White Paper:
A Survey of 3D Sync IR Protocols

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Introduction

The purpose of this document is to summarise the different IR communication protocols used by a selection of commercially available stereoscopic 3D Active Shutter Glasses.

Active Shutter Glasses (also known as Liquid Crystal Shutter (LCS) 3D glasses or just Shutter Glasses) are a commonly used selection device used to view stereoscopic 3D content on time-sequential stereoscopic displays. Time-sequential stereoscopic 3D displays operate by displaying discrete left and right images in alternating sequence often at image rates of 100, 120 or 144 images per second. This time-sequential approach can also be described as time-multiplexed. The active shutter glasses alternately blank the left and right eyes in sequence with the sequence of images shown on the display such that the left eye only sees the left perspective images and the right eye only sees the right perspective images. The active shutter glasses usually contain two liquid crystal cells, each acting as a shutter – one in front of each eye.

In order for the active shutter glasses to switch in synchrony with the sequence of left and right images presented on the time-sequential stereoscopic display, some form of timing signal must be sent from the display to the glasses. Most wireless active shutter glasses use an infrared (IR) communication protocol similar to that used for IR remote controls used for TVs, air conditioners and other consumer electronics. Some glasses use an RF (radio-frequency) communication protocol such as Bluetooth or ZigBee, however these are outside the scope of this document. The DLP Link™ protocol uses pulses of visible light in its protocol.

Active shutter glasses have been used as a viewing device for time-sequential stereoscopic displays as far back as 1922 for the Teleview system[1]. The first wireless active shutter glasses appear to be the StereoGraphics CrystalEyes which were released in the mid-80s, used liquid crystal shutters, and an IR communication protocol for synchronisation. Several other brands and designs of IR controlled wireless active shutter glasses have been released over the years[2] and in early 2010 the largest consumer release of active shutter glasses occurred with the consumer release of 3D HDTVs by several consumer electronics manufacturers (including Samsung, Panasonic, Sony, LG, Sharp, and others[3].)

Regrettably most of the IR controlled active shutter glasses released to date by various manufacturers have used a variety of different IR communication protocols which means that active shutter glasses from one manufacturer are generally not cross-compatible with another. For example, a pair of Panasonic active shutter glasses cannot be used directly with a Samsung 3D HDTV, and vice versa.

The reason for the incompatibility between different makes of active shutter glasses mostly relates to differences between the actual IR communication protocol used for each brand of glasses, but there are three other possible reasons for incompatibility: (1) some glasses use RF or visible light communications link instead of IR, (2) some displays need the glasses to switch with a reduced duty cycle for correct operation and only some glasses operate this way, (3) some glasses (i.e. Sony) don't have a front polariser on the shutter and rely on the display to output linear polarised light.

Amongst the active shutter glasses that use an IR communication protocol, there is very little information in the published literature as to how the various protocols differ. In 2010, we initiated a project to characterize the specifics of a wide range of 3D Sync IR protocols so as to gain an understanding of why various active shutter glasses are incompatible, how and why the protocols differ, what limitations there might be in creating a single standard 3D Sync IR protocol, and the possibility for display devices to output multiple protocols at the same time so that multiple makes of shutter glasses can be used with the one display.

This document summarises the 3D Sync IR protocol as used by a selection of emitters and glasses. The protocol summaries provided here are derived from the measurement of the actual protocol signal output by a selection of commercially available products. The protocol summaries provided here are not derived from any documentation defined by individual manufacturers and hence does not include any information on timing tolerances or perhaps advanced timing specifics. The manufacturers have not provided any of the protocol timing information described in this document.

A total of ten protocols were characterised in this study.

Testing Method

The protocols were measured by connecting the emitter/dongle or 3D display/projector to a 3D video or 3D sync source. In the case where the emitter was integrated into the 3D display/projector, the 3D display/projector was switched into 3D mode. A high-speed IR photosensor was directed at the IR emitter and analysed using a digital storage oscilloscope. The timing of the IR pulses were measured relative to the 3D Sync signal, the light field emitted by the display, and/or the timing of the shuttering of the eyewear.

The ten pairs of active shutter glasses tested in this study are shown in Figure 1. Some of the emitters tested in this study are shown in Figure 2.

Figure 1: The ten active shutter glasses tested in this study: (a) StereoGraphics Crystaleyes CE-1, (b) ELSA/H3D, (c) NuVision 60GX, (d) NVIDIA 3D Vision, (e) Panasonic TY-EW3D10U, (f) Samsung 2007, (g) Samsung (2010) SSG-2100AB, (h) Sony TDG-BR100, (i) Viewsonic PGD-150 DLP Link, (j) Xpand X103 Universal.

Figure 2: Some of the stand-alone IR 3D emitters tested: (a) Samsung 2007, (b) NuVision, (c) NVIDIA, (d) CrystalEyes 1, and (e) H3D/ELSA.

