O4
Control Interface
version 0.3.4

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1 Overview

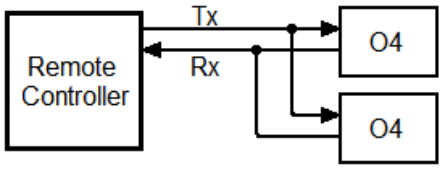
This document describes a control protocol for use with the Tek Gear O4 OLED Driver Board. The control protocol is based on a single transmission line topology. The Remote Controller will send data that is received by one or more O4 devices. The UART connection will operate a speed of 9600 baud with 8 data bits, no parity and 1 stop bit. A complete packet transmission will comprise of three frames to account for an address, command, value, and error checking.

2 Physical Interface

The physical interface between the remote controller and the O4 will be a standard UART interface, with signaling voltages will at +3.3V for logic '1', 0V for logic '0'. The nature of the UART interface calls for one transmitter and one receiver on the UART bus. While more than one device could receive information on a UART bus, the typical UART interface does allow multiple transmitters on one conductor, which means there would not be a method for both O4 driver boards to communicate back to the remote controller using the same UART connection. The O4 does allow for up to two (2) O4 devices to communicate back to the host controller by passively pulling its transmit (host Rx) conductor to 3.3V, which is the UART idle state. An individual O4 can be addressed to requested its data; in this instance the addressed O4 actively drives its transmit conductor to send data to the host while the opposite O4's transmit pin remains in a high impedance state with a passive pull-up.

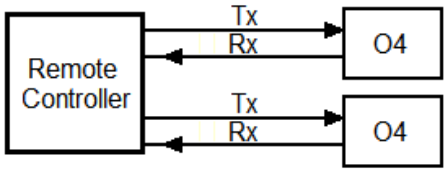
2.1 Shared Bus

The O4 supports half duplex communication. The Remote Controller broadcasts data packets that are received by both O4's. The packet identifies which O4 the information is intended for, the command that is issued, an appropriate value to go with that command, and an error checking field. Application of an O4 setting can be applied by addressing either the 'left', 'right', or 'both' O4 devices. Commands that request information to be sent from the O4 to the host must be addressed to a specific O4 because both O4 devices cannot transmit back their data simultaneously. This is the topology used in the remainder of this document.



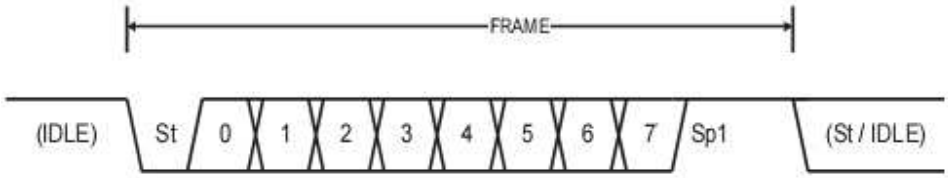
2.2 Separate Bus

An alternative bus topology is to use two separate UART connections. Essentially this is like two parallel monocular systems with remote control because the Packet does not need to identify a device address that the information is intended for. This topology can be used if the host has two UART interfaces available and the programmer wishes to be able to address both O4 devices simultaneously in readback scenarios



3 UART Frame Format

The operating speed of the UART will be 9600 baud, meaning each bit length segment of the frame is to be 1/9600 seconds in length (0.104167 milliseconds). The idle state is logic high (1) at 3.3V, and the frame format is to be 1 start bit, 8 data bits, no parity, and 1 stop bit, illustrated as follows:



St = Start Bit
n = n^{th} bit of byte. 0 = LSB, 8 = MSB
Sp1 = Stop Bit

4 Protocol Description and Timing

The control protocol packet will allow the remote controller to address up to 2 displays individually or simultaneously, send one command at a time to the receiver(s), include an appropriate data value respective of that command, and also include a checksum for error checking the packet.

