Experimental approach to an optical wireless interface for an avionics data bus

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Experimental Approach to an Optical Wireless Interface for an Avionics Data Bus

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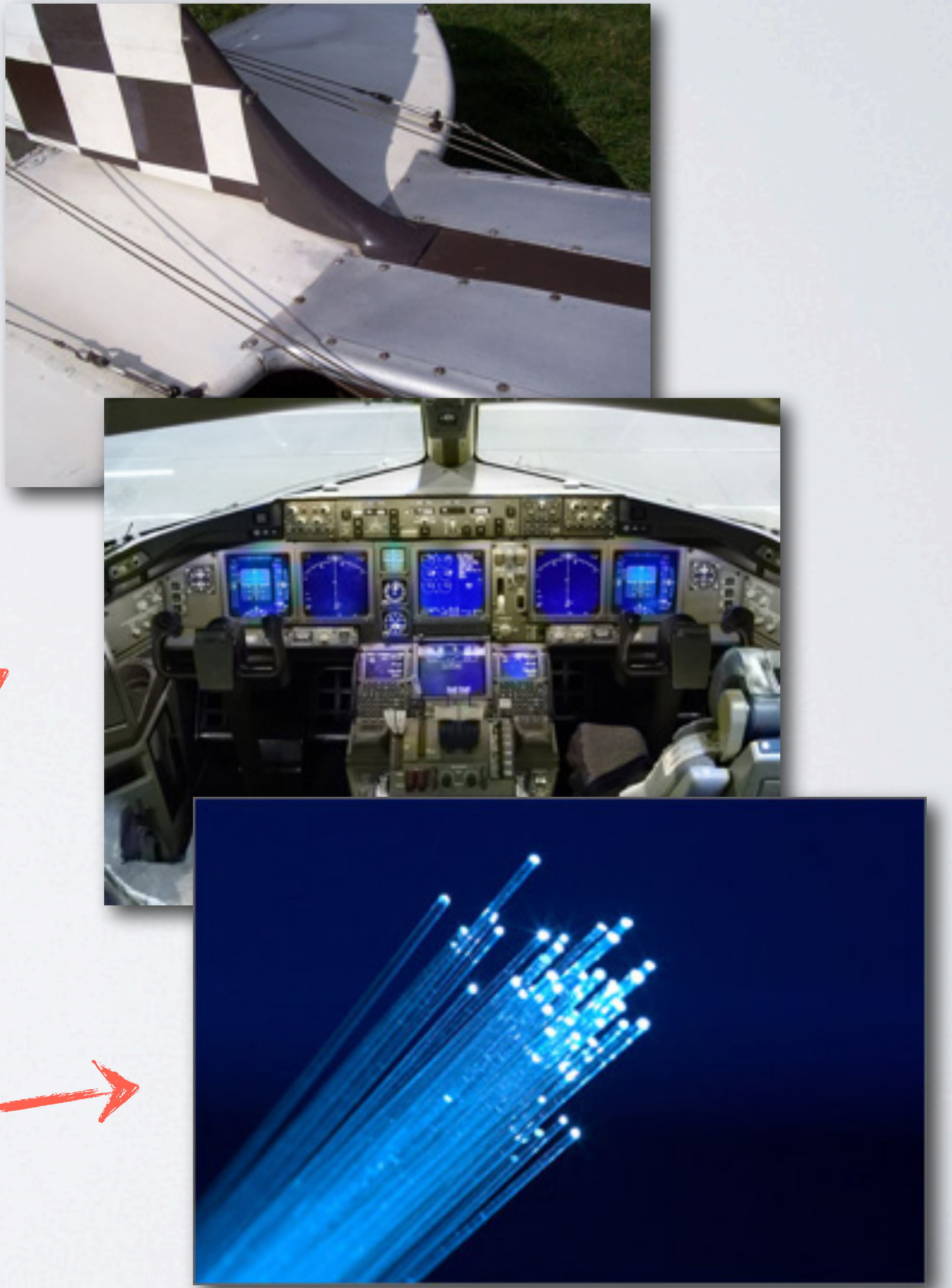
CONVENTIONAL AVIONICS

- Connectivity between different control surfaces is usually implemented by the use of mechanical connectors and cables.
- Pulleys and wires
- Fly-By-Wire (FBW)
- Fly-By-Light (FBL)

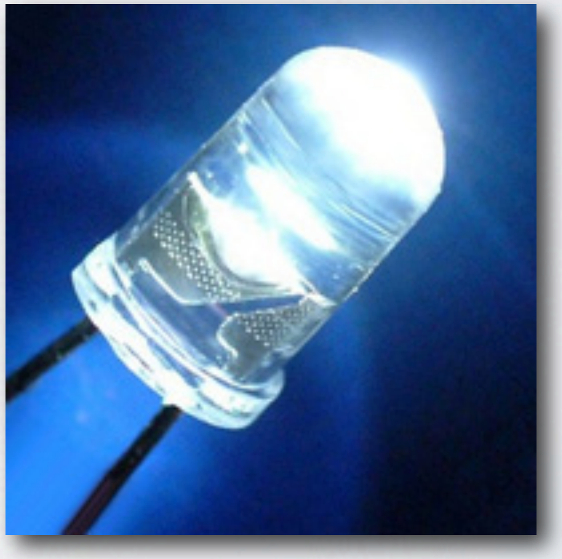


WIRELESS AVIONICS

- Avionic systems can be improved by using a topology and interconnectivity scheme like the one tipically used in Wireless Sensor Networks (WSN).
- The main advantages of this technology could be:
    - Harness and weight reduction achieved by removing physical cables and connectors.
    - Increased freedom when placing sensors or actuators across the aircraft's body.
    - Greater reliability due to optical link redundancy.