In order to verify the accuracy of the protocol measurements, a custom-built universal IR emitter was constructed[4] and used to send a regenerated version of the various IR protocols to the various active shutter glasses. We were able to reliably drive all of the tested active shutter glasses using the appropriate measured IR protocol. There was only one exception to this testing, which was that we were unable to reliably drive the Xpand X103 universal glasses in the Samsung (2010) protocol mode using our regenerated Samsung 2010 protocol. This might indicate a slight timing error in our measurement of the Samsung 2010 protocol, however we were able to use this protocol timing to drive an actual pair of the Samsung 2010 active shutter glasses.

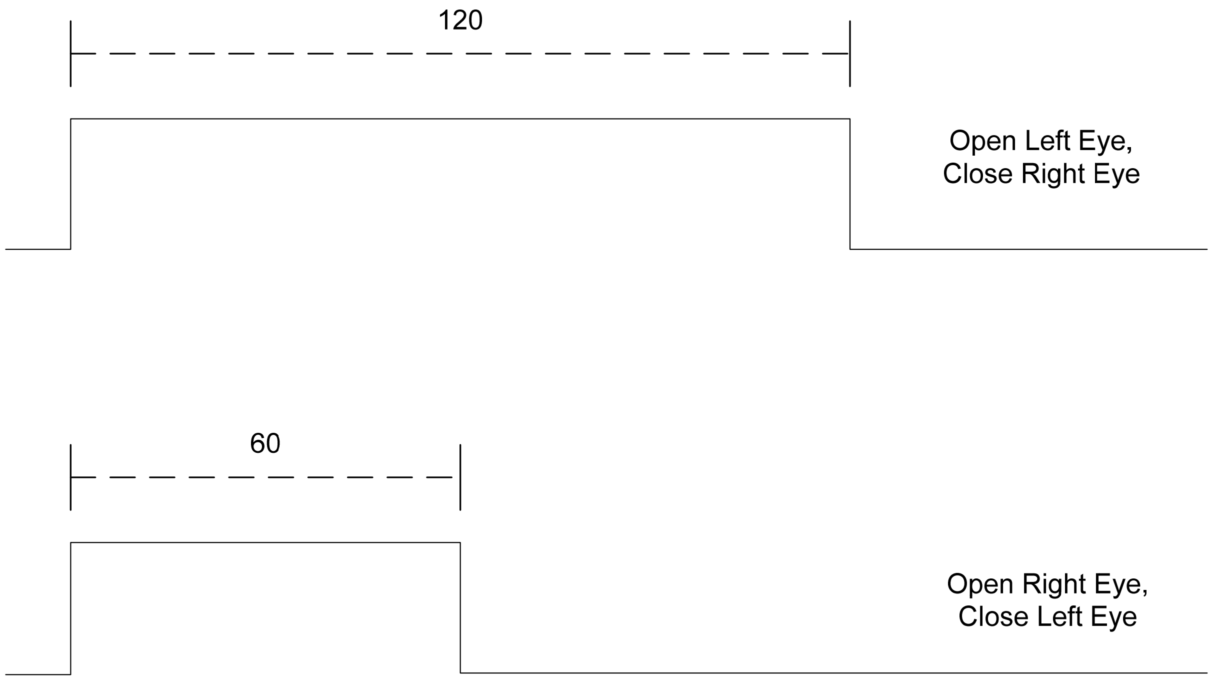
3D Sync Protocols Summary

The timing diagrams for the ten protocols measured in this study are detailed below.

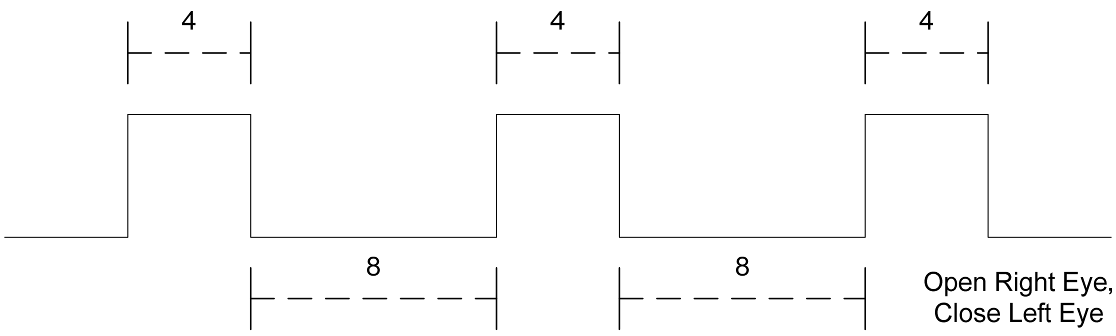
It is important to point out that:

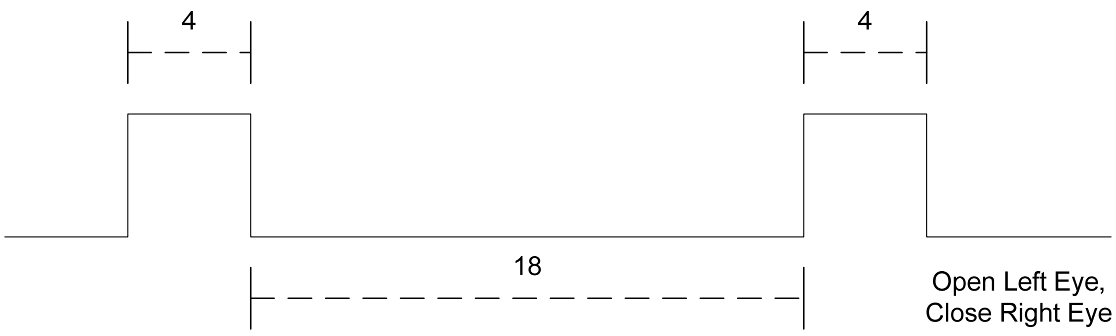
- not all of the diagrams are drawn to scale.
- the timings are as measured from commercially released hardware and were not provided or endorsed by the manufacturers.
- there might be timing errors in the descriptions.
- the Samsung and DLP Link protocols have a subtly different mode of operation which are detailed below.
- all units are in microseconds (µs)
- the timing of the opening and closing of the left and right shutters are not indicated in these diagrams and do not necessary coincide exactly with the timing of the tokens. These timings will be the subject of a future publication.

CrystalEyes Protocol (Stand-alone emitter)

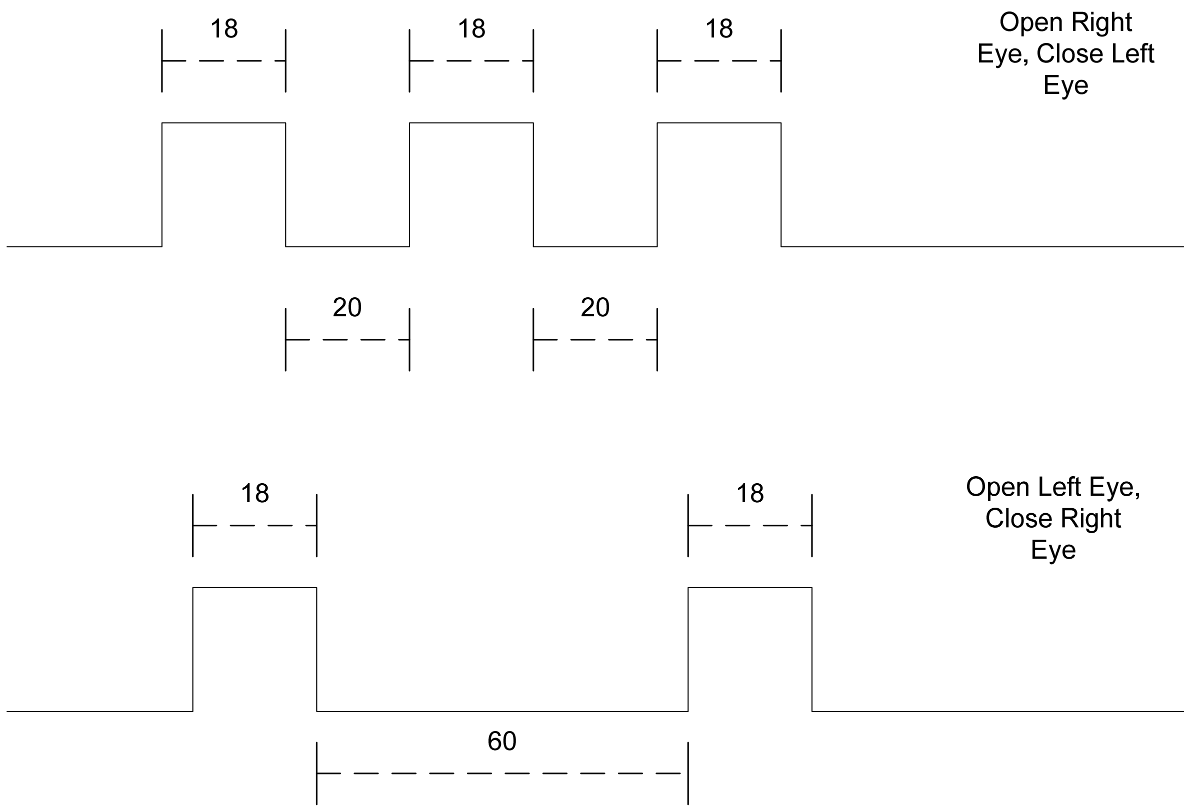


NuVision Protocol (Stand-alone emitter)

