External Synchronization

Synchronization Overview

Opal recordings can be precisely time synchronized with external equipment. There are two supported synchronization modes:

- Output synchronization: when the Opal system begins recording data, it will output a signal to external equipment when the recording starts. Output signals can be edge or level triggered.
- Input synchronization: the Opal system will immediately begin recording when it receives a signal from external equipment. Input signals can be edge or level triggered as well.

External Synchronization requires:

- An APDM External Synchronization Box, or "Sync Box"
- A 3.5 mm 4-conductor cable to connect the Sync Box to the access point
- An APDM access point
- That the Opal system is configured for wireless streaming

Synchronization Hardware

APDM's Sync Box (v2)

Access Point ↔ Sync Box Connectors and Cable Both the access point and Sync Box have a 4-conductor 3.5 mm receptacle. A standard 1 m long, 4-conductor, 3.5 mm cable is included with the Sync Box to connect it to the access point. These cables are often called "AV" cables becaus they contain 4, not the usual 3, conductors. A regular stereo audio cable will *not* operate correctly. A longer 4-conductor, 3.5 mm cable may be used, up to 10 m. This cable provides power from the access point to the Sync Box, and provides bidirectional communication between the two (using the Controller Area Network, or CAN, protocol). A green light on the side of the access point, near the 3.5 mm receptable, indicates that the access point is providing power to the Sync Box.

Mode Switch A toggle switch on the top of the Sync Box allows you to switch the operational "mode" of the Sync Box:

- **Normal Mode:** When in normal mode, the In and Out signals are controlled by software, and the square buttons on the top of the Sync Box are ignored.
- **Manual Mode:** When in manual mode, the square push buttons just below the "Out" and "In" LEDs allow the user to manually trigger input and output events. Pressing the "Out" button will toggle the output synchronization signal on the "Out" BNC connector high and low. Pressing the "In" button will toggle the input synchronization signal that goes into the access point high and low. In Manual mode, output signals sent by APDM software and actual input signals from external equipment are ignored.

Status indicator The Status LED is illuminated when the Sync Box has power. It is green when the Sync Box is in "Normal" mode, and blue when in "Manual" mode (described above).
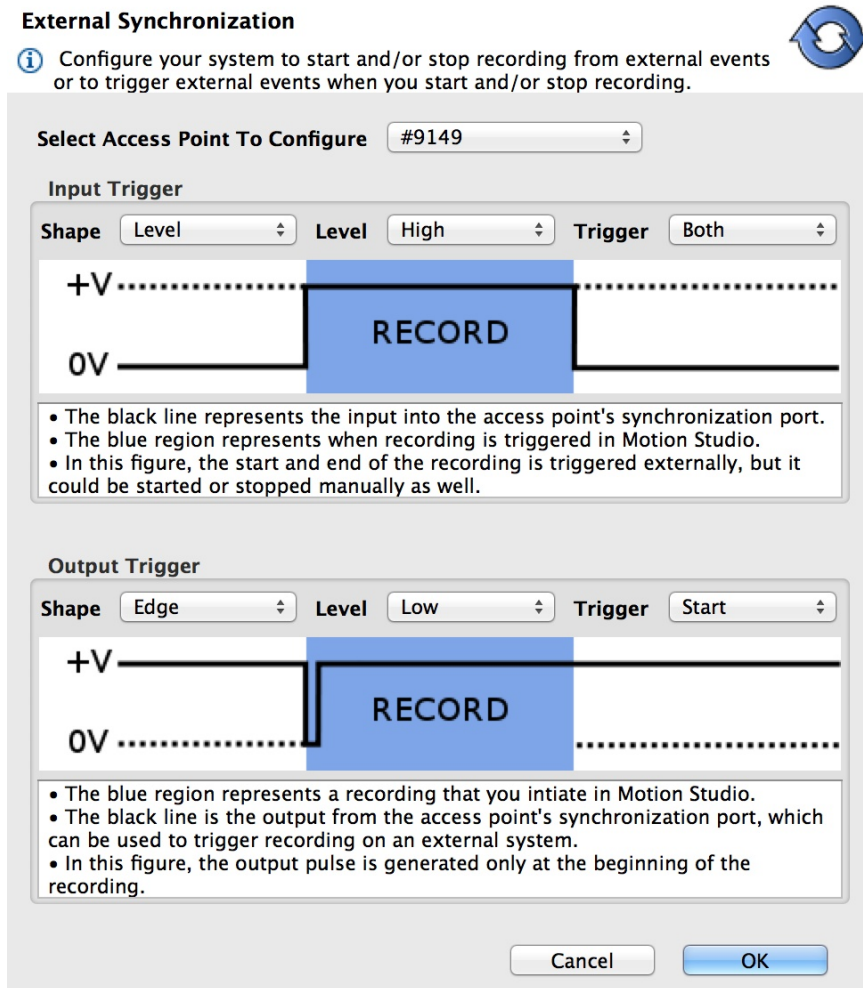
External Synchronization Connectors (BNC Connectors) The Sync Box has two external BNC connectors, labeled "In" and "Out".