THE EMI PROBLEM

- Instruments within an aircraft are highly sensitive to electromagnetic interference (EMI).
- This fact prevents classical RF wireless networks to be implemented.
- Solution: Use.... LIGHT!!

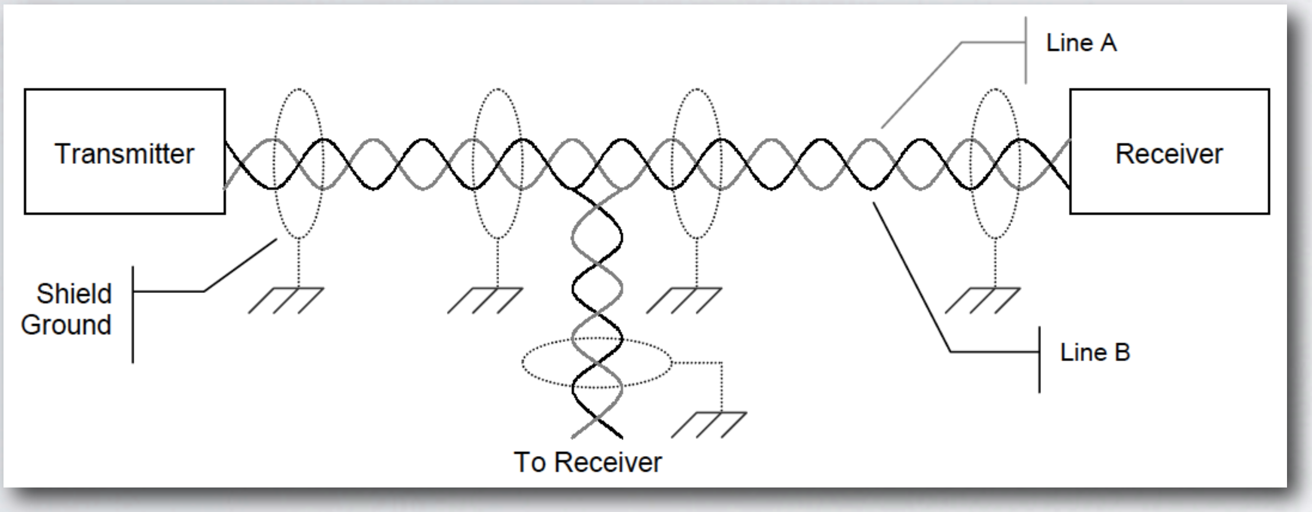


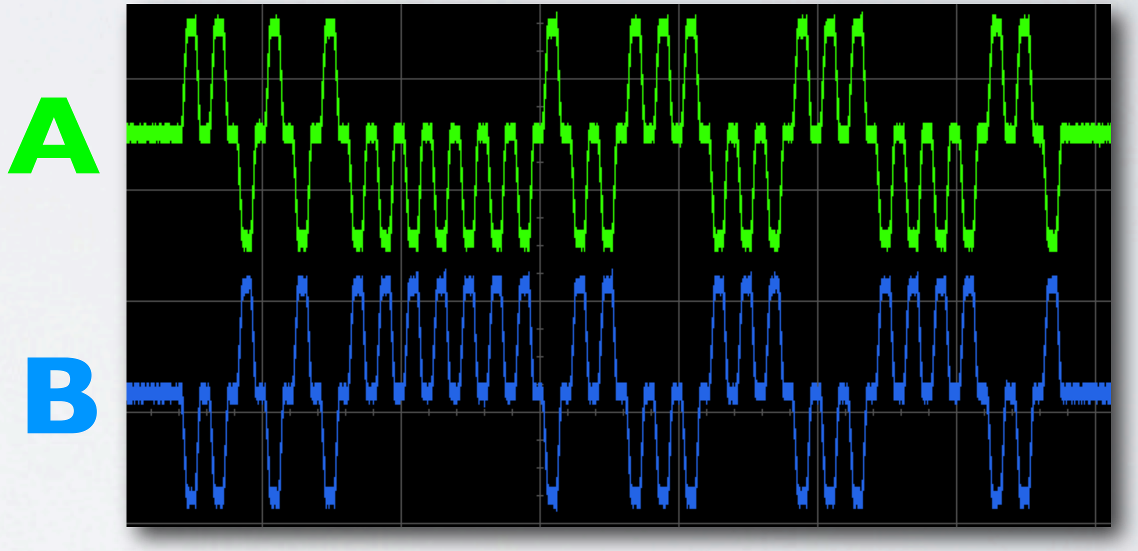
WIRELESS OPTICAL LINKS

- Light sources provide no EMI capable of interfering with other electronic equipments.
- LEDs can be pulse-modulated in order to transmit information ranging from a few bps up to several Mbps.
- Lasers can be used to achieve larger distances and higher data-rates.
- Optical wireless links have been widely used in many critical operations throughout the history of communications (Eg. ESA - OWLS Project).