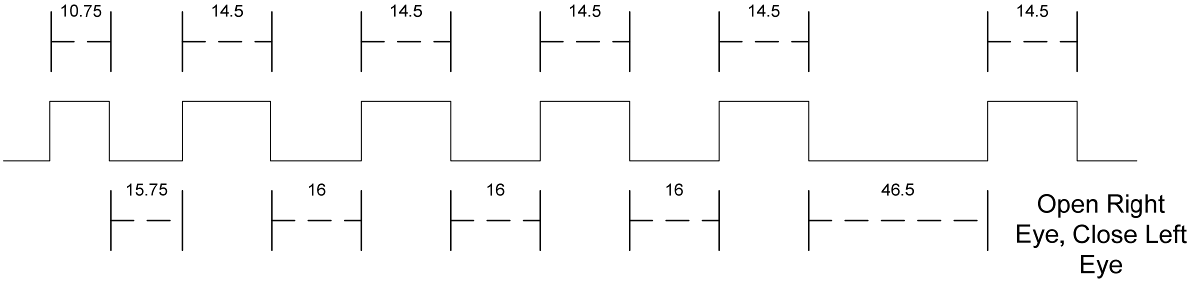


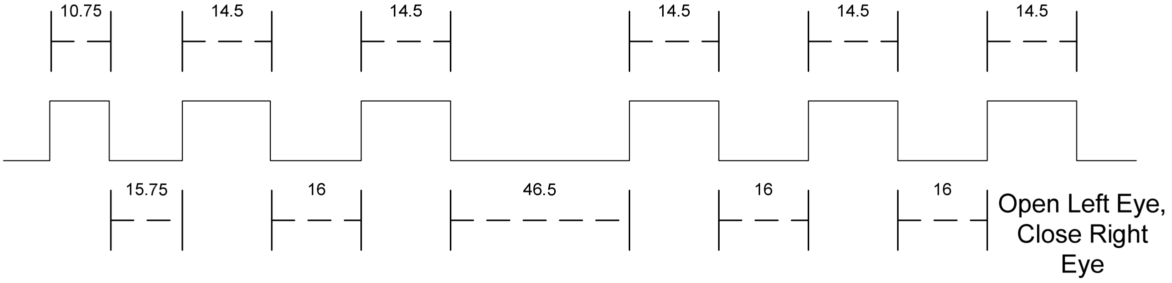


Xpand Protocol (Stand-alone emitter)

