

ANSI/CTA Standard

Command-Driven Analog IR-Synchronized Active Eyewear

ANSI/CTA-2038 R-2017

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(Formulated under the cognizance of the CTA **R4 Video Systems Committee**.)

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FOREWORD

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Command-Driven Analog IR-Synchronized Active Eyewear

1 Scope

CTA-2038 defines a standard method of Infrared (IR) emitter-to-eyewear signaling that provides a basis for interoperability between time-multiplexed (including stereographic and dual-mode) display systems manufactured by different manufacturers for use in the home. The method synchronizes eyewear with display refresh timing by controlling the activity of the eyewear shutters using a standardized unidirectional IR emitter-to-eyewear signal, having standardized wavelength, carrier frequency, burst patterns, codes, timing, frequency range, and maximum distance. The method allows display manufacturers to optimize the duty cycle and switching points of the eyewear to suit the characteristics of each display model or technology. Therefore, improvements in display technology are reflected in the timing of the signals generated by the display/emitter and modifications to standard eyewear are not required. Likewise, improvements in eyewear technology do not impact the design of standard display/emitter devices. The method avoids conflict with legacy emitter-to-eyewear signaling systems so that eyewear may be designed to interoperate with legacy systems as well. The method addresses interference and susceptibility issues relating to other IR devices that might also be found in a typical home environment. The method supports a wide range of display types – including LCD, PDP, and DLP. In the case of LCD displays, the method supports both continuous and LED back-lit displays.

1.1 Overview

In stereographic and dual-mode display systems, a display renders dual image content in a time-multiplexed manner, which requires viewer's eyes to be blocked from viewing the display's screen at specific points in time. In the stereographic use case, a viewer (or n viewers) wear(s) active eyewear in order to view 3D content rendered by the display. In this use case, content may sometimes switch between 3D and 2D material (e.g. during a commercial break). In the dual-mode use case, two viewers wear active eyewear - each seeing an independent 2D gaming image rendered by the display.

The eyewear is synchronized with the display's refresh timing using a standardized unidirectional IR synchronizing signal, which is the subject of this standard. The IR synchronizing signal comes from an emitter, which may be separate-from or integrated-into the display. Eyewear does not necessarily interoperate between systems, hence the primary motivation for this standard.

For reliable operation, eyewear must not be susceptible to local interference from the rendered picture on the display's screen, sunlight, modulated and unmodulated infrared light sources (whether they be fluorescent, LED, neon, 3-wavelength types), IR headphones, IR remote controls, or IR data interfaces such as IrDA. Eyewear may also be susceptible to local interference from emitters associated with other displays in retail, tradeshow, and gamefest environments.

The emitter should not interfere with local IR headphone, IR remote control, or IR data interfaces (e.g. IrDA).

2 General

2.1 Definitions

For the purposes of CTA-2038, the following definitions apply.

Eyewear – Active glasses with electronically controlled optical characteristics requiring synchronization with a display. Blocks viewer's left and/or right eyes from seeing the wrong image of a single view L/R stereo pair or dual view Image1/Image2 (gaming) pair.

Emitter – Provides invisible synchronizing signal to eyewear – so that viewer's left and/or right eyes are blocked at the correct moment(s) in time.

Image – Single displayed picture a one moment in time intended for one or both eyes to see.

Display – Renders a visible image.

Single View – An environment where all viewers see the same 2D image or 3D image pair, which is also referred to as single 2D and single 3D in this document.

Dual View – An environment where viewers see one of two independent 2D images, which is also referred to as dual 2D in this document.

3D Image Pair – Left and Right images grouped together for 3D viewing. Left images are always numbered odd and come before their right pairing. Right images are always numbered even and come after their left pairing.

Image Cycle – Period during which the display transitions between all the independent time multiplexed images.

Duty Cycle – Percent of cycle when the lens is open for one of the images. Also used to describe the active time of the carrier.

Closed Duty Cycle – Percent of cycle when the lenses are closed for one of the images, which is also referred to as T_{cduty} in this document.

Command – An N-bit value used to communicate an instruction to eyewear

Command Sequence – A sequential set of commands occurring during the image cycle.

Command Repetition Period – Period at which the command sequence repeats, which is also referred to as T_{period} in this document.

Carrier – Frequency of an N-pulse pattern used to transmit a command.

Command Transmission Period – Time it takes to transmit one command, which is also referred to as $T_{command}$ in this document.