- **In BNC Connector:** The In signal is designed to receive a 0 to 3.3 V (5V maximum) signal from external equipment. The logic high threshold is at 2.3V and the logic low threshold is 0.99V. This means a valid input signal must be below 0.99V when low, and above 2.3V when high. When the input signal is low, the In LED is off. When input is high), the In LED is green. For more technical details on the In signal, please see the *Schematic of Sync Box Input and Output Signals* (below).
- **Out BNC Connector:** The Out signal sends a 0 to 3.3V signal to external equipment. When not excessively loaded, the output high signal is greater than or equal to 2.9V and is typically 3.3V. When the output signal is low, it will be 0.4V or less. When output is low, the Out LED is off, and when output is high, the Out LED is green. For more technical details on the Out signal, please see the *Schematic of Sync Box Input and Output Signals* (below).

Firmware Updates If there is ever a need to update the Sync Box's firmware in the field, there is a small panel on the side of the Sync Box which exposes a USB port that can be used to perform the update.

Configuration

External synchronization options are selected using the External Synchronization Configuration dialog. You must specify the access point that will be connected to the Sync Box. Only one access point (and thus one Sync Box) can be specified at a time.

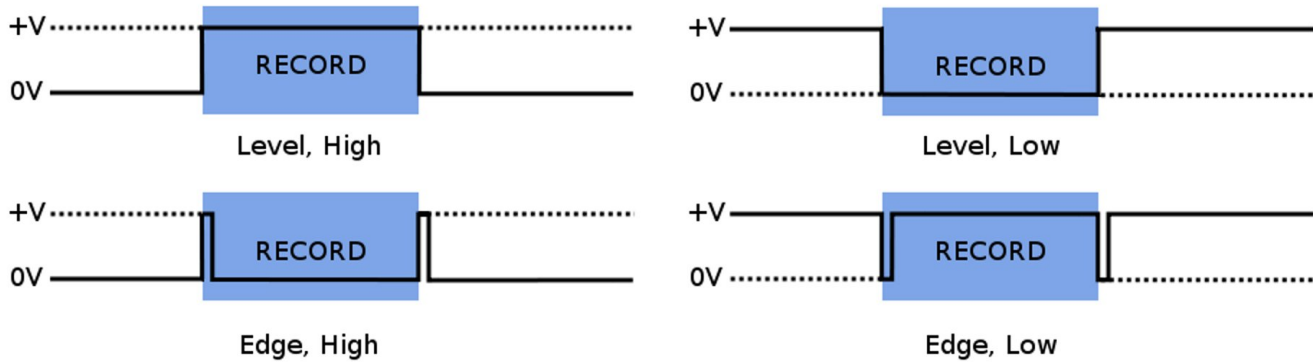**The External Synchronization Configuration Dialog**

Input Trigger Shape

The input trigger shape indicates the type of signal that will be input into the specified access point and how you want your Opal system to respond. In the figure above, the four basic trigger shapes are shown. The solid black line represents the external synchronization signal being sent to the access point. The blue shaded region represents the period that will be recorded by your Opals.

