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Improving Event-Based Synchronization Using the Prophesee EVK4 Event-Based Sensor

by Darren Webb

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14. ABSTRACT
The Prophesee Evaluation Kit 4 (EVK4) is an event-based vision sensor, offering a fundamentally different approach to sensing compared with traditional cameras by only registering changes in pixel brightness. This dynamic vision system excels in high-speed, high-dynamic-range scenarios, proving particularly useful for applications within the ARL mission scope. However, a limitation of the EVK4, and event-based cameras in general, lies in the relatively short distance over which reliable camera-to-camera synchronization can be achieved—specifically, only 1 m with the EVK4. This constraint limits the scope of use for larger applications where greater distances are desired. A custom circuit was created aimed at extending the synchronization distance and incorporating additional functionality. The circuit overcame the distance limitations and unlocked new potential for multicamera, event-based systems.

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Photonics, Electronics, and Quantum Sciences; sensing; circuits

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1. Introduction, Experimental Setup, and Results

A laboratory experiment was conducted to determine the synchronization distance limit of the Prophesee Evaluation Kit 4 (EVK4) sensors. Two EVK4 sensors were mounted on tripods (Figure 1) facing a common target, i.e., a blinking LED positioned on the opposing wall. A development computer was connected to the designated master sensor, and the slave sensor was linked to the master via an ix Industrial type B connector (Figure 2) using the integrated synchronization pins. Testing proceeded incrementally, with cable lengths of 0.5, 1, 2, and 3 m tested in ascending order. The maximum synchronization distance was defined as the longest cable length at which the slave sensor reliably detected and reported the blinking LED signal.

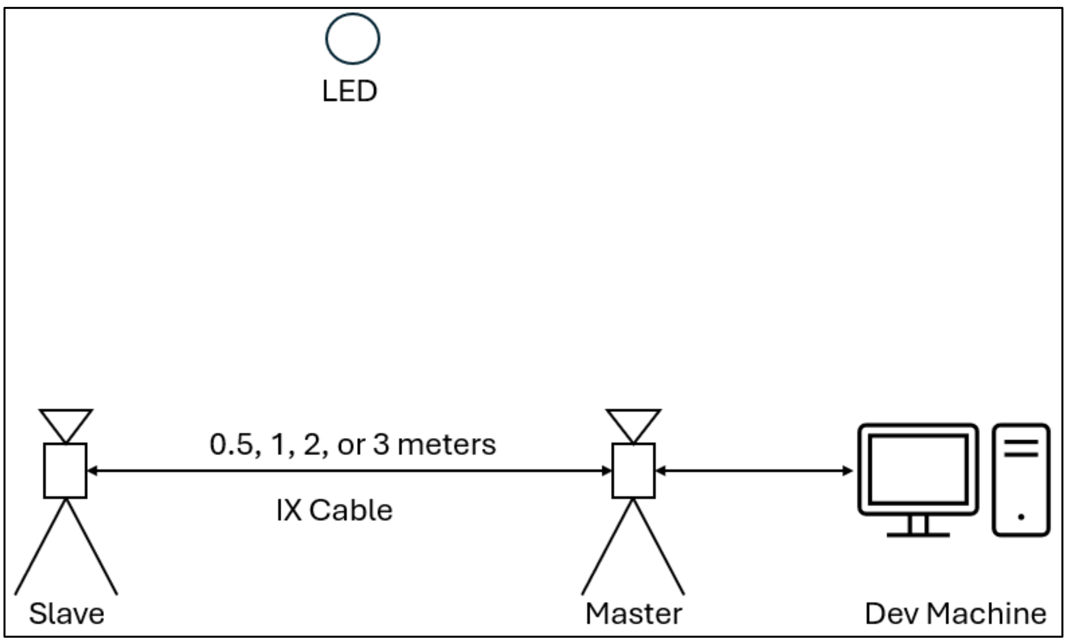

Figure 1. Experiment setup.