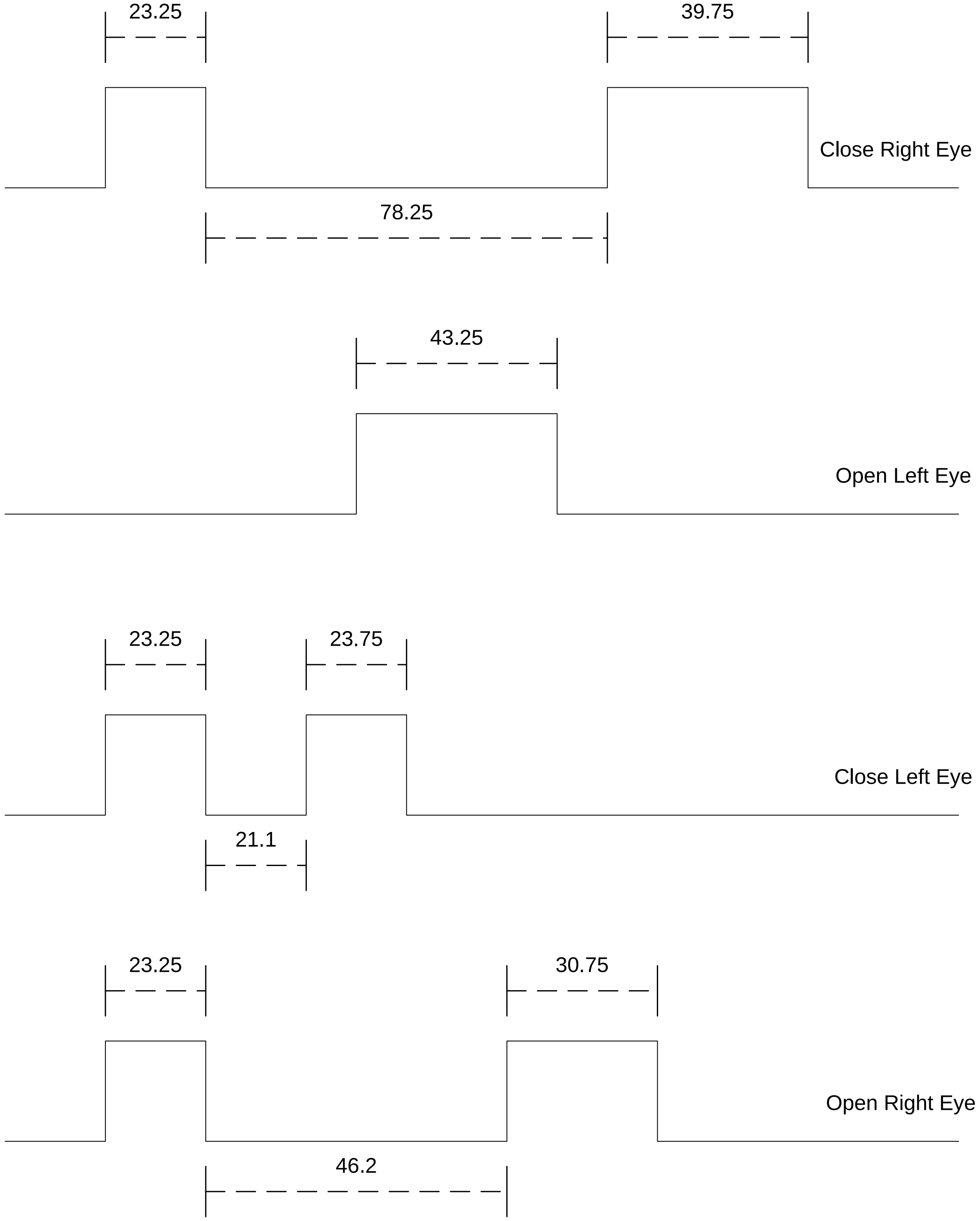


H3D / ELSA protocol (Stand-alone emitter)





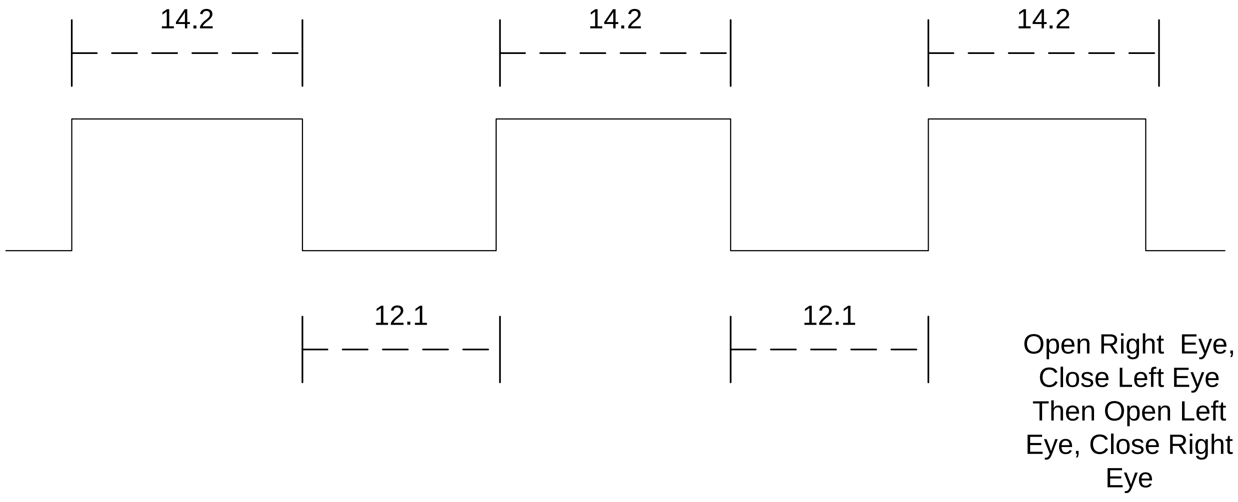
NVIDIA Protocol (Stand-alone emitter)



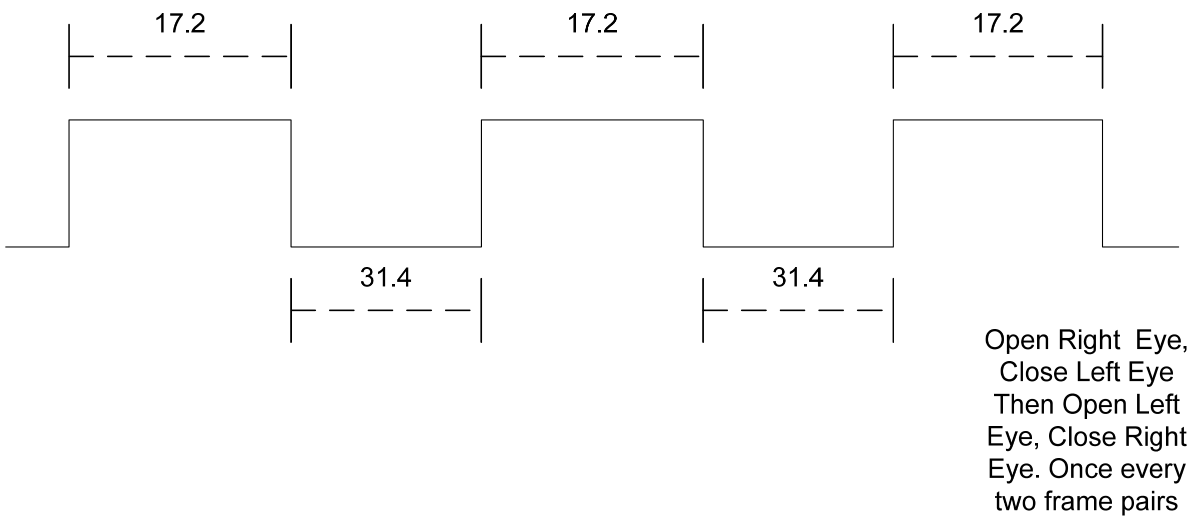
Notes:

- This is a four token protocol and hence allows the display to specify the duty cycle for the glasses to operate.