Input Trigger Level

Input triggers can be either low or high, depending on the nature of the signal generated by your external synchronization source.

Input Synchronization

Input synchronization trigger types

Input Trigger

There are three input trigger options available:

- Start: The external trigger will only be used to start recording by your Opals.
- End: The external trigger will only be used to stop recording by your Opals.
- Both: The external trigger will be used to start and stop recording by your Opals.

Sample Selection with External Input Trigger Events

The time of the external input trigger events may not align exactly with the time of an individual samples being collected in Motion Studio due to the discreet sampling interval. If the start trigger event time does happen to align exactly with a sample captured in Motion Studio, the first sample recorded will correspond exactly to the time of the start trigger event. If these do not align exactly (as will generally be the case) the sample following the start trigger event will be the first sample recorded. Similarly, if the stop trigger event aligns exactly with a sample captured in Motion Studio, the last sample recorded will correspond exactly to the time of the stop trigger event. If these do not align exactly, the sample preceeding the stop trigger event will be the last sample recorded.

Annotation of Externally Triggered Recordings

Note: Annotations are implemented for the HDF file format only. When an external "Start" trigger event is detected, an annotation is added to the recording that indicates the name of the event (in this case "External trigger start time") along with the timestamp of the event in epoch microseconds. Similarly, when an external "Stop" trigger event is detected, a timestamped annotation is added to the recording (in this case labeled as the "External trigger stop time"). These annotations allow you to align the recording captured by your Opals with your external events in the case where the external trigger event times do not exactly align with the samples captured in your HDF file.
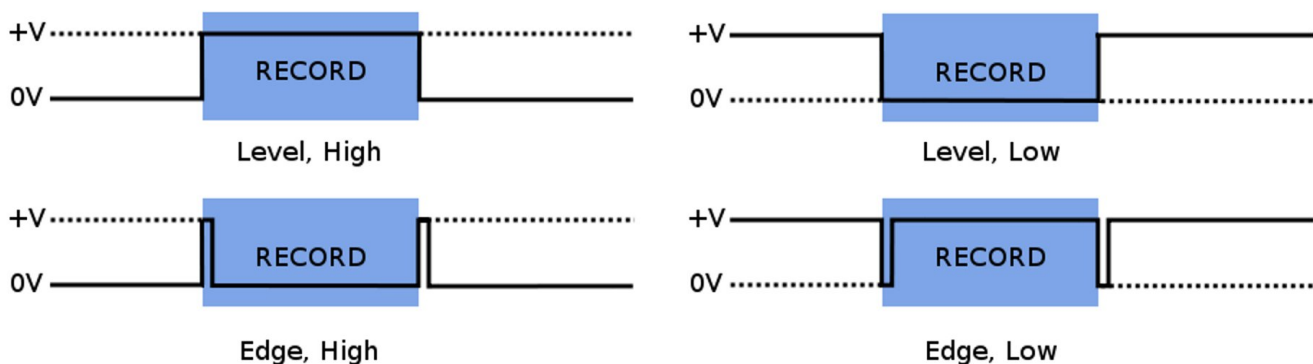
Output Trigger Shape

The output trigger shape indicates the type of signal that will be generated by the specified access point when recording is started and stopped by your Opals. The output trigger shapes are identical to the input trigger shapes, but in this case the solid black line in the figure above represents the signal being output by the configured access point. The blue shaded region represents the period being recorded by your Opals, initiated either through user selection of the start/stop buttons in the "Stream" dialog, use of the wireless remote, or an external synchronization event. Unlike input triggers, output triggers are processed even if the "External Sync" option is not specified in the "Record Duration" panel of the "Stream" dialog.

