addition, optimization of both the convergence and focus of the whole screen is difficult, and invariably results in some degree of trade-off. The key goals of this development project are low manufacturing cost, a high level of integration of functions, and application in a wide variety of different TV sets and standards.

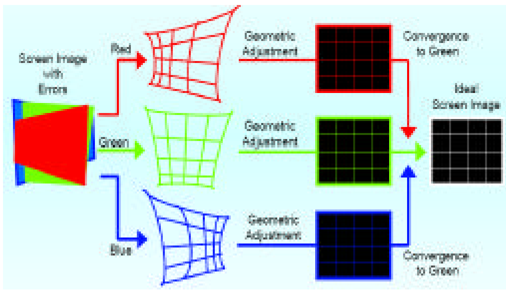

Fig. 1 The geometrical distortion of the projected image for each color.

2. Principle

Convergence correction for one color at one point on the grid consists of the sum of a dynamic component which is typically different for each point of the video grid, and a static component which is equivalent to an offset and valid for the whole grid. The primary use of the static adjustment is to compensate, by feedback, the temperature drift characteristic problem of components, such as the amplifiers, which is used to control the current in the convergence coils. Another use of static adjustment is the compensation for the situation that the convergence is influenced by the orientation of each CRT with respective to the earth's magnetic field, which tends to be screened out naturally by the metallic parts of the set, but which is always present to some degree.[2] However, in order for the set to produce accurate pictures, proper alignment of the beams must be maintained. That is, the CRTs must be calibrated so that their beams are focused at the same point on the screen. The calibration of the CRTs is often referred to the convergence procedure, and the beam alignment is often referred to convergence.[3] For PTV, most screen distortions can be corrected with the primary waveform, secondary waveform, and their combined waveform in the horizontal cycle (H) and vertical cycle (V). The correction of coarse adjustment against major screen distortions can be achieved by using the basic H and V primary and secondary waveforms and their basic composite waveform generated through digital control. The corresponding adjustment the figure 2 display.

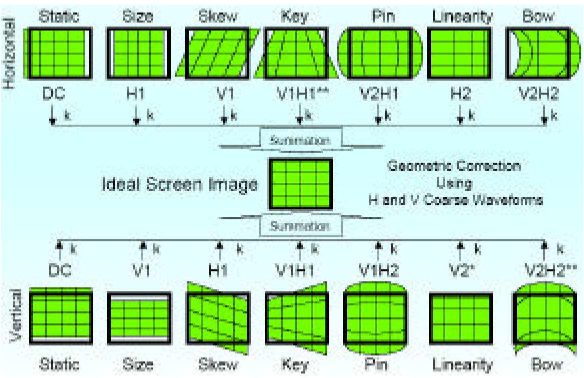

Fig 2. The coarse convergence solution

3. System Architecure

As figure 3 shows, the system includes four convergence photo sensors. These sensors are located at the periphery of the screen, behind a screen frame. During convergence operations, the sensors generate analog signals which are passed to an A/D convert. The A/D converter receives the signals and converts them to digital voltage signals, and passes the digital voltage signals to a controller. The controller then uses the digital voltage signals to perform the convergence calculations and determine the amount of any necessary beam alignment corrections.

Figure 3 is a television system including photo sensors. The system includes a television screen and three CRTs forming images on the screen. Each CRT emits a beam of monochromatic light in one of the three primary colors, and each includes a deflection yoke. Control of the CRTs for the purpose of forming images on the screen is performed by a video processor, includes a pattern generator for forming the convergence test patterns. Convergence adjustment of the CRTs is performed through a deflection yoke driver.

It has been recognized that output signal levels of red, green and blue sensors vary even if an input intensity level is constant or substantially the same. When the input intensity to a photo sensor is maintained at substantially the same level for each of color light beams, the output level of the sensor may varies based on the color. To compensate for the variations in output signal levels of the sensors as indicated in figure 4, a special pattern of photo sensor may be used. Namely, because of the low input signal level which may be additionally influenced by a noise signal level, the resolution of the A/D convert will be so low that the conversion accuracy will be significantly affected.