ARINC 429 AVIONICS DATA BUS

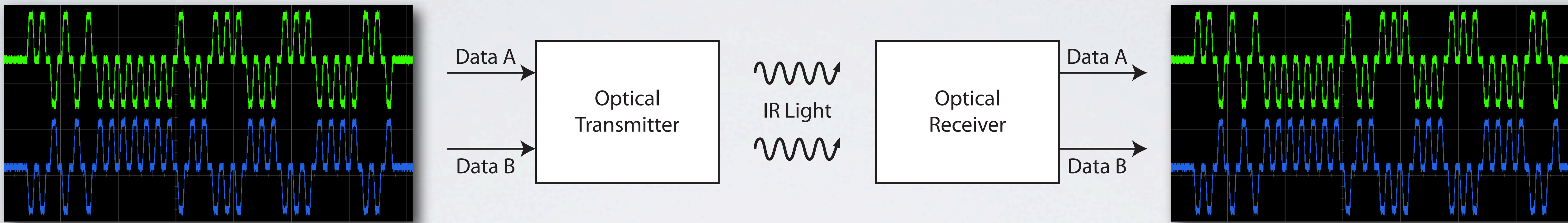
- Defines the electrical, word structure and protocol characteristics for the implementation of a secure and reliable avionics data bus.





- Data is transmitted in 32-bit data words by means of a shielded twisted-pair cable (A and B signals), using a complementary, tri-state, bi-polar, RZ line coding scheme.

OPTICAL WIRELESS INTERFACE

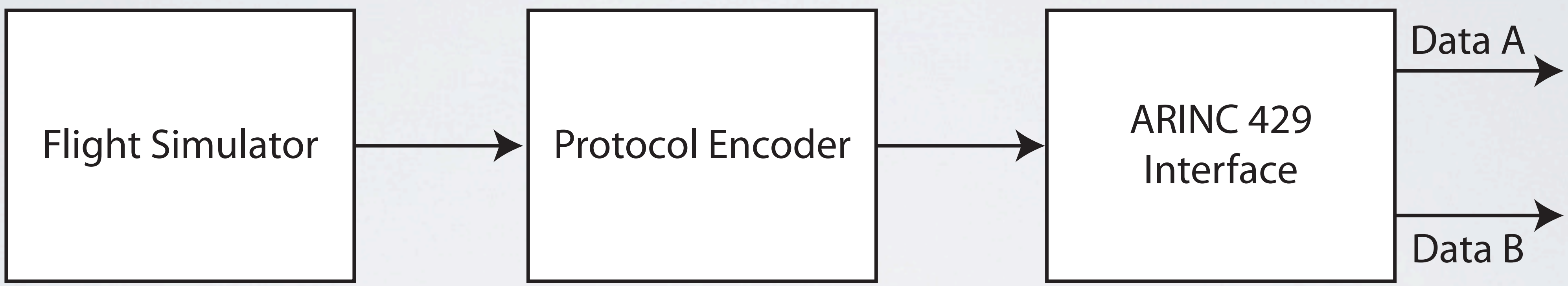


- A completely transparent optical wireless interface will be provided. Any avionics equipment at either end of the interface should remain unaware of its presence in the bus.

- To ensure compatibility with existent avionics hardware, the optical wireless interface will be tested with a real Attitude Director Indicator (ADI).

HARDWARE-IN-THE-LOOP (HIL) SIMULATOR

Block Diagram



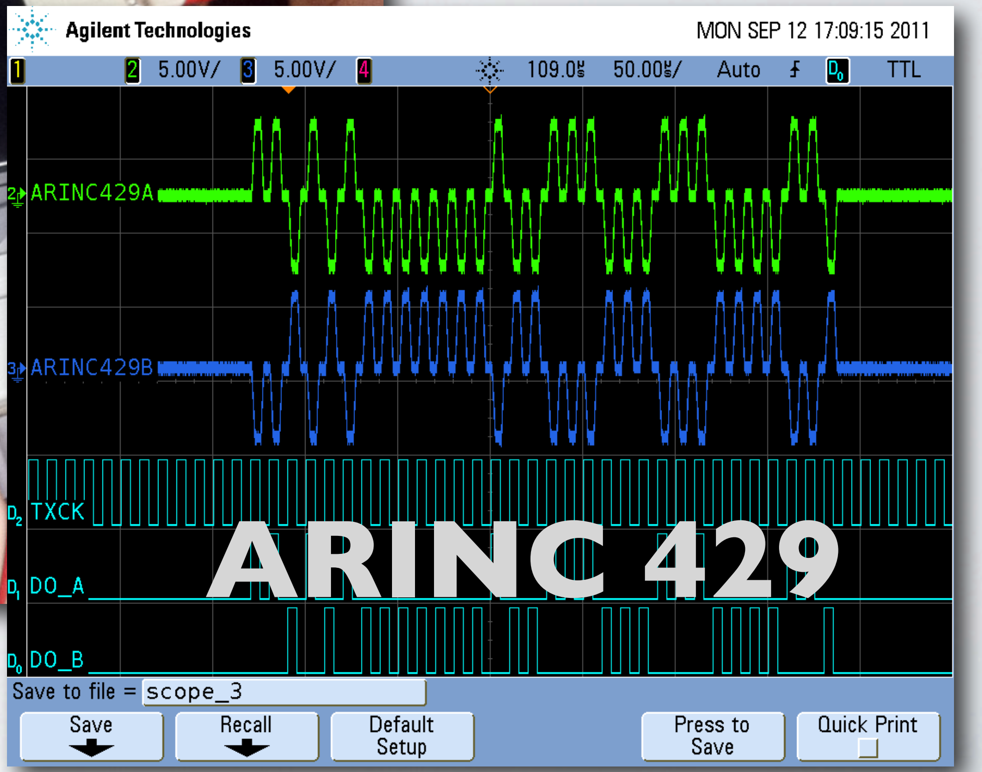
- This device serves as an interface between a flight simulator software and the ARINC 429 avionics bus.

- To correctly interface with the ADI the HIL simulator extracts pitch and roll values from the flight simulator and codes them into valid ARINC 429 data words.