Each frame is 10 bit intervals in length, or about 1.042 milliseconds, which makes the Packet size about 3.125 milliseconds. A small amount of latency between Packet transmissions is required to allow for the appropriate response to be performed by the receiving O4. The minimum time between the end of the last frame of a Packet to the start of the first frame of the next Packet is 20 milliseconds. If more 20 milliseconds passes since the last received frame, the packet byte counter will be reset and the O4 will interpret the next frame received as the first frame of a new packet. This automatic reset of the packet interpreter helps to "clean the slate" in case only a partial packet is received and the O4 would otherwise be expecting the next frame to conclude the previous packet, not begin a new packet.

It is possible for the O4 to receive packets sooner than every 20 milliseconds between the conclusion and start of subsequent packets. However, there is no guarantee that the reduced time between packets is sufficient to complete the requested operation. It is the responsibility of the remote control device to space the packets so that 20 milliseconds of idle time on the UART bus is present after the last frame of a packet is completely transmitted.

5 Packet Format

The packet format described below is based on a shared bus topology described in section 2.1. The packet comprises of a sequence of 3 bytes sent in series: a Command byte, a Value byte, and a Checksum byte. A new UART frame, described in section 3, is generated for each of the bytes to send to the receiver. After all three bytes have been sent, the packet transmission is complete.

Frame 1	Frame 2	Frame 3
COMMAND	**DATA**	**CHECKSUM**

5.1 Command Byte

The Command Byte is the first of the three bytes in the Packet, which identifies both the receiver that is the packet is intended for (notably for multiple display systems) and the command that is to be issued to that receiver. The structure of the Command Byte and the meanings of the bit fields are as follows:

MSB Command Byte LSB

7	6	5	4	3	2	1	0
0	0	COM3	COM2	COM1	COM0	ADDR1	ADDR0

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Bit Field	Value	Description
Bit 7:6 - Reserved	00	<reserved>
Bit 4:2 - COM3:COM0 - Command	0000	Set Luminance
	0001	Set Gain *All*
	0010	Set Offset *All*
	0011	Set Options
	0100	Save Settings
	0101	Load Settings
	0110	Set Vblack
	0111	<reserved>
	1000	Set Gain *Red*
	1001	Set Offset *Red*
	1010	Set Gain *Green*
	1011	Set Offset *Green*
	1100	Set Gain *Blue*
	1101	Set Offset *Blue*
	1110	Set Gain *Mono*
	1111	Set Offset *Mono*
Bit 1:0 - ADDR1:ADDR0 - Address	00	<reserved>
	01	Right Display
	10	Left Display
	11	Both Displays

A packet that is addressed for a particular O4 will only be processed by that O4; the opposite O4 will ignore the packet. Both displays can be addressed by using a "Both Displays" value in the Address field. A physical switch on the O4 hardware will identify its address: Left or Right channel.

The Set Gain and Set Offset will set those particular values for each Red, Green and Blue color channel equally.

5.2 Data Byte

The Data byte is the second of the three bytes in the Packet. The range of values allowed in the Data Byte is dependent on the command that was issued in the Command byte. A Data out of the ranges defined below are reserved and are ignored by the display controller.

MSB Data Byte LSB

7	6	5	4	3	2	1	0
D7	D6	D5	D4	D3	D2	D1	D0

5.2.1 Set Luminance

Controls the variable luminance setting employed by the O4. Minimum luminance is value 0, while value 255 represents maximum luminance.

Data Range: 0 to 255
Default Value: 192 (0xC0)

5.2.2 Set Vblack

Controls the Vblack reference voltage into the O4. Minimum value is 0 representing 3.50V, maximum value is 255 representing 3.75V. Default value is 103 (0x67) representing 3.6V; the eMagin-recommended default.

Data Range: 0 to 255
Default Value: 103 (0x67)

5.2.3 Set Gain <channel>

Gain controls the amplification of the input signal on the applicable channel, ranging from 50% of the input signal up to 150% of the input signal's full scale value. Value 0 denotes 50% amplification, value 128 denotes 1:1 scaling (no amplification), and value 255 represents scaling the input signal to be 50% larger.
Applies to commands 'Set Gain All', 'Set Gain Red', 'Set Gain Green', 'Set Gain Blue', 'Set Gain Mono[1]'.

