Woods, Docherty, Koch (1991) "The use of flicker-free television products for stereoscopic display applications" in Stereoscopic Displays and Applications II, J. Merritt, S. Fisher, editors, Proceedings of SPIE Vol. 1457, 25-27 February 1991, San Jose, California.
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The use of flicker-free television products for stereoscopic display applications

Andrew Woods [1]
Tom Docherty [1]
Rolf Koch [2]

[1] School of Electrical & Computer Engineering / Centre for Marine Science & Technology,
Curtin University of Technology, G.P.O. Box U1987, Perth W.A. 6845, AUSTRALIA.

[2] School of Mathematical and Physical Sciences,
Murdoch University, South Street, Murdoch W.A. 6150, AUSTRALIA.

ABSTRACT

A low cost flicker-free field-sequential stereoscopic display has been developed. The system uses commercially available television products developed for the removal of flicker problems associated with the world interlaced television standards. These products reduce overall circuit complexity and implementation costs.

1. INTRODUCTION

Stereoscopic video systems are increasingly being used in areas such as computer graphics and control of remotely operated vehicles (ROVs). The specific aim of this project is the development of a stereoscopic closed circuit television system for the control of an underwater ROV used in the inspection of an offshore oil platform.

The easiest way to display stereoscopic images with a standard interlaced television system is to use alternate fields for the left and right eye images. A selection device is then used to direct the correct image to the correct eye[1]. Currently used selection devices include shutter glasses and switchable polarising screens. This technique is called field-sequential display.

Standard television systems (PAL, NTSC & SECAM) operate at a field frequency of 50 or 60 Hz. In a stereoscopic display system images are therefore presented to each eye at a frequency of 25 or 30 Hz, resulting in unacceptable flicker. This problem can be overcome by doubling the display frequency[2]. This is done by writing the fields at 50 Hz into a video memory and reading out each field twice at a rate of 100 Hz.

Domestic television sets have recently been released which operate at display frequencies of 100 Hz. The components used in these sets are now commercially available and with suitable modifications are being used in this project to develop a flicker-free field-sequential stereoscopic display. Although these displays are already available, the use of domestic television products reduces the implementation complexity and cost.

2. METHODS AND HARDWARE*

The existing broadcast television standards use a 2:1 interlaced field rate of 50 or 60 Hz as a compromise between flicker, resolution and bandwidth. Flicker occurs as large area flicker and edge flicker. Large area

* Most of this paper is discussed in relation to the PAL 50 Hz, 625 line system. However, the principles discussed are equally applicable to the NTSC 60 Hz, 525 line and SECAM 50 Hz, 625 line systems.

flicker is due to the low display rate and it is normally acceptable at 50 Hz. However, it can be disturbing, especially at high brightness levels and with large size screens. It can be completely removed by increasing the display frequency to 100 Hz. Edge flicker occurs at 25 Hz when high contrast horizontal lines are displayed on a 50 Hz interlaced system[3].

2.1 Flicker reduction methods

Techniques to overcome these flicker defects use digital frame store technology to repeat or double displayed fields. They are generally known as Improved Definition Television (IDTV) or Enhanced Quality Television (EQTV). Two basic frequency doubling techniques exist and they differ in the order in which fields are repeated. If the standard interlaced video signal is represented by the following order of 'O'dd and 'E'ven fields: $O_1E_1O_2E_2$ (50 Hz), the first method (frame doubling) repeats fields at 100 Hz in the order $O_1E_1O_1E_1O_2E_2O_2E_2$. This method removes the flicker defects mentioned earlier. However, in areas where there is significant movement between fields a motion artefact or blurring effect (movement modulation) is evident. This occurs because the display time sequence of the fields is partially reversed. Interfield processing and motion detection are required to overcome the motion artefacts caused by this method. The second method (field doubling) repeats fields at 100 Hz in the order $O_1O_1E_1E_1O_2O_2E_2E_2$. This method removes large area flicker and avoids motion artefacts, however it does not remove edge flicker. This is the flicker reduction technique used by several manufacturers, since no interfield processing is required and only one field has to be stored in memory at any one time, thereby reducing memory costs.

Another technique for flicker reduction is 'de-interlacing' where the two interlaced fields are displayed together in a single (non-interlaced or progressive scan) frame (50 Hz frame rate, twice horizontal frequency). This technique is not suitable for stereoscopic display because the two fields (which contain the left and right images) would be mixed. The field-sequential technique requires the two fields to stay separate for individual presentation to each eye.