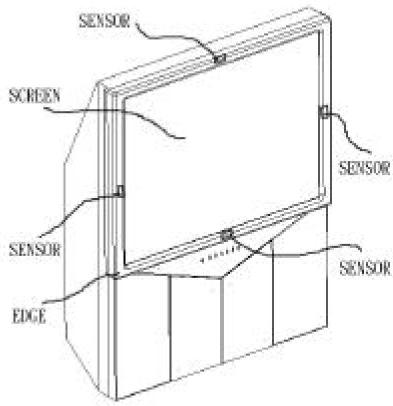

Fig 3. The position of solar cells photo sensor

For this reason, the solar cells pattern is divided into two major parts, one is full sensor area part and the other is the black area that has no response to beam light. The square beam light pattern which has the same width with the full sensor area of the solar cells is projected onto photo sensor. The position of sensors central position P1 to P4 is shown in the figure 4, if the center position of the sensor can be recognized then the position difference can be used to calculate the convergence compensative parameter. The difference between the reference OSD pattern display position with deviation-free convergence and the OSD pattern display position with convergence deviation is given as the unit of coarse adjustment factor by the micro-control. The deviation in the X direction and Y direction given by the micro-control for calculation reflects the result to the coarse adjustment waveform.

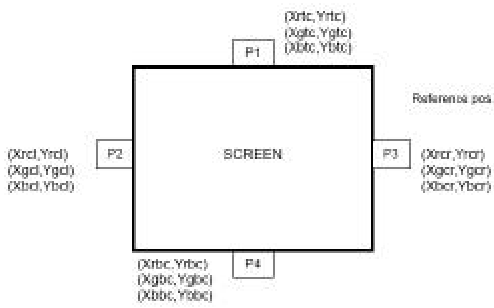

Fig 4. Parameters required for auto convergence

4. The Algorithmic of Detecting Center Position

As the figure 5 indicates, the light beam grows from left to right or top to down. The maximum A/D convert value that transfers to micro-control unit occurs when the beam light occupies the whole full sensor area and the values are recorded in the process when the beam light is spreading through the photo sensor.

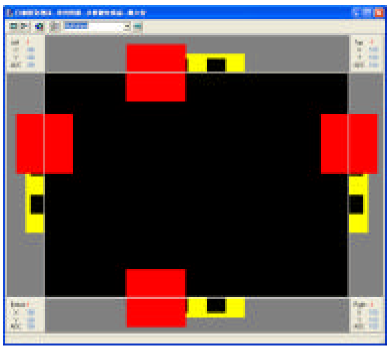

Fig 5. The pattern of solar cells photo sensor by using red color beam

The output voltage of the area photo sensor is proportional to the illuminated area. The voltage sensitivity map can be regarded as an analog function i(x, y), which specify the illumination to voltage intensity at each position coordinate (x, y). If the voltage is processed with a micro computer unit, the analog signal must be converted to an equivalent digital representation. The spatial coordinates (x, y) are sampled at discrete intervals (kΔx,jΔy). If there are m samples along the x coordinate and n samples along the y coordinate, the results in a sensor will be m*n elements. As equation (1) shows, the value of the voltage associated with the elements in row k and column j will be the average intensity of the elements.

$$I(k,j)=\frac{\int_0^{\Delta x}\int_0^{\Delta y} i((k-1)\Delta x+x,(j-1)\Delta y+y)dydx}{\Delta x\Delta y} \quad ...(1)$$

An area photo sensor has only one voltage signal output, which is the summation of the illuminated elements. If the color light beam covers all the sensor elements, the maximum voltage output V_{max} is as equation (2).

$$V_{max}=\sum_{k=1}^{m}\sum_{j=1}^{n} I(k,j) \quad ...(2)$$

When the growing step index is denoted as **s**, the ADC value function will be $V_{lr}(s)$ in equation (3) if the light beam pattern grows from left to right and be $V_{rl}(s)$ in equation (4) if the light beam pattern grows from right to left.

$$V_{lr}(s)=\sum_{k=1}^{s}\sum_{j=1}^{n} I(k,j) \quad ...(3)$$

$$V_{rl}(s)=\sum_{k=s}^{m}\sum_{j=1}^{n} I(k,j) \quad ...(4)$$

The figure 6 shows the ADC diagram of the special designed photo sensor. By using equation (5), a special effect will be produced when the ADC data is shifted to q step and summated.

