OCULUS VR, INC

[redacted]

# Positional Tracker DK2 Specification

*Authors:*
John Robertson

*Date:*
May 29, 2014

[redacted]

[redacted]

Oculus VR, Inc. 19800 MacArthur Blvd Suite 200 Irvine, CA 92612

[redacted]

All brand names, product names or trademarks belong to their respective holders.

**Disclaimer**

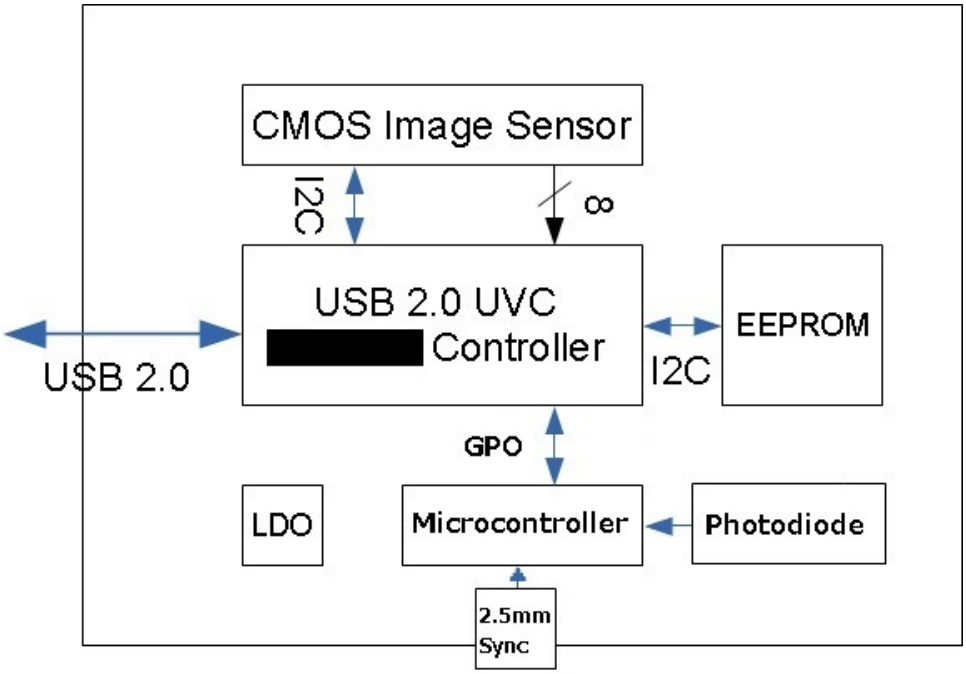
THIS PUBLICATION AND THE INFORMATION CONTAINED HEREIN IS MADE AVAILABLE BY OCULUS VR, INC. AS IS. OCULUS VR, INC. DISCLAIMS ALL WARRANTIES, EITHER EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE REGARDING THESE MATERIALS.

[redacted]

# 1 Introduction

Positional Tracker DK2 is a High Speed USB device used to provide optical tracking data for the Oculus Rift. Its large 1/3" format global shutter image sensor enables short exposures, providing high contrast marker tracking data over a wide field of view. Targeting the standard USB Video Class (UVC) will enable wide compatibility with minimal driver development.

## 1.1 Block Diagram



# 2 Industrial Design

## 2.1 PCB

The Positional Tracker DK2 PCB is 51.4x24mm with mounting holes for the M12 mount (M1.6) and housing (M2). A mini USB connector and a 2.5mm stereo jack attach to removable cables on the side of the device. A daughter-board containing a blue status LED and NIR photodiode is positioned in the front of the case.

## 2.2 Internal M12 Lens Mount

The lens mount is M12, centered on the image sensors optical axis.

## 2.3 Housing

The DK2 Positional Tracker housing design is unique industrial design and consists of two main parts, tracker housing and removable stand. Housing is designed for lens barrel attachment, cover for IR transmissive sensor, for PCBA mounting, removable filter assembly, and removable stand attachment. The housing cover has two dedicated openings for connector connection on the side. The back of the housing has dedicated recess surface area for product label attachment.