2.2 Stereoscopic flicker

A stereoscopic display using the field-sequential method presents left and right images during alternate fields. In the system we have implemented, two genlocked video cameras are used to capture the left and right images. A video switch or multiplexer is then used to select odd fields from the left camera and even fields from the right camera. Only a single video channel is required as half the information from each camera is discarded. The field-sequential video signal therefore consists of the following order of 'L'eft and 'R'ight images (occupying the odd and even fields, respectively): $L_1R_1L_2R_2$ (50 Hz).

If this video signal is displayed using the field doubling technique as discussed above, the field sequence will be $L_1L_1R_1R_1L_2L_2R_2R_2$ (100 Hz). This is not suitable for stereoscopic display because an effective 25 Hz display rate per eye is still perceived due to the grouping of doubled fields. However, if the display is implemented using frame doubling instead of field doubling with the display sequence $L_1R_1L_1R_1L_2R_2L_2R_2$ (100 Hz), an acceptable 50 Hz display rate per eye will result.

2.3 Flicker reduction hardware

The conversion of the video signal at 50 Hz to an equivalent at 100 Hz is a question of standards conversion and is most easily achieved by digital methods and the use of video memories. The synchronisation and timing is the most difficult aspect to handle with the video signal being input to the memory at 50 Hz and simultaneously output at the new rate of 100 Hz.

Television manufacturers who are currently releasing television sets using "flicker-free display technology" include Siemens, Philips, Sony and Grundig. The field doubling component used in the Siemens FS940 and

FS985 television sets is called 'Featurebox'[4,5] and it is this product which we have used to implement a flicker-free field-sequential stereoscopic display.

2.3.1 Siemens Featurebox

The Siemens Featurebox implements flicker reduction using the field doubling method, and is designed to replace all of the standard television structure which deals with the baseband video processing and also the deflection control. The Featurebox is fully compatible with the PAL, NTSC and SECAM television standards.

The block diagram of the Featurebox is shown in Figure 1. The composite video signal is sampled at 13.5 MHz with a 7 bit analog to digital converter and then colour decoded using a multi-standard device into one luminance and two quadrature chrominance components. To reduce bandwidth and therefore memory requirements the chrominance is sampled at one quarter the rate of the luminance. The resolution of the Featurebox is 696 pixels/line for luminance and 2 x 174 pixels/line for chrominance. This does not degrade the display quality since the eye is less sensitive to colour than to luminance.

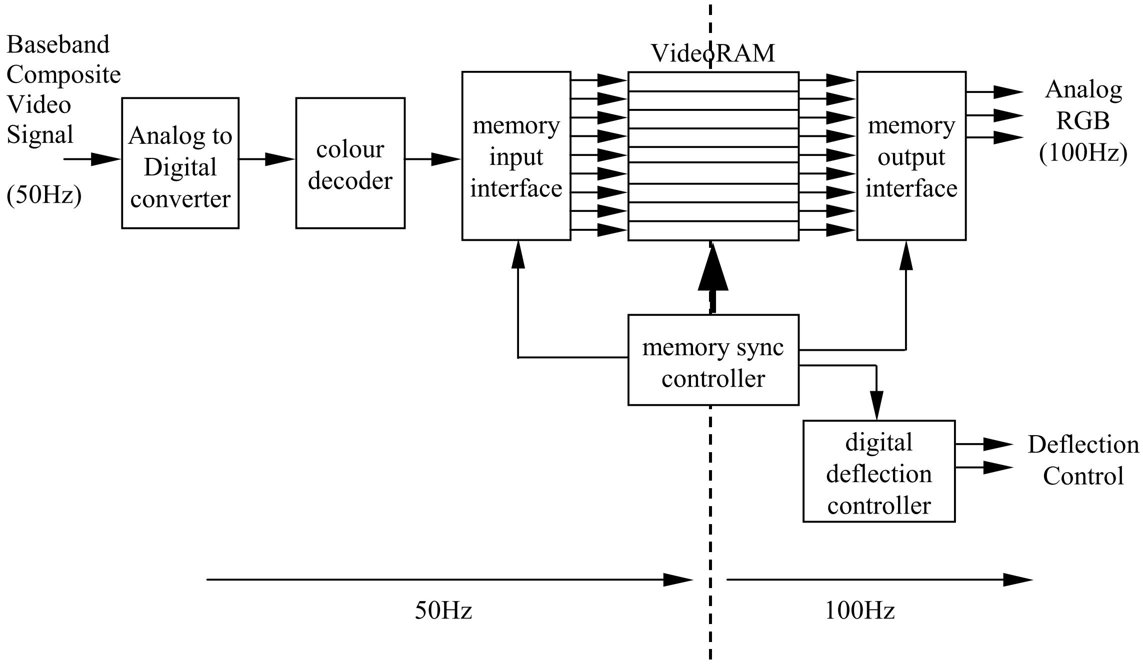

Figure 1. Block diagram of the Featurebox

The standards conversion is performed with three main ICs and nine 64kx4 VRAMs (288 kbytes). VRAMs are equivalent to a standard Dynamic RAM with an inbuilt serial port which can function almost independently from the conventional random access port. With reference to figure 1, the three main ICs are (a) Memory Input Interface (MIIF) (or Picture Processor) which formats the digital video information into a format suitable for writing into the random access port of the VRAMs, (b) Memory Sync Controller (MSC) which generates control signals and addresses for the VRAMs as well as the horizontal and vertical synchronous signals, and (c) Memory Output Interface (MOIF) which receives the video data from the serial port of the VRAMs and converts this into analog video components at 100 Hz.