2.2 Symbols and Abbreviations

2D	Two dimensional
3D	Three dimensional
CTA	Consumer Electronics Association
DLP	Digital Light Processing, a technology used in projectors and video projectors
IR	Infrared
IrDA	Infrared Data Association port for the short-range exchange of data using infrared light
LCD	Liquid Crystal Display, a type of flat panel display
LED	Light-emitting Diode, a type of LCD backlight or modern room lighting
PDP	Plasma Display Panel, a type of flat panel display

2.3 Compliance Notation

As used in this document, “shall” denotes mandatory provisions of the standard. “Should” denotes a provision that is recommended but not mandatory. “May” denotes a feature whose presence does not preclude compliance and implementation of which is optional. “Optional” denotes items that may or may not be present in a compliant device.

3 System Description

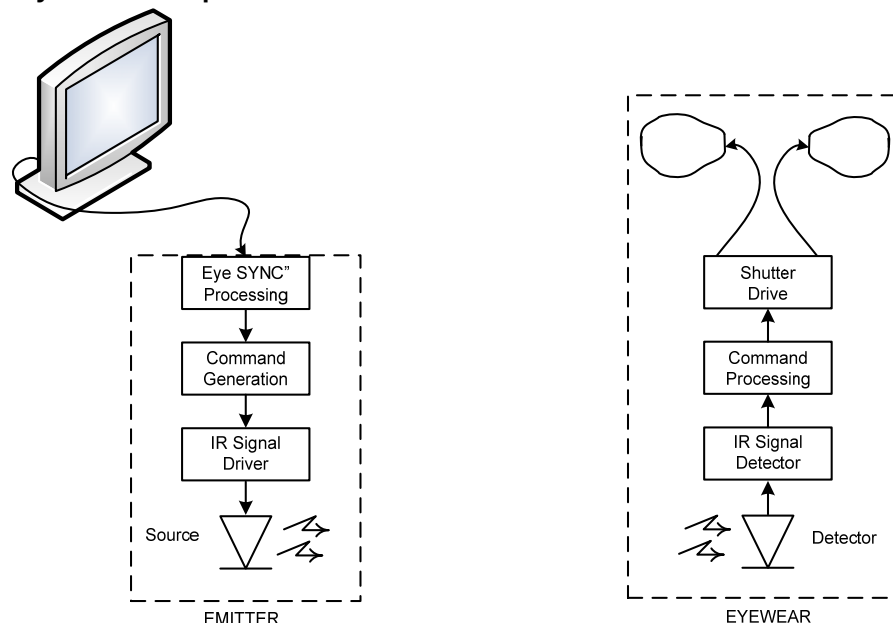


Figure 1: Block diagram of active eyewear system

An active eyewear system consists of three main elements, the display device, the control signal emitter, and the eyewear.

The display device alternately displays left and right eye images at a rate which produces a comfortable viewing experience for the user. In addition, the display device either contains the control signal emitter or provides a signal which indicates which eyes' image is currently active to an externally mounted control signal emitter.

The control signal emitter resolves the update rate and timing characteristics of the display device to that of the eyewear. The design of the control signal emitter is tightly coupled to that of the display, but is intended to be independent of the particular eyewear in use as long as the eyewear is compliant with this standard.

The eyewear acts on the signals received from the control signal emitter, no attempt is made to validate the “reasonableness” of the control signals, and as such the eyewear is independent of the particular display device or control signal emitter utilized in a specific installation.

Products using this standard should disclose the modes they support.

4 System Requirements

4.1 IR Wavelength

- Receiver shall operate when receiving the minimum signal energy from 830 nm to 950 nm.
- Emitters should nominally emit peak energy at 830 nm.

4.2 Command Encoding Carrier Frequency

- The command encoding carrier frequency ($1/t_{\text{cycle}}$) shall be 26.2KHz, as measured at the 50% emitted IR intensity levels.
- The maximum variation of the carrier frequency shall be $\pm 5\%$ of $1/t_{\text{cycle}}$, as measured at the 50% emitted IR intensity levels.
- The duty cycle of the carrier frequency ($t_{\text{high}}/t_{\text{cycle}}$)% shall be between 55% and 45%, as measured at the 50% emitted IR intensity levels.
- The time for the emitted IR intensity to go from 10% to 90% (t_r) shall not exceed 5% of t_{cycle} .
- The time for the emitted IR intensity to go from 90% to 10% (t_f) shall not exceed 5% of t_{cycle} .