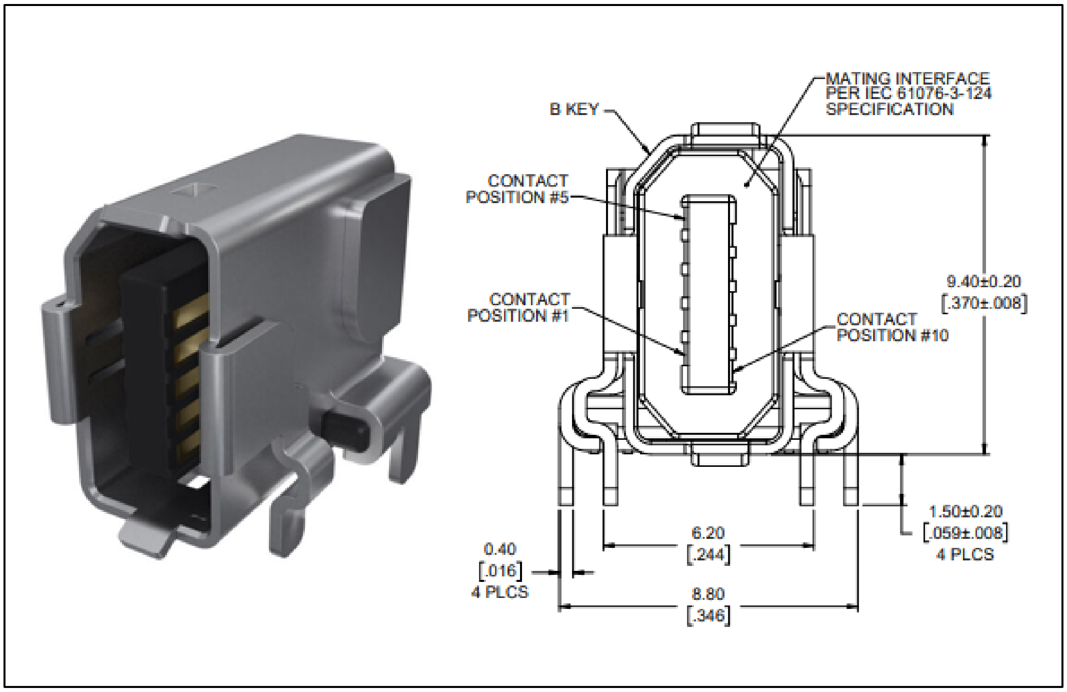

Figure 2. ix Industrial type B connector found on the EVK4 sensor.

The experimental results indicated successful synchronization between the EVK4 sensors was consistently maintained up to a cable length of 1 m. Increasing the cable length to 2 m resulted in a loss of signal integrity, preventing the slave sensor from remaining synchronized with the master. This inability to synchronize beyond 1 m significantly constrains the potential applications of a stereo EVK4 setup. Specifically, this distance limitation restricts the baseline for depth perception and impacts the achievable accuracy and effective working volume for imaging and diagnostics. This necessitates the use of a signal amplification circuit or alternative synchronization method to overcome this constraint and broaden the applicability of multicamera EVK4 configurations.

2. Synchronization Amplifier Circuit

The EVK4 sensor uses four pins of the 10-pin type B connector to synchronize between sensors. Two of the other six pins are trigger input and ground pins while the remaining pins are unused (Table 1)

Table 1. Pin assignments for the type B connector used on the EVK4.

CONNECTOR PIN ASSIGNMENT	
POSITION NUMBER	WIRE COLOUR (DIN 47100)
1	WHITE
2	BROWN
3	GREEN
4	YELLOW
5	GREY
6	PINK
7	BLUE
8	RED
9	BLACK
10	VIOLET

1	SYNC_OUT_P	Synchronization output positive · Directly connected to +3.3V.
2	SYNC_OUT_N	Synchronization output negative · Open collector (float or GND).
3	SYNC_IN_P	Synchronization input positive · Opto-coupler anode
4	SYNC_IN_N	Synchronization input negative · Opto-coupler cathode
5	TRIG_IN_P	Trigger input positive · Opto-coupler anode
6	TRIG_IN_N	Trigger input negative · Opto-coupler cathode

A dedicated optocoupler/amplifier circuit was designed to transmit the SYNC_OUT signals to the SYNC_IN pins of the slave sensor (Figure 3). The ACPL-064L-560E optocoupler was selected for signal isolation and amplification, paired with the SN74LVC2G04DBVR inverter to ensure proper signal conditioning. Both components operate at 3.3 V and are powered by an LM1086 3.3-V linear regulator, which accepts a 5-V input via micro-USB. The design is compact and fits within a 48- × 48-mm printed circuit board (PCB) area (Figure 4). Also included in the design are the two aforementioned type B connectors (one for the master input and the other for the slave output), two 10-µF capacitors on the 5-V and 3.3-V lines for electrical noise isolation, external trigger input pads, and three resistors in series (822-ohm equivalent) on the positive trigger output of the master for proper input impedance.