The Digital Deflection Controller (DDC) generates the horizontal and vertical deflection signals at the new rates of 100 Hz vertical and 31 kHz horizontal.

All the main functions of the Featurebox are software controllable with the two wire control bus 'I^2C' developed by Philips. In addition to the implementation of field doubling, the Featurebox also implements such functions as still picture, picture in picture, zooming and programmable interlace. We have not used all of these functions, however the versatility of the Featurebox makes it highly suitable for the development of a flicker-free stereoscopic display.

2.4 Stereoscopic display hardware

The Featurebox nominally operates using the field doubling method, however it has been found that the Featurebox architecture can be modified to operate using frame doubling technique. The implementation of this technique requires memory for the simultaneous storage of two fields instead of the single field storage required for the field doubling method. The Featurebox therefore required the amount of onboard VRAM to be doubled to 576 kbytes and the provision of synchronisation and decoding circuitry to support the additional memory.

The Featurebox was designed to be an integral part of the television set in which it is implemented, however in the stereoscopic display system constructed it was decided to make the frequency doubling hardware independent of the display monitor. This was done to allow different monitors to be used with the system without any modifications. The digital deflection controller was therefore bypassed, and the monitor is driven indirectly by making the output of the Featurebox compatible with the signals required by multisync monitors. This was done to reduce the overall circuit complexity and provide more system versatility. The display size can be changed easily by using different size multisync monitors.

In the current experimental system a SHARP PC-E500 handheld computer is used to program the Featurebox configuration parameters via the I^2C bus. This allows dynamic control of the Featurebox parameters while maintaining portability.

The selection device being used with this system is a Tektronix SGS410 liquid crystal polarising screen[6]. Multiple viewers can then wear passive polarising glasses to view the stereoscopic scene.

3. RESULTS AND CONCLUSION

A flicker-free field-sequential stereoscopic display system has been constructed using commercially available domestic television equipment. Other than the display device, the system maintains compatibility with existing video standards and therefore standard video equipment can be used, resulting in a system which is easily and cheaply implemented.

The multi-sync monitor we are currently using (Mitsubishi FL6615) sometimes encounters timing problems with synchronising signals which are not highly synchronous, such as the timing derived from video tape recorders. This is because multi-sync monitors are normally used to display video signals derived from computers which produce highly synchronous timing signals. It would be expected that the system would be able to handle non-synchronous signals more effectively if the Digital Deflection Controller were used to drive the television tube directly.

As mentioned earlier the field-sequential display technique leads to a loss of vertical resolution because half of the video information for each eye (i.e. each alternate field) is discarded at the cameras. In the currently implemented stereoscopic system each eye receives $312^1/_2$ lines in a 50 Hz non-interlaced (or progressive) refresh. A fully interlaced 625 line 50 Hz display (per eye) could be also be achieved within the Featurebox architecture by additional modifications. Duplication of part of the input circuitry (the A/D, colour decoding and MIIF sections) would make it possible to use all the fields from two interlaced 50 Hz video channels. The system could then display 625 line interlaced frames at a rate of 50 Hz to each eye. This does however require that two video channels are provided between the cameras and the display.

In the current system no horizontal or vertical adjustments between the two fields (left and right) are possible. These controls would be an advantage in an experimental system in order to remove vertical parallax and correct horizontal parallax, which occur because of camera misalignment and other factors. In a domestic system, however, these controls would be unnecessary as all corrections could be made before broadcast.

With minor modifications many of the current 100 Hz television sets could be made to display flicker-free field-sequential 3D television images. Alternatively field-sequential 3D transmissions could be decoded such that only a monoscopic view is displayed. This would be done by suppressing alternate fields.

The system which has been implemented will be field tested in the near future on an underwater ROV which Woodside Offshore Petroleum is operating at their 'North Rankin A' offshore oil platform located off the North West coast of Western Australia.

4. ACKNOWLEDGEMENTS

This work was performed during the Masters Degree Studies of A. Woods at Curtin University. The authors wish to thank Woodside Offshore Petroleum for their support of this project.

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