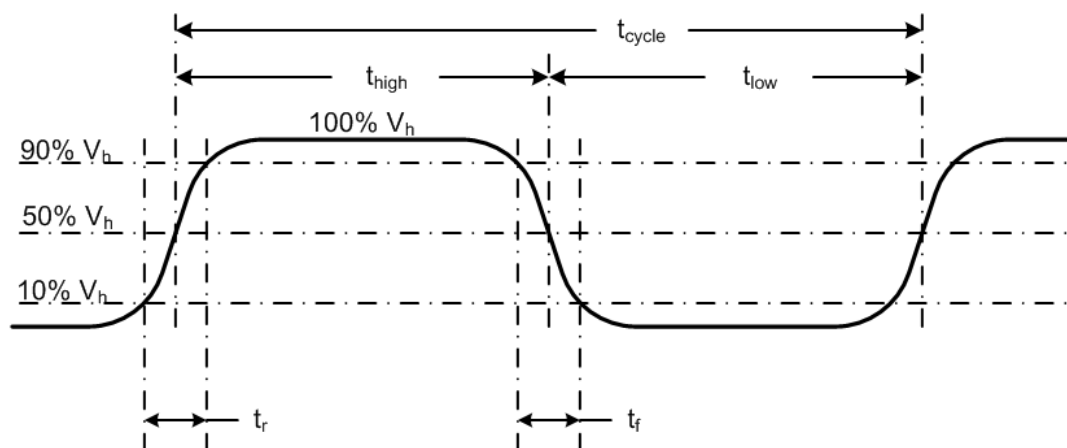


Figure 2: Carrier timing

4.3 Command Timing & Sequencing

4.3.1 Overview

Four commands are defined to control the shuttering of the eyewear; After1 (“A1”), Before1 (“B1”), After2 (“A2”), and Before2 (“B2”). The command sequence (order and repetition of commands) per image cycle define the mode of operation. The mode of operation specified by the command sequence communicates information like Dual View versus 3D to the eyewear. The number of images per image cycle is specific to the mode of operation. The 3D Image Pairs shall come Left (odd image number) then Right (even image number) together in the Image Cycle.

The operation modes defined for the command set is summarized in the following table, a more detailed description of these modes can be found in Annex A of this document.

Table 1: Operating Mode Summary

Mode Number	Mode Name	Eyewear Support	Description
1	Shutdown	Required	Both Shutters open
2 & 3	Symmetrical Single 3D	Required	Single 3D image sent as 1 st image to Left eye and 2 nd image to Right eye. Variable shutter close timing.
4	Swap Single 3D	Required	Single 3D image sent as 1 st image to Left eye and 2 nd image to Right eye. Both shutters are never closed simultaneously.
5 & 6	Symmetrical Dual 2D ³	Optional ⁴	Individual images are sent to the Left & Right eye. Variable shutter close timing.
7	Swap Dual 2D ³	Optional ⁴	Individual images are sent to the Left & Right eye. Both shutters are never closed simultaneously.
8 & 9	Single 2D	Optional ⁴	Image is sent to the Left & Right eye simultaneously. Variable shutter close timing.
10	Half Single 2D	Optional ⁴	Image is sent to the Left & Right eye simultaneously. Shutters are open 50% of the time.
11 & 12	Symmetrical Dual 3D ²	Optional ⁴	Two 3D images are sent as images 1&3 to the Left eye and images 2&4 to the Right eye Variable shutter close timing.
13	Swap Dual 3D	Optional ⁴	Two 3D images are sent as images 1&3 to the Left eye and images 2&4 to the Right eye. Both shutters are never closed simultaneously.
14 & 15	Symmetrical Quad 2D	Optional ⁴	One of four individual images is sent to the Left & Right eye. Variable shutter close timing.
16 & 17	Asymmetrical Dual 2D ¹ or Asymmetrical Single 3D	Optional ⁴	Individual 2D images sent to Left & Right eyes or single 3D image sent as 1 st image to Left eye and 2 nd image to Right eye.

¹ Multiple 2D views or 3D view are selected on the eyewear and support is optional, however eyewear without selection supporting such modes shall default to 3D.

² Multiple 3D views are selected on the eyewear and support is optional, however eyewear without selection supporting such modes shall default to 3D with 1st and 2nd images.

³ Multiple 2D views are selected on the eyewear and support is optional, however eyewear without selection supporting such modes shall default to 2D with 1st image.

⁴ Unsupported modes shall be treated as the shutdown mode by the eyewear.