Stand Assembly is designed for removable from the housing and allow the upper housing to tilt forward and backward. The stand is design for multiple position usage and folded position for desk top uses, and unfolded position for monitor mounting uses. The bottom of stand surfaces consist with anti-slip rubber pads to minimize movement and with screw thread for tripod mounting of the tracker.

**Physical Characteristics**

| Parameter | Specification |
|---|---|
| Housing | Black plastic injeciton molded PC |
| Front Coverplate | Black plastic injection molded PC IR transmissive |
| Stand Assembly | Black plastic injection molded PC |
| Weight | 70 grams |
| Finish (Housing) | Matte (Sandblasted Tool) |
| Finish (Cover Plate) | Glossy (Polished Tool) |
| Finish (Stand) | Matte (Sandblasted Tool) |


# 3 Optical System

The optical system consists of a 850nm band-pass filter, lens, lens-mount, and image sensor.

## 3.1 Image Sensor

The image sensor used in the Positional Tracker DK2 is Aptina MT9V034C12STC CMOS sensor[1] with the following feature set:

- 752x480 pixel resolution
- Color (Bayer filter array pattern)
- 60 FPS at full resolution
- 1/3” image format
- Global shutter
- High sensitivity at 850 nm

## 3.2 Lens Optics

The optical system will use low profile lens with a M12 mount. The target for field of view is 70° horizontal. Like the viewing optics, distortion in the edges of the field can be corrected for in software, allowing for use of smaller/cheaper optics than would be possible with stringent distortion requirements. A NIR 850nm band-pass filter is included to enable play in high ambient lighting conditions (with some minor transmission loss in the NIR band).

[1] http://www.aptina.com/products/image_sensors/mt9v034c12stm/

# 4 Microcontroller

The Positional Tracker DK2 will include a STM8S003F3 microcontroller to handle synchronization between the LEDs on the HMD and the image sensor exposure. The STM8S003F3 is programmed over a standard 4-pin SWIM header, and controls a status LED. Field upgrades over USB are not supported.

The microcontroller contains the following I2C registers for configuration:

| Address | Name | Description |
|---|---|---|
| 0x00 | FW VERSION | Firmware version number |
| 0x02 | SYNC PERIOD | Timeout to wait between wired syncs before switch to NIR if enabled |
| 0x03 | EXT SYNC PERIOD | Detected external sync period |
| 0x05 | LED ON START | LED PWM start count |
| 0x06 | LED TOTAL | LED PWM total count |
| 0x07 | SYNC SOURCE SEL | Current sync mode (0 == WIRE, 1 == NIR) |
| 0x08 | NIR SYNC EN | Set to 0 (default) disables NIR sync option, otherwise enabled |

# 5 USB 2.0 UVC Controller

To handle USB 2.0 HS isochronous transfers of image sensor frame data to the computer, an Etron eSP570 [2] is used. This part is interfaced to the image sensor over a 8-bit image data bus, with status/control strobes, and I2C for image sensor register access. The eSP570 implements the standard USB Video device Class (UVC 1.1) [3] via its internal 8051 core.

Etron claims 50 percent of the UVC controller market in China [4]

Firmware is loaded onto the attached EEPROM over USB. The eSP570 part ships with an internal bootloader, so that new devices can be immediately programmed over USB. There is a Windows programming tool that loads the firmware binary into the EEPROM. Field upgrades are supported.