Samsung 2007 Protocol (Stand-alone emitter)



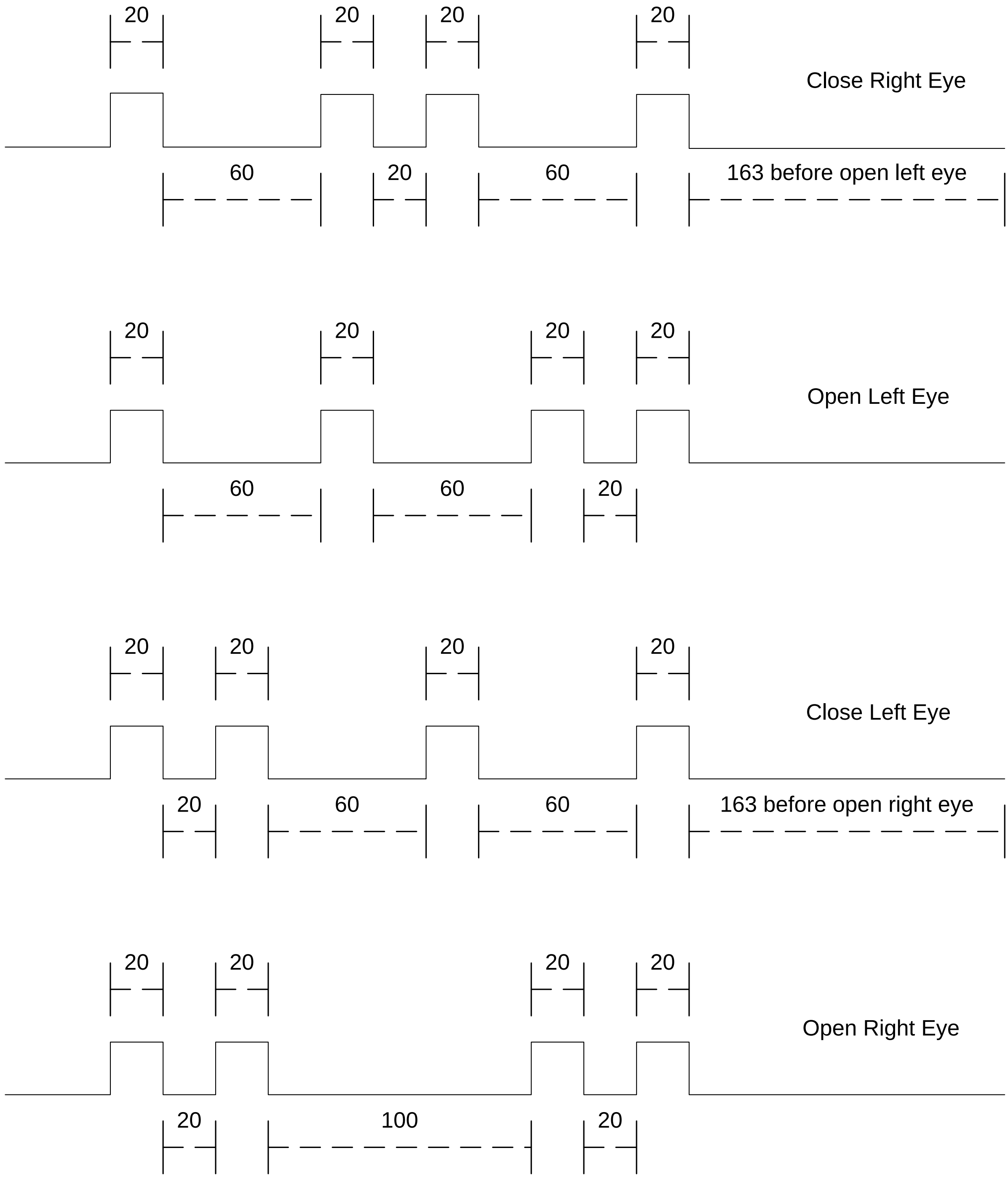
Samsung 2010 Protocol (Internal TV Emitter)



Notes:

- Both the Samsung 2007 and the Samsung 2010 protocols are a one token protocol. The Samsung 2007 token is output once every right+left frame pair period (at the beginning of the right frame period) and the Samsung 2010 protocol once every two right+left frame pair periods. The glasses must assume a duty cycle of approximately 50% and calculate the intermediate timing internally.