4.3.2 Command Timing

- a. The transmit time for each command shall be equal, the actual time depends on the short or long encoding selected.
- b. The actual transmit time shall be 305uS for short command encoding, and 1220uS for long command encoding.
- c. The time between a command and the associated shutter action for all symmetric modes shall be $1/16^{\text{th}}$ of the command repetition period as measured at the center of the command.
- d. The time between a command and the associated shutter action for all asymmetric modes shall be equal to the command transmission time offset from the center of the command.
- e. The time between a command and any shutter action for all symmetric modes should be $1/16^{\text{th}}$ of the command repetition period as measured at the center of the command.
- f. The time between a command and the any shutter action for all asymmetric modes should be equal to the command transmission time offset from the center of the command.
- g. The commands should be separated by at least one command transmission period.
- h. The lens transition from open to closed shall be when the transmittance is at or below 1%.
- i. The lens transition from closed to open shall be when the transmittance is at or above 1%.
- j. A swap transition of the lenses for 3D modes shall first close the previously open lens, and then open the previously closed lens if the actions cannot be simultaneous due to system design. The swap lens transition shall be complete when the closing lens transmittance is at or below 1% and the opening lens reaches a transmittance of 1%.
- k. Simultaneous lens transactions for 2D modes shall have the same lens transitioning first for opening and closing transitions to ensure more balanced timing between the lenses. Simultaneous lens transitions shall be complete when the last lens has transitioned to the 1% transmittance. See Annex A for detailed timing diagrams show valid and invalid cases.
- l. See detailed description of operational modes in Annex A for implied lens open and close times.

4.3.3 Command Sequencing

The following table summarizes the command sequences and resulting implied modes of operation. More detailed timing diagrams can be found in Annex A.

Table 2: Command Sequence Summary

Operational Mode	Closed Duty	Command Sequence	Command Timing Dependence*	Mode Number
Eyewear Shutdown	NA	No Commands	None	1
Symmetrical Single 3D	Short	A1, B1	$[\text{Time}(\text{B1}) - \text{Time}(\text{A1})] > T_{\text{period}}/2$	2
	Long	B2, A2	$[\text{Time}(\text{A2}) - \text{Time}(\text{B2})] > T_{\text{period}}/2$	3
Swap Single 3D	None	A1	None	4
Symmetrical Dual 2D	Short	A1, B1	$[\text{Time}(\text{B1}) - \text{Time}(\text{A1})] < T_{\text{period}}/2$	5
	Long	B2, A2	$[\text{Time}(\text{A2}) - \text{Time}(\text{B2})] < T_{\text{period}}/2$	6
Swap Dual 2D	None	A2	None	7
Symmetrical Single 2D	Short	A1, B2	None	8
	Long	B1, A2	None	9
Half Single 2D	50%	B2	None	10
Symmetrical Dual 3D	Short	A1, B1, B1	$[\text{Time}(\text{B1}) - \text{Time}(\text{A1})] > T_{\text{period}}/2$	11
	Long	B2, A2, A2	$[\text{Time}(\text{A2}) - \text{Time}(\text{B2})] > T_{\text{period}}/2$	12
Swap Dual 3D	None	B1	None	13
Symmetrical Quad 2D	Short	A1, B1, B1	$[\text{Time}(\text{B1}) - \text{Time}(\text{A1})] < T_{\text{period}}/2$	14
	Long	B2, A2, A2	$[\text{Time}(\text{A2}) - \text{Time}(\text{B2})] < T_{\text{period}}/2$	15
Asymmetrical Dual 2D or Single 3D	Short	A1, B1, A2, B2	None	16
	Long	B1, A1, B2, A2	None	17

*The timing dependence shown is necessary but not sufficient. Detailed sufficient timing is in ANNEX A.

4.4 Command Codes

The commands are transmitted to the eyewear using ON-OFF Keying (OOK) of the carrier. Each command consists of two ON periods separated by a single OFF period; all commands are of equal length. The proportional relationship between the ON and OFF periods can be used to decode the commands, determining the actual number of carrier cycles in each period is not required. To assist in interference rejection only two lengths of commands will be supported, short and long.

In order to facilitate decoding of the commands and increase noise immunity the minimum ON or OFF period shall be two carrier clocks. The maximum ON and OFF periods are defined in order to reduce system power and limit interference with other IR controlled and shall be a

maximum of sixteen carrier clocks. The following table lists the short and long versions of the commands.

Table 3: Command Encoding

Command	Short Encoding	Long Encoding
After1 "A1"	11110011	111111111111111110000000011111111
Before1 "B1"	11001111	111111111000000001111111111111111
After2 "A2"	11000011	111111111000000000000000011111111
Before2 "B2"	11100111	111111111111100000000111111111111

- Emitters should use short command encoding to reduce emitted energy and lower power consumption.
- Emitters may use long command encoding to allow for better immunity in noisy environments.
- Eyewear shall respond to short and long command encodings.