[2] http://www.etron.com/en/products/PositionalTrackerDK2_detial.php?Product_ID=17/

[3] en.wikipedia.org/wiki/USB_video_device_class

[4] http://www.digitimes.com/supply_chain_window/story.asp?datepublish=2010/09/28&pages=PR&seq=201

# 6 Data Stored in EEPROM

| Address | Size | Name | Written by |
|---|---|---|---|
| 0x0000 | Variable, max 0x1000 bytes | Etron Firmware | Jabil Etron Programmer |
| 0x2000 | Variable, max 0x800 bytes | Calibration block | Bundle Adjustment Testware |
| 0x2800 | 32 | Serial Number | Bundle Adjustment Testware |
| 0x2820 | 32 | Jabil Serial Number | Jabil Software |

## 6.1 Calibration Block

The calibration block is a variable length block that contains calibration parameters and CRC in little endian

```
typedef struct
{
    UINT32 magic; // should always be 0xe2978900
    UINT16 length; // length of serialization block plus this header
    UINT16 version; // 1 for simple list of coefficients
    UINT16 coefficientCount; // 9 for version 1
    UINT32 crc; // Checksum of coefficients in this block
} CalibrationHeader;
```

Each calibration value is specified with a calibration header:

```
typedef struct
{
    UINT16 identifier;
    UINT16 length; // Size of this block plus header
} CalibrationValue;
```

CRC is computed with the entire block and the CRC value as 0

## 6.2 Serial Number

- 20 bytes HMD GUID
- 12 bytes Jenkins hash of 20 byte HMD GUID

## 6.3 Jabil Serial Number

- 0-7 bytes epoch date in milliseconds LE, 8-31 bytes Jabil serial number incrementing from 0 LE

# 7 Image sensor syncrhonization to external strobe

Synchronizing the image sensor exposure to the illumination of the IR LEDs on the HMD allows for minimum exposure time and LED power consumption.

A Vishay TSOP75585NTT IR Receiver module demodulates the signal emitted from the LEDs on the HMD to trigger the image sensor exposure. The TSOP75585NTT has a field of view comparable to the image sensor lens, such that it can receive a sync signal when the HMD is in the image sensors field of view. While the HMD LEDs are not in view, the STM8S003F3 microcontroller can be continue to trigger the image sensors exposure at the set frame rate. To relax the synchronization constraint, the image sensor exposure must be extended relative to the LED on time (for 150us LED, 300us shutter is used) when in NIR sync mode.

The 2.5mm stereo jack provides a sync signal and ground from the HMD. This cable can be used as an alternative to the IR sync (noisy environments). The 2.5mm sync signal has priority over the IR sync.

The image sensor triggers exposure on negative sync edges

# 8 USB Identification

- **Vendor ID:** *0x2833*
- **Product ID:** *0x0201*
- **Vendor String:** *Oculus VR, Inc.*
- **Product String:** *Positional Tracker DK2*
- **Supported Resolutions:** *752x480 60fps*

# 9 Using the Positional Tracker DK2

All target operating systems include support for UVC-compatible image sensors for streaming video data. Demosaicing can be preformed in usermode after acquiring the data.

## 9.1 Windows

Windows 7,8 have a system-supplied universial serial bus Video Class driver [5], UsbVideo.sys (Windows XP support may require SP2). The image data is packed in a YUY2 container with half the horizontal resolution (two raw pixels per YUY2 pixel).

## 9.2 Linux

UVC 1.1 video streaming is supported by the Linux UVC driver [6] from 2.6.26 this is included in kernel source distribution.

## 9.3 Mac OS X

Mac OS X has shipped with a UVC driver since version 10.4.3

[5] http://msdn.microsoft.com/en-us/library/windows/hardware/ff568651.aspx
[6] http://www.ideasonboard.org/uvc/

# 10 Revision History

| Revision | Date | Description |
|---|---|---|
| 0.8 | 29-05-2014 | Cleanup |
| 0.7 | 19-05-2014 | Part number updates, USB Product String, EEPROM map, STM8S I2C regs data |
| 0.6 | 18-12-2013 | Part number updates, USB Product String |
| 0.5 | 20-10-2013 | Cleanup |
| 0.4 | 18-10-2013 | Included sync information, removed accelerometer, added microcontroller. Specified color Aptina part. |
| 0.3 | 19-8-2013 | Fixed markup |
| 0.2 | 30-7-2013 | Updated block diagram. |
| 0.1 | 27-7-2013 | Preliminary specification. |