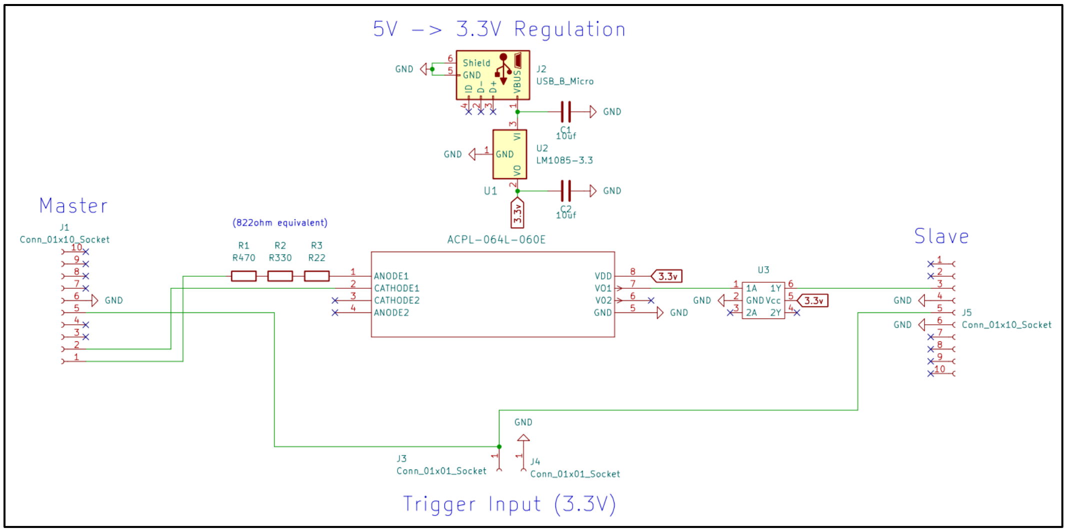

Figure 3. Synchronization circuit featuring an external trigger input and integrated voltage regulation.

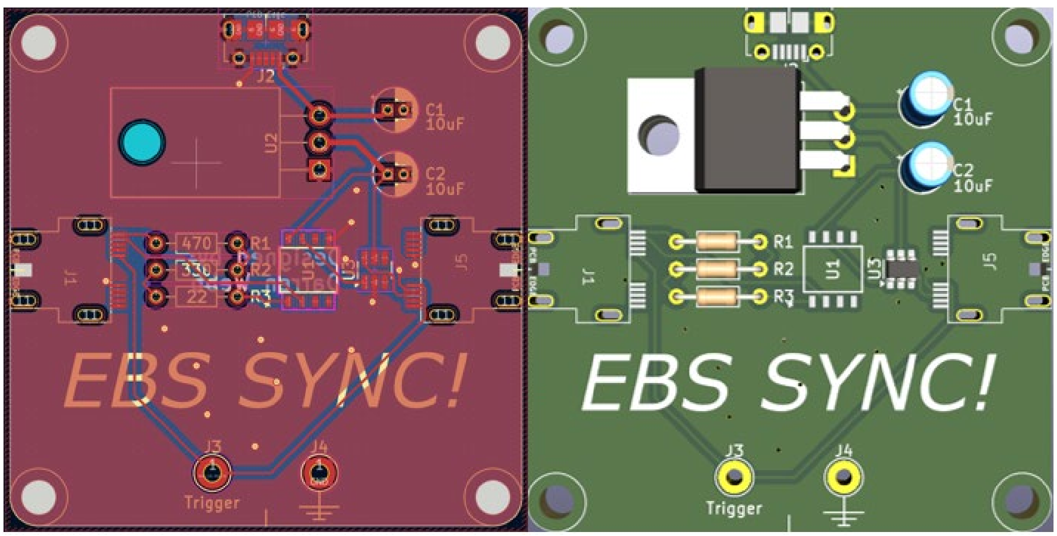

Figure 4. PCB board layout (left) and 3D model of board (right).