HARDWARE-IN-THE-LOOP (HIL) SIMULATOR

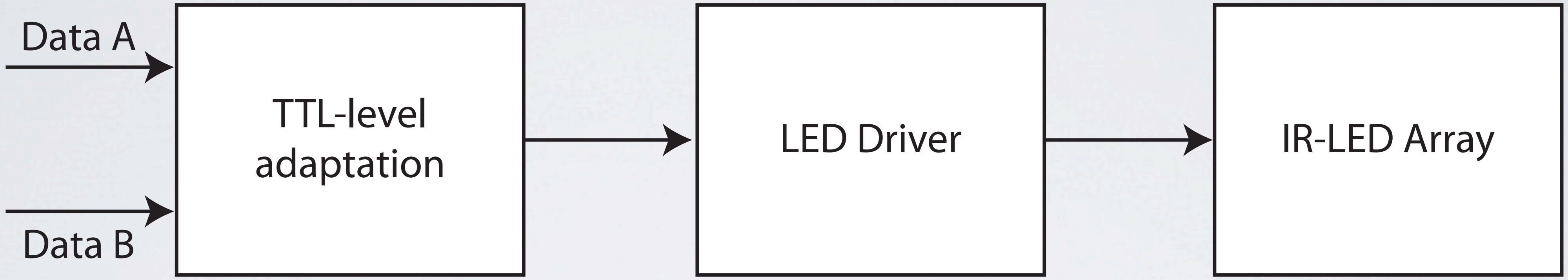
Protocol
Encoding

Electrical-level
Conditioning



OPTICAL TRANSMITTER

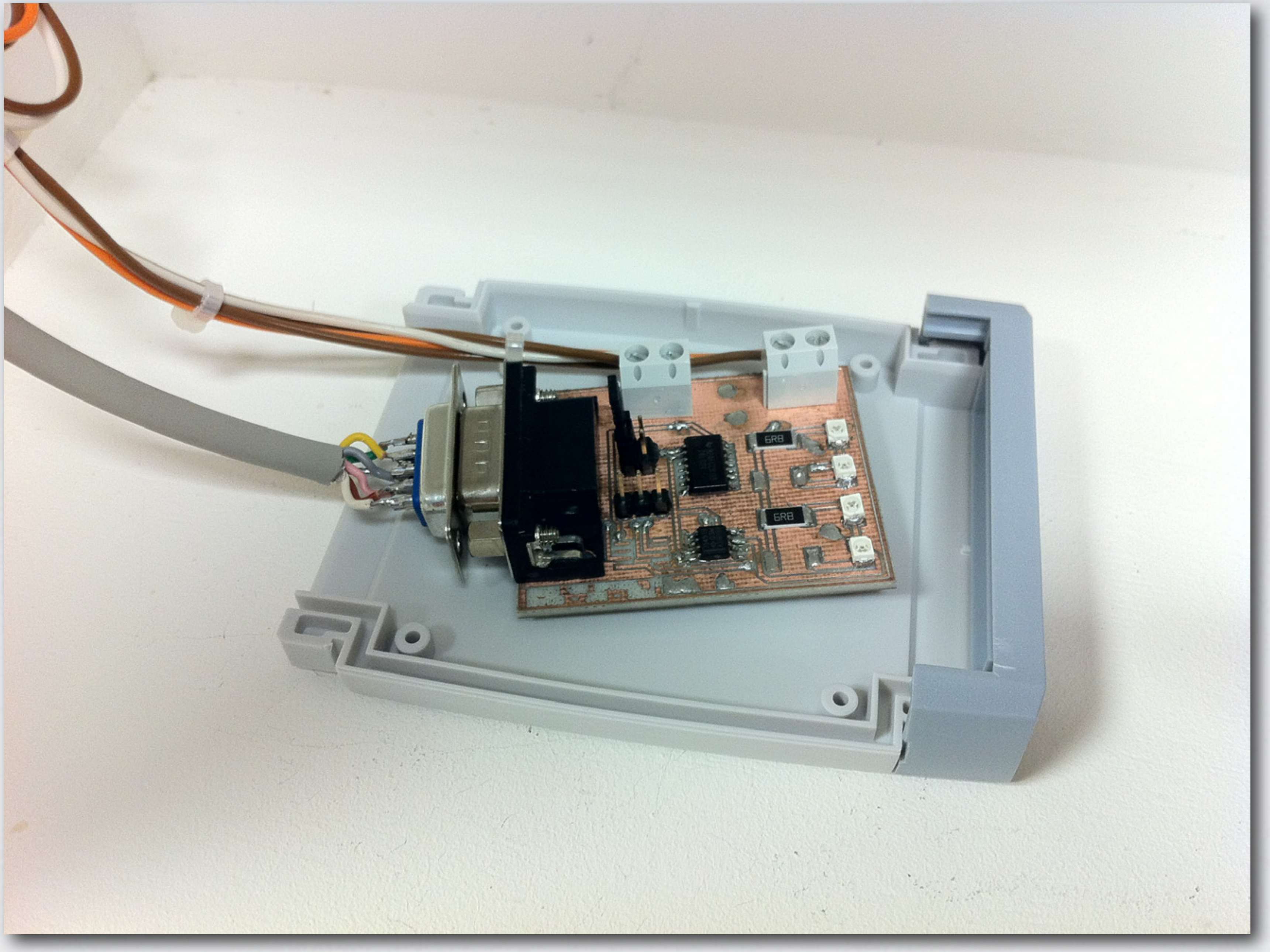
Block Diagram



- Serves as an interface between the physical layer of the ARINC 429 avionics bus and the proposed optical wireless link.