Output Trigger Level

Output triggers can be either low or high, depending on the requirements of the external system receiving the synchronization signal.
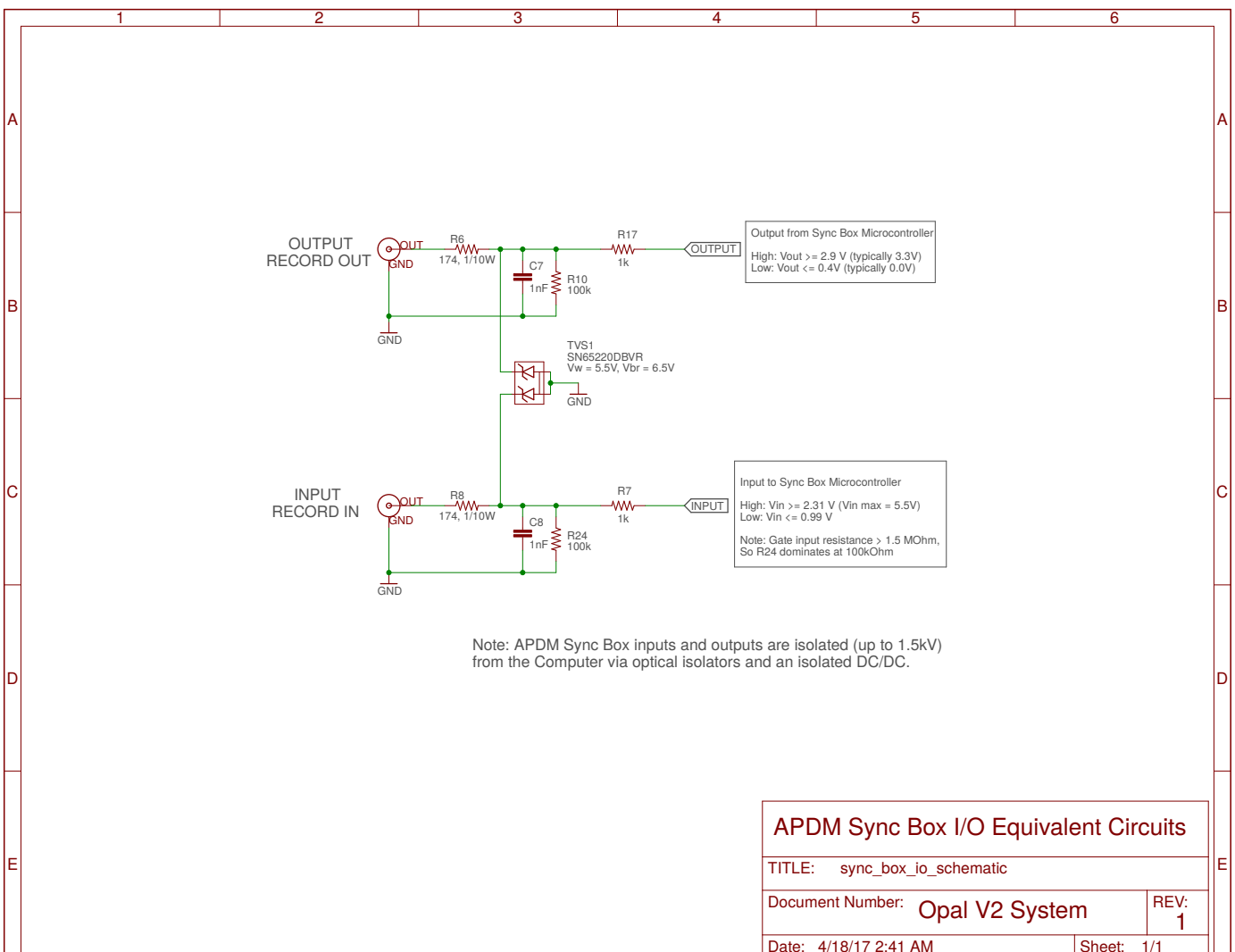
Output Synchronization

Output synchronization trigger types

Output Trigger

There are three output trigger options available:

- Start: The external signal will only be generated when recording is started by your Opals.
- End: The external signal will only be generated when recording is stopped by your Opals.
- Both: The external signal will be generated when recording is started and stopped by your Opals.

Schematics

Schematic of Sync Box Input and Output Signals