A 3D-printed enclosure was designed and constructed to house the circuit prototype (Figure 5). The enclosure measures 54 mm (L) × 54 mm (W) × 32.5 mm (H), excluding the external Bayonet Neill–Concelman (BNC) connector for triggering, resulting in a footprint comparable to the EVK4 sensor itself. This compact size optimizes the unit for its intended application. The four sides of the enclosure provide access to the circuit's inputs and outputs: master sensor input, slave sensor output, micro-USB power, and the external trigger BNC. The enclosure lid is clearly labeled to ensure ease of use and prevent misconfiguration. A complete bill of materials to produce one complete unit is listed in Table 2.

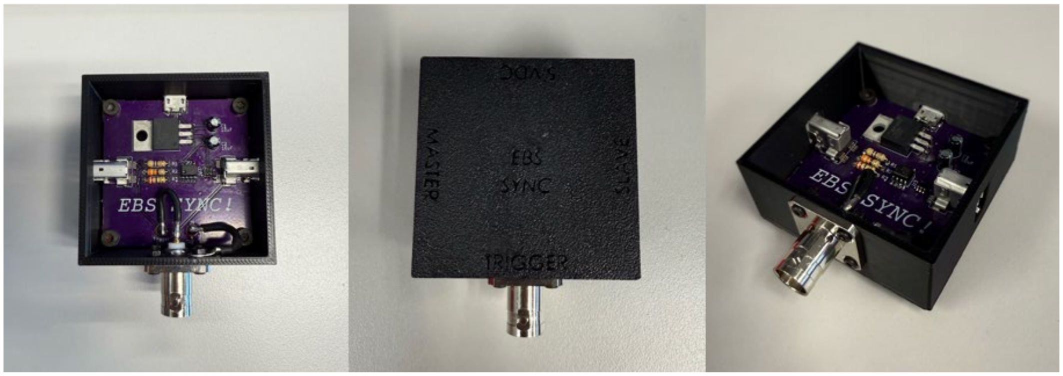

Figure 5. **Completed EBS synchronization circuit.**

Table 2. **Complete bill of materials for one completed circuit with encloser.**

Part	Description	Vendor	Qty	Cost	Extended cost
3D-printed enclosure	NA	In-house	1	$1.50	$1.50
Bare PCB	NA	OSH Park	1	$5.95	$5.95
Thru-hole resistors (470 Ω, 330 Ω, 22 Ω)	NA	In-house	3	$0.10	$0.30
ACPL-064L-560E	Optocoupler	Digikey	1	$4.91	$4.91
SN74LVC2G04DBVR	Inverter	Digikey	1	$0.22	$0.22
ND9BS1400	ix Industrial type B connector	Digikey	2	$3.74	$7.48
LM1086CT-3.3/NOPB	3.3-V regulator	Digikey	1	$2.36	$2.36
10-µF capacitor	NA	In-house	2	$0.10	$0.20
10118193-0001LF	Micro-USB	Digikey	1	$0.43	$0.43
1-1337446-0	External BNC	Digikey	1	$6.24	$6.24
Total					$29.59

3. Follow-up Experiment and Results

A revised experimental setup (Figure 6) was implemented to validate the performance of the synchronization circuit. Replicating the setup of the initial experiment, two EVK4 sensors were mounted on tripods facing a blinking LED with a development computer connected to the master sensor. However, instead of a direct connection, the synchronization circuit was inserted between the master and slave sensors with a 1-m cable, a distance previously verified for reliable synchronization. The output of the circuit was then connected to the slave sensor with varying cable lengths of 0.5, 1, 2, and 3 m.