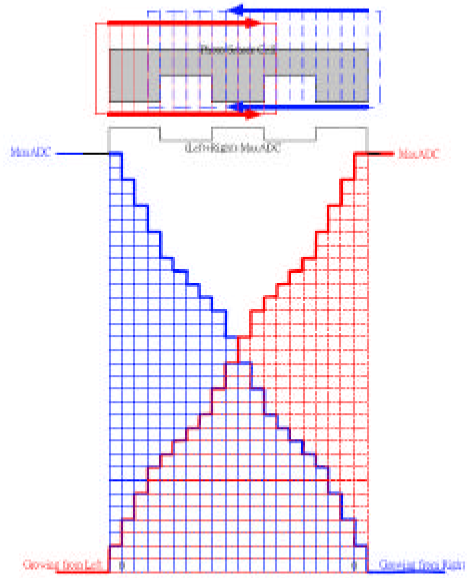

Fig 6. The ADC value of area photo sensor measured from two growing direction beam.

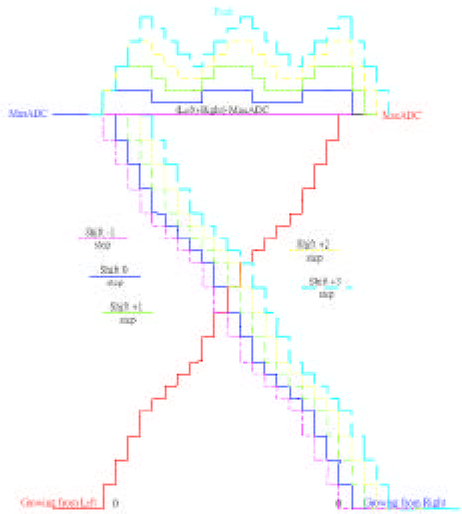

Fig 7. The correlation figure of the ADC value by shifting -1、+0、+1、+2、+3 growing step.

$$U(q) = V_{lr}(s+q) + V_{rl}(s) = V_{\max} + \sum_{k=s}^{s+q}\sum_{j=1}^{n} I(k, j) \cdots (5)$$

$$W(q) = U(q) - V_{\max} = \sum_{k=s}^{s+q}\sum_{j=1}^{n} I(k, j) \ldots (6)$$

As $U(-1) = V_{\max} =$ MaxADC = constant, so we can use $V_{lr}(s)$ and $V_{rl}(s)$ function data to reproduce the ADC value of the strip projection beam line of width (q+1) by calculating from equation instead of reproducing from projecting light beam to the photo sensor. The figure 7 and the equation (6) demonstrate the process. ADC diagram of Shift(-1)=W(0) is equal to MaxADC value; Shift(0)=W(1) one step width project line ADC chart; Shift(1)=W(2) two step width project line width ADC chart; Shift(2)=W(3) three step width project line width ADC chart. From W(3) the peak value can be found easily and the position difference between the origin factory set and now can be calculated, the same method can be applied to another direction then the convergence parameter can be found.

5. Conclusion

The method of using light beam growing on the sensor area can avoid electronic noise. By using the mathematic algorithmic, the slight change in the converted ADC value can be detected and PTV convergence can be efficiently adjusted to realize high adjustment accuracy.

6. References

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[3] M. Winzker and U. Rabeler, “Electronic Image Correction for Projection Displays”, SID 02 Digest, pp. 272 – 275, 2002.