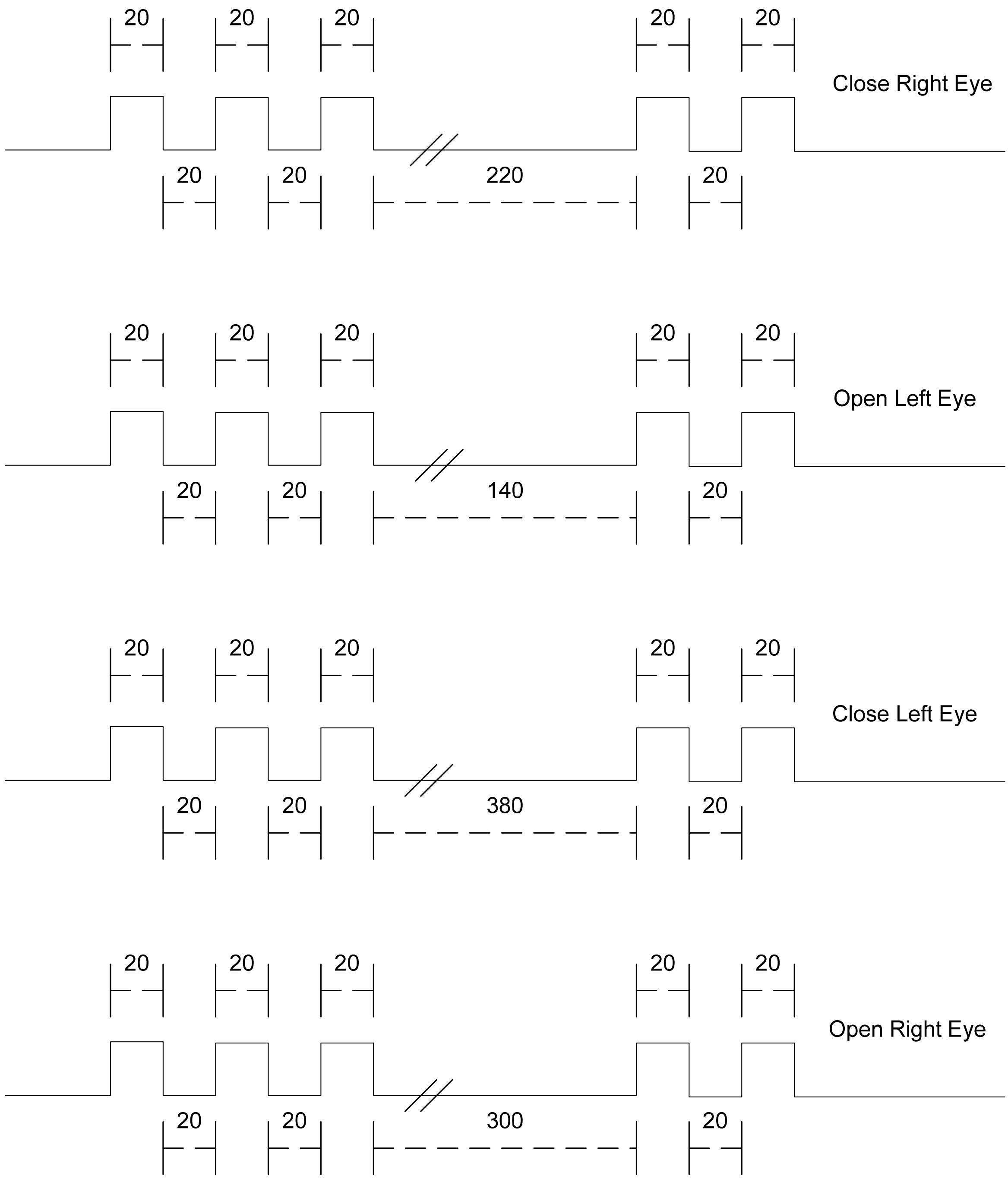
Panasonic Protocol (Internal TV emitter)



Notes:

- This is a four token protocol and hence allows the display to specify the duty cycle for the glasses to operate.