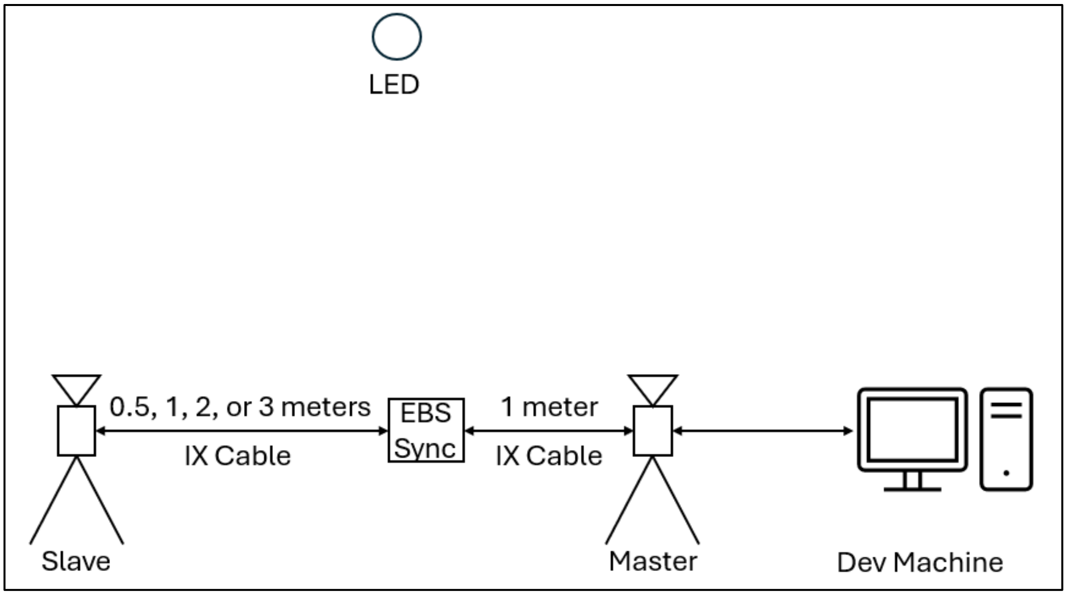

Figure 6. Revised experimental setup.

The results demonstrated successful synchronization between the sensors with a 3-m cable connecting the circuit to the slave, achieving a total separation of 4 m. The maximum synchronization distance remains undetermined due to limitations in available cable length. While daisy-chaining additional circuits could theoretically extend the range further, this was not evaluated during this experiment. Nevertheless, the EBS Sync circuit increased the synchronization distance by at least 300%, significantly expanding the potential applications for stereo EVK4 configurations.

4. Future Work

Further research is warranted to fully characterize the limitations of the current synchronization circuit. This includes testing with increasingly longer cables to determine the absolute maximum synchronization distance and evaluating the performance of daisy-chained circuits for signal integrity and scalability. As multiple circuits are connected in series, more rigorous testing is also needed to verify signal fidelity and synchronization accuracy.

Future circuit revisions could benefit from several improvements focused on reducing size, complexity, and cost. One potential modification involves replacing the micro-USB input and internal regulator with a removable CR2032 lithium battery. The CR2032 provides a nominal 3.3-V output and, with a typical 250-mAh capacity, offers sufficient power for the efficient onboard circuitry over an extended operational period. Alternatively, power could be transmitted over any of the four unused pins of the slave output connector, enabling in-line power boosting for subsequent circuits and eliminating the need for external power sources at each circuit. These design considerations aim to create a more streamlined and practical synchronization solution for multicamera EVK4 systems.

5. Conclusions

The developed synchronization circuit successfully demonstrated a 300% increase in synchronization distance for the Prophesee EVK4 sensors. This enhancement to the operational range expands the potential applications for these sensors considerably in stereo configurations, paving the way for more versatile and robust multicamera deployments in fields such as robotics, object tracking, and dynamic scene analysis. While further research is needed to fully characterize its limitations and explore scalability through daisy-chaining, the current design represents a valuable and practical tool for the current research being conducted for ARL.

List of Symbols, Abbreviations, and Acronyms

3D	three-dimensional
ARL	Army Research Laboratory
BNC	Bayonet Neill–Concelman
DEVCOM	U.S. Army Combat Capabilities Development Command
EVK4	Evaluation Kit 4
GND	ground
LED	light-emitting diode
NA	not applicable
PCB	printed circuit board
PLCS	places
USB	Universal Serial Bus

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