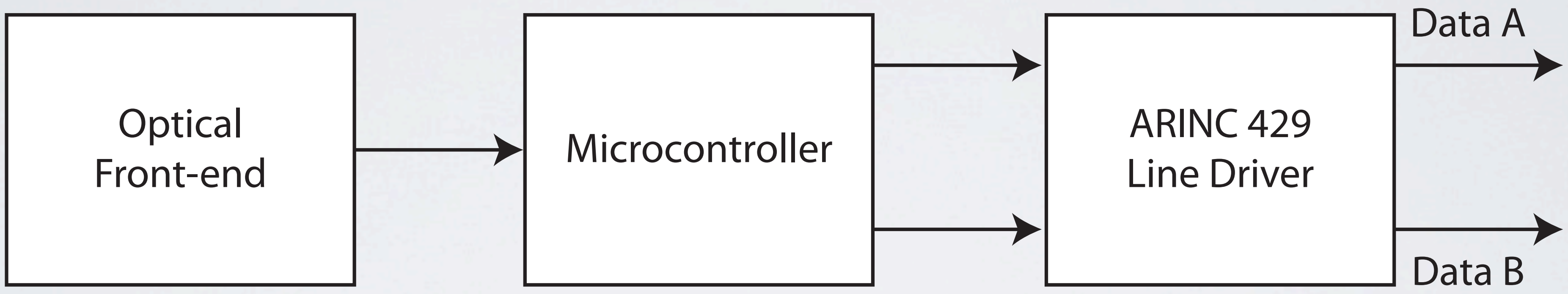
- Accepts ARINC 429 A and B signals and transforms them into light pulses ready to be transmitted by an array of IR-LEDs.