Data Range: 0 to 255
Default Value: 127 (0x80) (eMagin recommended)

5.2.4 Set Offset <channel>

Offset controls the DC-shift of the input signal on the applicable channel, ranging from 50% below to 50% above of the input signal's full scale value. Value 0 denotes a negative 50% DC offset, value 64 denotes no DC shift, and value 127 represents a positive 50% DC offset.
Applies to commands 'Set Offset All', 'Set Offset Red', 'Set Offset Green', 'Set Offset Blue', 'Set Offset Mono[2]'

Data Range: 0 to 127
Default Value: 48 (0x30) (eMagin recommended)

5.2.5 Set Options

Controls a selection of auxiliary features on the O4 and OLED.

Data Range: 0 to 5

0 sets OLED luminance to an OFF state
1 sets OLED luminance to an ON state (default)

2 sets OLED white-only (grayscale) mode OFF (default)
3 sets OLED white-only (grayscale) mode ON

4 sets OLED zoom-mode[3] (852x600 pixels) OFF for 60 and 72Hz RGB inputs (default)
5 sets OLED zoom-mode (852x600 pixels) ON for 60 and 72Hz RGB inputs

6 sets OLED extended luminance mode OFF (default)
7 sets OLED extended luminance mode ON (default)

5.2.6 Save Settings

Saves current settings to non-volatile memory, including the Gain and Offset values for Red, Green, Blue and Offset channels, as well as settings for luminance, white-only mode, and zoom mode.

Data Range: 0

5.2.7 Load Settings

Loads the saved or factory default settings to become the current settings, or transmits the current settings to the remote controller for review.

Data Range: 0 to 2

0 Loads saved settings from non-volatile memory
1 Loads factory default settings
2 Requests a readback transmission of the current O4 settings. Not applicable for address ADDR1:ADDR0 = BOTH

[1] SVGA+ OLED displays only
[2] SVGA+ OLED displays only
[3] SVGA+ OLED displays only

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5.2.7.1 Readback Current Settings

Readback packet format is comprised of 12 frames (bytes), starting with the luminance value and ending with a checksum byte. Summation of bytes 1-12, mod 256, will equal 0.

1	2	3	4	5	6	7	8	9	10	11	12
Luminance	Vblack	Gain Red	Offset Red	Gain Green	Offset Green	Gain Blue	Offset Blue	Gain Mono	Offset Mono	Options	Checksum

5.2.7.1.1 Byte 10: Options

MSB Byte 10: Options LSB

7	6	5	4	3	2	1	0
Op7	Op6	Op5	Op4	Op3	Op2	Op1	Op0

The Options byte presents the remote controller with the current state of O4 settings flags, including the current state of the on-board 4-position DIP switch, the state of the white-only mode option, the state of the zoom-mode option, and the state of the extended luminance mode option. The DIP switch schematic is active low: 'ON' position is represented by value 0, 'OFF' is represented by value 1. See section *7 Overview* for details on the meaning of the DIP switch positions.

Bit Op7: <reserved> value 0
Bit Op6: Extended luminance mode. 0 is OFF, 1 is ON
Bit Op5: Zoom mode. 0 is OFF, 1 is ON
Bit Op4: White-only grayscale mode. 0 is OFF, 1 is ON
Bit Op3: Current ON or OFF position for DIP switch 4 'Horizontal Scan Direction'
Bit Op2: Current ON or OFF position for DIP switch 3 'Vertical Scan Direction'
Bit Op1: Current ON or OFF position for DIP switch 2 'CVBS Signal'
Bit Op0: Current ON or OFF position for DIP switch 1 'Display Select'

5.3 Checksum

The Checksum byte is present to validate the data that is received by a particular receiver. If the checksum calculation performed by the receiver determines the packet was corrupted, the packet is ignored.