4.5 Emitter Requirements

- The emitters shall emit in a way which guarantees the minimum signal energy of $1.2\text{mW}/\text{M}^2$ is present at the maximum targeted viewing distance and angles.
- Emitters used in single user computer environments where the viewers will be within 2 meters shall emit a minimum signal irradiance of $7\text{mW}/\text{sr}$ at $\pm 35^\circ$.
- Emitters used in multiple user entertainment environments where the viewers will be within 10 meters shall emit a minimum signal irradiance of $150\text{mW}/\text{sr}$ at $\pm 45^\circ$.
- Emitters should emit the minimum amount of energy necessary to maintain the minimum required levels in order to reduce interference on other IR emitting devices.
- When the display is in single 2D display mode, then the emitter shall CTASE emitting after a maximum of 0.5s if it does not support single 2D transition modes 8, 9 or 10.
- When the display is in single 2D display mode and supports single 2D transition modes 8, 9 or 10, then the emitter shall CTASE emitting after a maximum of 10 minutes.
- The emitter shall transition between modes within 0.5s of the display changing modes.
- The emitter shall support shutdown mode 1, and at least one of the single 3D modes 2, 3 or 4
- Shall operate with a minimum image cycle frequency range of 48Hz to 144Hz

4.6 Eyewear Requirements

- Shall block one or both the viewer's eyes from viewing the display's screen at specific points in time, while the display renders L/R stereo 3D, two different 2D images, or other image cycle image combinations in a time-multiplexed manner.
- Shall have standard LC shutter polarization (see optical section).
- Shall operate with a minimum signal energy of $1.2\text{mW}/\text{M}^2$ between $\pm 25^\circ$ degrees of incidence.

- d. Should operate with a maximum signal energy of 400mW/M^2 between ± 25 degrees of incidence.
- e. Shall operate with a minimum image cycle frequency range of 48Hz to 144Hz
- f. Shall adapt to the period of the image cycle established by the emitter.
- g. Prolonged loss of IR signal greater than five seconds shall cause both eyes to open
- h. Shall assume that the sequence of operations (e.g. L/R-cycle to L/R-cycle) will not change.
- i. In the event of moving object interference blocking the IR signal, should continue switching the shutters using the last valid command sequence for a period of time up to five seconds. During this period, the shuttering phase and frequency should be maintained within 1%.
- j. Shall power off within 2 minutes of signal loss
- k. Shall detect, validate, and begin shuttering according to the command sequence after receiving the command sequence for a maximum of 0.5s.
- l. Shall detect, validate, and begin shuttering according to a new command sequence after receiving the new command sequence for a maximum of 0.5s.
- m. Eyewear shall support shutdown mode 1.
- n. Eyewear shall support 3D modes 2, 3 and 4. For eyewear which supports multiple 2D modes 5, 6, 7, 14, or 15 a mechanism for setting the eyewear to show the image A or image B or ... should be provided.
- o. At a minimum the eyewear shall operate in multiple 2D modes 5, 6, 7, 14, or 15 by showing image A or shut down within the normal "no signal" shutdown time.
- p. For eyewear which supports multiple 3D modes 11, 12, or 13 a mechanism for setting the eyewear to show the images A or images B or ... should be provided.
- q. At a minimum the eyewear shall operate in multiple 3D modes 11, 12, or 13 by showing images A or shut down within the normal "no signal" shutdown time.
- r. Eyewear may support the single 2D modes 8, 9, or 10 for smoother transitions to and from single 2D mode.
- s. At a minimum the eyewear shall operate in single 2D modes 8, 9, or 10 by shutting down within the normal "no signal" shutdown time.
- t. For eyewear which supports asymmetrical modes 16 or 17 a mechanism for setting the eyewear to show single 3D or dual 2D image A or image B should be provided.
- u. At a minimum the eyewear shall operate in asymmetrical modes 16 or 17 by showing single 3D or shut down within the normal "no signal" shutdown time.

5 Optical Specification

- a. The transmission axis of the lens front polarizer shall be 90 degrees.
- b. The transmission axis of the lens front polarizer shall be within ± 2 degrees of 90 degrees.

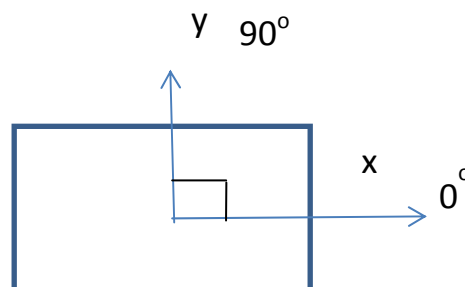


Figure 3 : Polarization Axis