OPTICAL TRANSMITTER



OPTICAL RECEIVER

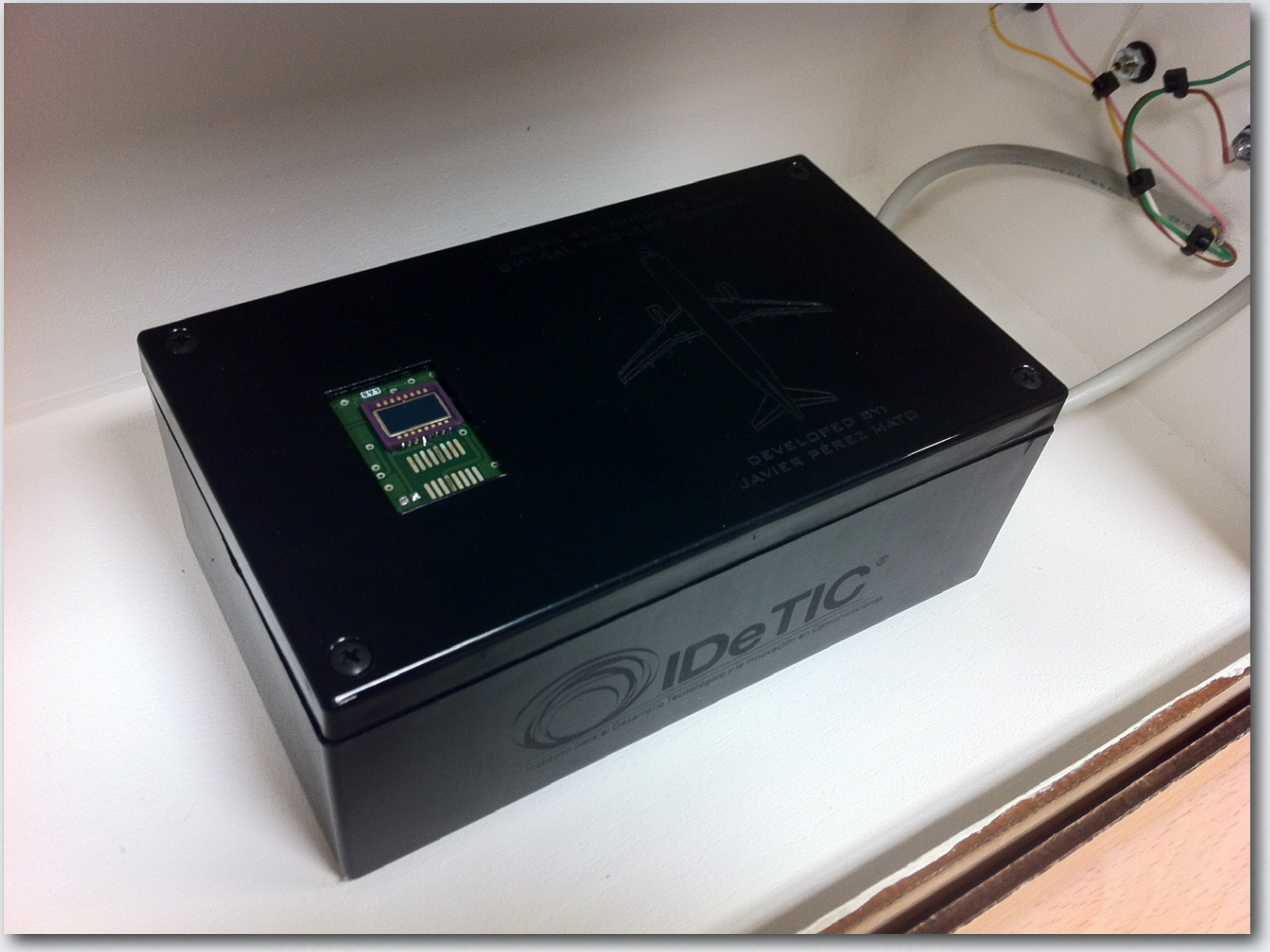
Block Diagram



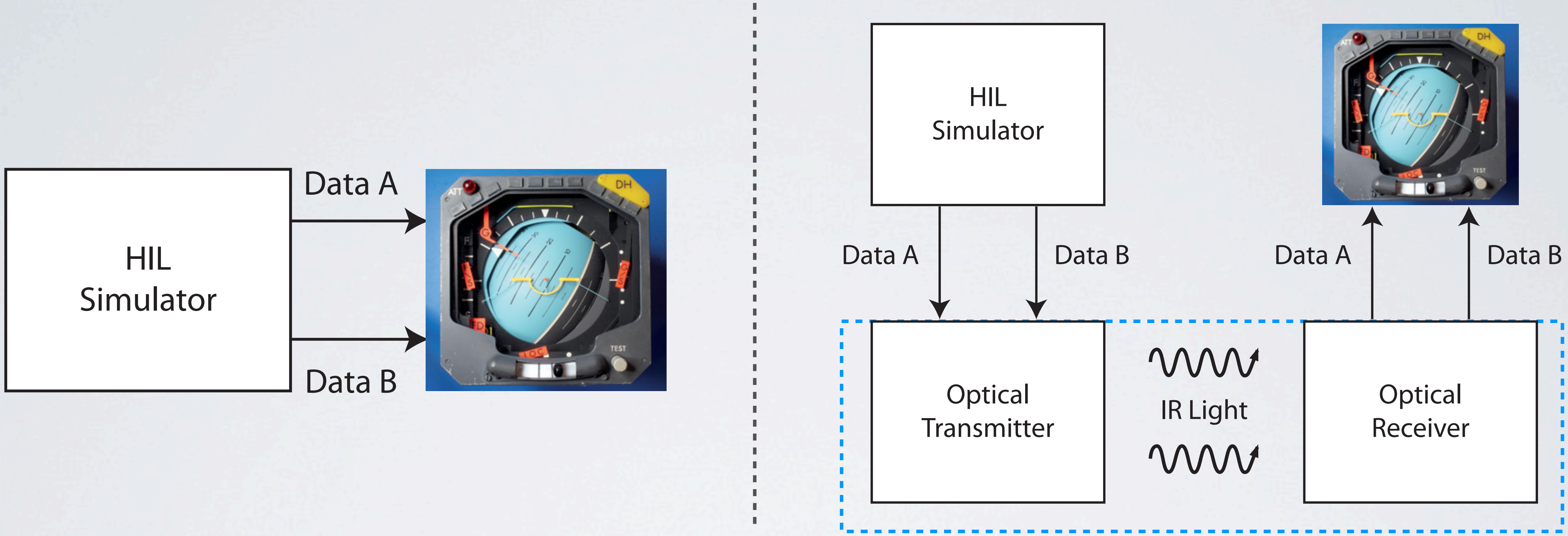
- Detects light pulses generated by the IR-LEDs in the optical transmitter and transforms them into a digital TTL signal.

- From this TTL signal both ARINC 429 A and B signals are fully recovered, ready to be sent over another wired segment of the ARINC 429 avionics bus.