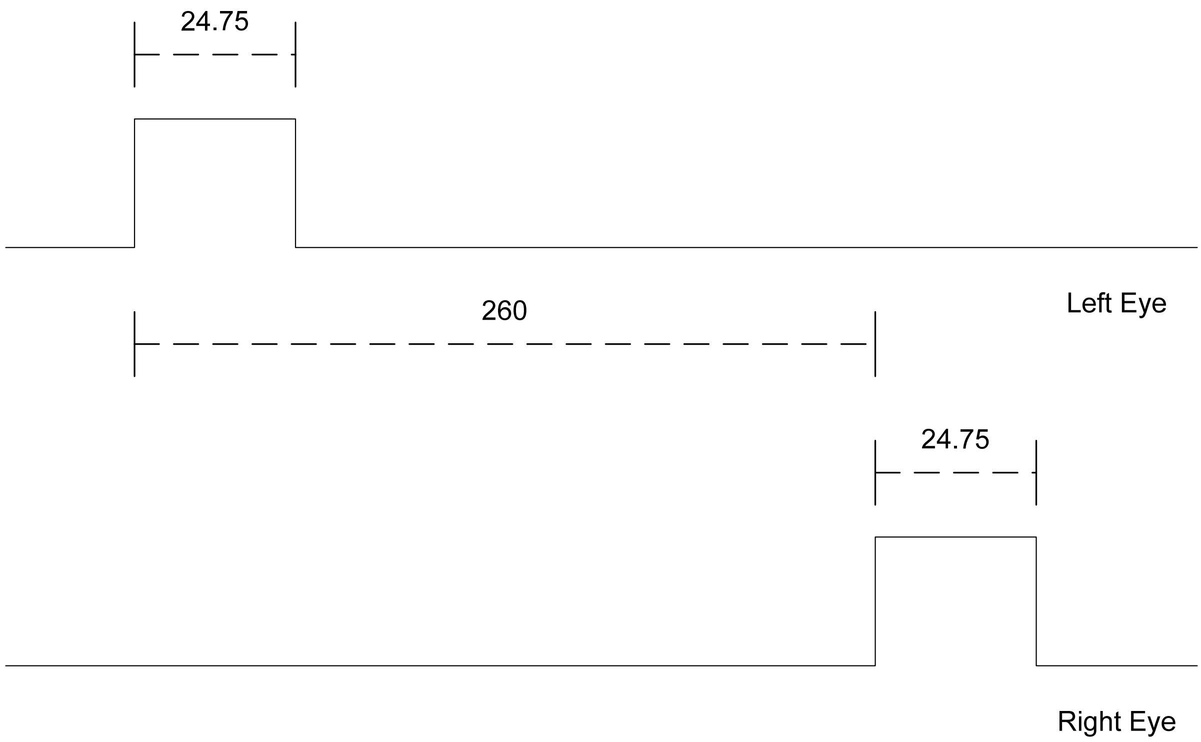
Sony Protocol (Stand-alone emitter)



Notes:

- This is a four token protocol and hence allows the display to specify the duty cycle for the glasses to operate.

DLP Link™ Protocol (visible light - internal)



Notes:

- The left eye token and the right eye token do not differ in width, but in relative timing. The right eye token is delayed relative to the sync reference by 260µs as compared to the timing of the left eye pulse. Another way of interpreting this is to say that the timing between pulses for the right perspective image period is 520µs (2 × 260µs) less than the timing between pulses for the left perspective image period.
- Aspects of this protocol appear to be the subject of US Patent Application 2008/0151112 A1.

Discussion

As mentioned above, one of the main differences between the various protocols is the number of tokens as summarised in Table 1.

Table 1: The number of tokens used by the various 3D Sync protocols.

Glasses	Tokens
NuVision	2
Xpand	2
Elsa/H3D	2
CrystalEyes	2
Panasonic	4

Glasses	Tokens
DLP Link	2
Samsung 2007	1
Samsung 2010	1
NVIDIA	4
Sony	4

It is worth noting that the 4 token protocols are capable of being used to implement reduced duty cycle operation of the glasses which is necessary for some displays for optimal performance. The use of a 4 token protocol would therefore seem to offer the most flexibility.

There is a lot of variation in the relative complexity of the various protocols – some use a simple single pulse for each token whereas others use a combination of pulses and some use more pulses than others. The glasses that use a more complex token are less likely to be mis-triggered by spurious IR signals and reject other IR signals, however a more complex token also has more chance of being interfered because it has a longer period.

Something that is not revealed by these results is the tolerance for signal timing variation of the various glasses. A considerable amount of additional testing would be needed to establish this and then it would only be valid for a particular set of glasses. Obviously input from the manufacturers would be necessary to establish this tolerance correctly. One example of this tolerance is that the NuVision 60GX glasses can successfully sync to the Xpand protocol, but the Xpand X103 glasses will not accept the NuVision protocol.

Tight tolerance would mean that a pair of glasses would be less likely to be triggered or mis-triggered by the protocol meant for another pair of glasses.

Another reason for wanting to establish protocol timing tolerance is to work out whether one glasses protocol might drive or mis-trigger another set of glasses. This is important to know so that it can be determined whether a TV can successfully output multiple protocols to drive multiple brands of glasses at the same time.

The cross-compatibility of protocols is also determined by the similarity of the number and timing of the pulses. For example, it has already been established that the Xpand and Samsung 2010 protocols won't coexist because both protocols use a three-pulse protocol with similar pulse widths but with opposite polarity. A more extensive analysis of cross-compatibility will be the subject of a future publication.

Conclusion

The analysis of the various 3D Sync IR protocols has certainly been an interesting revelation into what is normally an invisible process. The results have revealed a considerable amount of variation between protocols and also some overlap. It is hoped that the results of this paper will provide useful background information towards the definition of a single standard for active shutter glasses.

Please note that the protocol measurements outlined in the document have been provided for research and discussion purposes only. The protocol measurements may be subject to error and should not be used as an actual technical definition of the protocols.

Acknowledgements

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References

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