MSB LSB

7	6	5	4	3	2	1	0
CS7	CS6	CS5	CS4	CS3	CS2	CS1	CS0

The Checksum byte is to be calculated by adding the hexadecimal representation of the Command Byte and the Data Byte together to create a sum X. The sum X is then ensured to fall within the range of 0 to 255, which is done by performing a modulus 256 on the sum to create value Y. Lastly a 2's complement is performed on Y to generate value Z. The 2's complement is calculated by, in binary notation, flipping each of the bits and then adding 1 to the result Z. Z is the 8-bit checksum byte that will be sent as the 3rd byte of the Packet.

The result can be checked by adding together the three bytes of the frame, and the result, modulo 256, will equal 0x00.

e.g. COMMAND = 0x02 (set Left Display Luminance)
DATA = 0xA4 (luminance value 164 out of 255)
CHECKSUM = 2's complement of ((0x02 + 0xA4) mod 256)
= 2's complement of <1010 0110> = 0101 1010 = 0x5A

Validate that checksum is correct: COMMAND + DATA + CHECKSUM = 0x02 + 0xA4 + 0x5A
= 0x100, drop the carry bit, and the result is 0x00

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6 Control Mode

The O4 is capable of two types of control: Command Control and Manual Control. By default, the O4 is in Command Control input mode at power-up. The O4 is not available to receive control commands for one (1) second after power-up while it performs its own configuration.

The O4 will remain in Remote Control input mode if at least one complete packet is correctly received within four (4) seconds after power-up. If a packet is not correctly received between one (1) and four (4) seconds after power-up, the O4 will switch to Manual Control mode and will be unresponsive to Command packets sent to the O4.

The two control input pins, Control0_RX and Control1_TX, are shorted to ground to control the O4 Luminance. Shorting Control0_RX to ground decreases the O4 luminance, shorting Control1_TX increases the luminance, and shorting both Control0_RX and Control1_TX to ground simultaneously will reset the luminance to the factory default setting. The luminance settings are automatically saved when the control inputs are released, and will be retrieved at the next power-up cycle.

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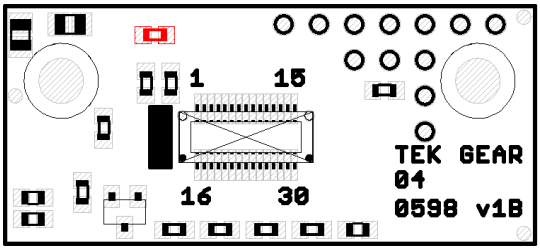
7 O4 Setup

The O4 address has a number of settings that can be configured on-board prior to deployment. There is a bank of four (4) DIP switches on the front of the O4, and an address selection resistor on the reverse.

DIP Switch	Setting Name	OFF position (value 1)	ON position (value 0)
1	Display Select	SVGA-3D	SVGA+
2	CVBS Signal (SVGA+ only)	PAL	NTSC
3	Vertical Scan Direction	Bottom to Top	Top to Bottom
4	Horizontal Scan Direction	Right to Left	Left to Right

The address selection resistor is identified by the red location in the following image of O4 hardware version 1b.



Right eye: Remove resistor (open)
Left eye: Leave 0-ohm resistor on board (short)

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8 Revision History

Revision	Date	Author	Notes
0.1	2007 06 06	EA	Initial Draft
0.1.1	2007 06 06	EA	Corrected descriptions in section 4.2
0.2	2007 06 29	EA	Added Load Settings command, added protocol description and timing section, added input mode selection section, general formatting
0.2.1	2007 07 12	EA	Added signal voltage spec, general editing
0.2.2	2007 10 31	EA	Edited control modes section
0.3.0	2008 01 18	EA	Added channel-specific gain/offset commands
0.3.1	2008 02 05	EA	Updated Physical Interface description Re-ordered color-specific gain/offset commands for better consistency with other documents. Added white-only-mode and zoom-mode option commands Added Read-back Settings command Revised Section 5 to expand command and data descriptions Updated Control Mode description
0.3.2	2008 06 11	EA	Added command for setting Vblack; also added to readback command
0.3.2	2009 01 05	EA	Added Set Vblack section
0.3.2	2009 01 16	EA	Updated Table of Contents
0.3.3	2009 02 03	EA	Added extended luminance range mode
0.3.4	2009 05 22	EA	