OPTICAL RECEIVER



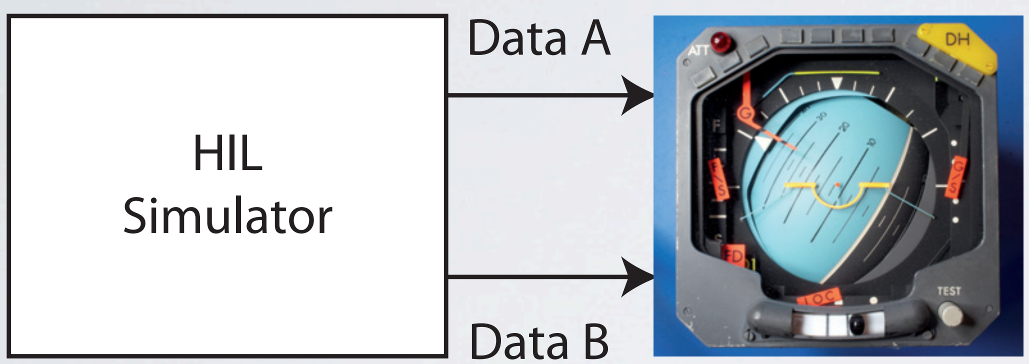
EXPERIMENTAL SETUP

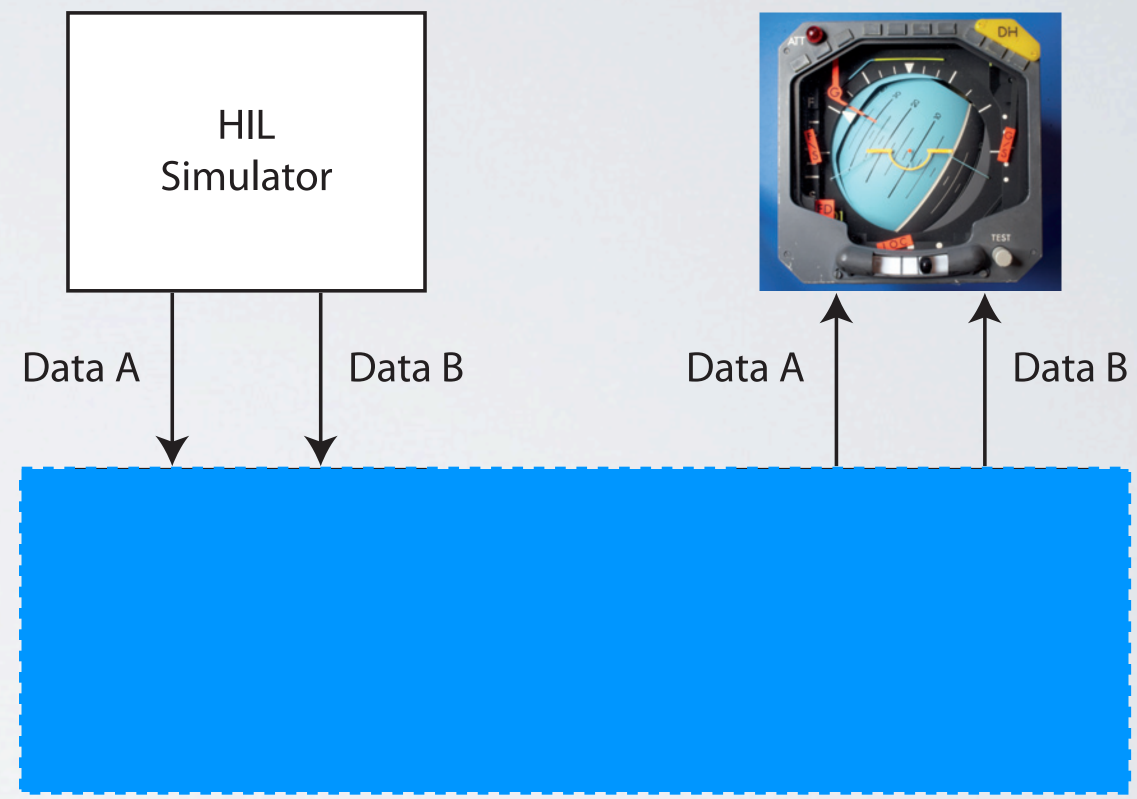


- Real avionics hardware was used to validate both the HIL simulator and the optical wireless interface.

- Both behavioural and electrical-level tests were performed in order to ensure compatibility with the ARINC 429 standard definition.

EXPERIMENTAL SETUP





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DEMO VIDEO

This video shows the optical wireless interface driving a real ADI by transmitting valid ARINC 429 pitch and roll data words generated by a flight simulator connected to the HIL simulator.

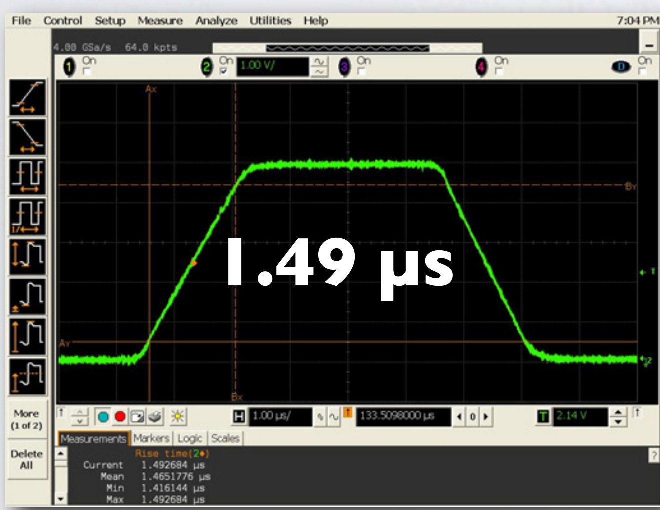
http://www.youtube.com/watch?v=pWYorIfUM5I

RESULTS

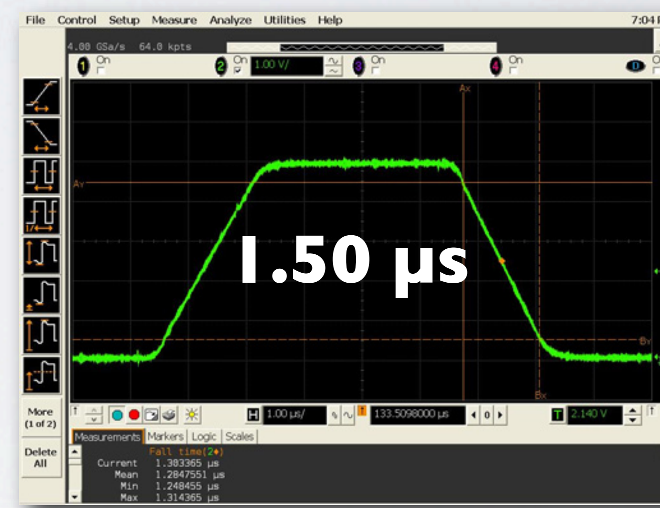
Rise and Fall Times (A and B Signals)

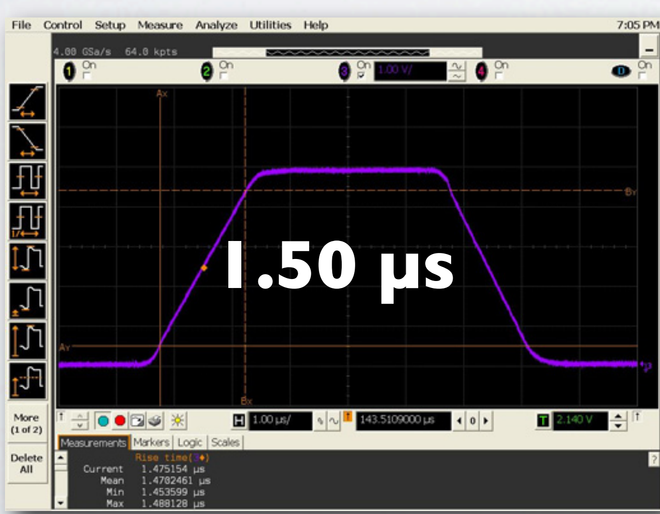
ARINC 429 Specification: 1.5 µs ± 0.5 %

Rise Times



←A→





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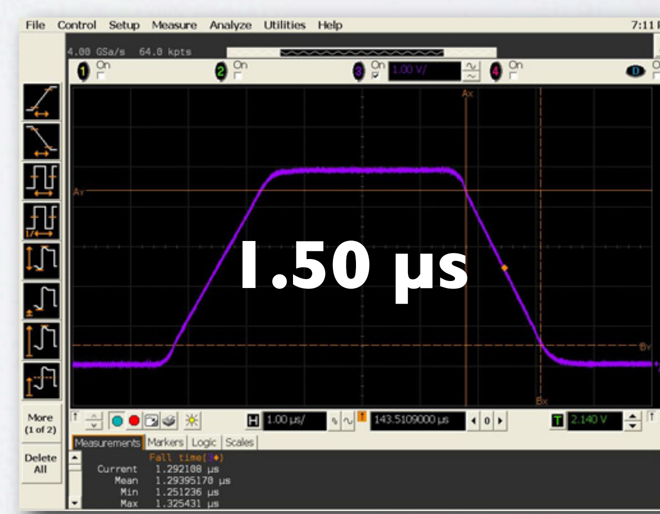


Fall Times

RESULTS

Bit and Half-Bit Duration (A and B Signals)

ARINC 429 Specification: 10 µs ± 2.5 % / 5 µs ± 5 %

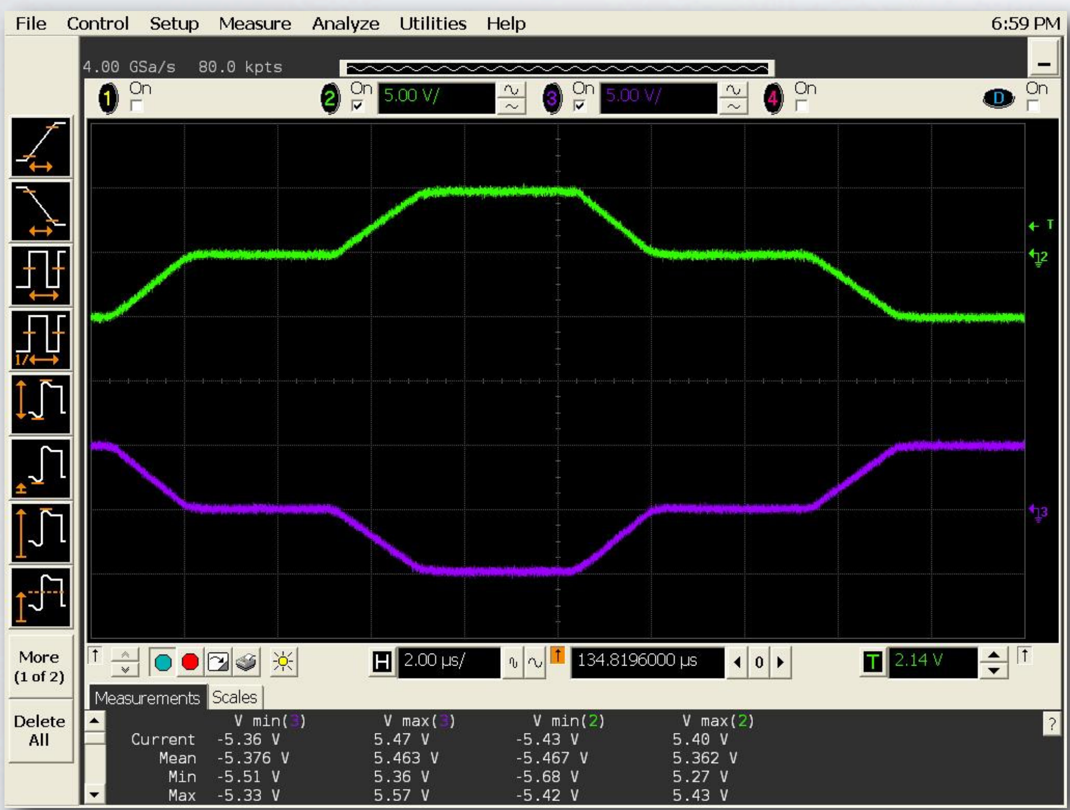
Bit Duration

Half-Bit Duration

RESULTS

Voltage Levels and Transmission Delay (A and B Signals)

ARINC 429 Specification: 5 V, 0 V, -5 V ± 0.5 V



	HIGH	NULL	LOW
A	5.36 V	0.12 V	-5.43 V
B	5.42V	0.11 V	-5.38V

CONCLUSIONS

- The implementation and feasiblity of an optical wireless interface for the ARINC 429 has been demonstrated.
- A low-cost HIL simulator for the ARINC 429 has also been developed, which is able to replicate real flight data within a laboratory environment.
- The developed interface complies with all electrical and timing restrictions described in the ARINC 429 definition.

CONCLUSIONS

- Avionics network topologies can benefit from the advantages of wireless communications without introducing any hazardous sources of EMI.
- The proposed solution can be easily ported to other avionics data buses.
- A dramatic reduction in weight can be achieved due to the removal of electrical wires, helping to reduce fuel consumption and achieve a greater efficiency.

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IDeTIC® Instituto para el Desarrollo Tecnológico y la Innovación en Comunicaciones

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Questions?

For further information, please contact:
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