



AEROSPACE INFORMATION REPORT

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Aerospace Fly-by-Light Actuation Systems

RATIONALE

This document contains information addressing aspects of technology that are not currently undergoing substantial development.

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1. SCOPE:

This SAE Aerospace Information Report (AIR) has been prepared to provide information regarding options for optical control of fluid power actuation devices. It is not intended to establish standards for optical fluid power control, but rather is intended to provide a baseline or foundation from which standards can be developed. It presents and discusses approaches for command and communication with the actuation device via electro-optic means.

The development of standards will require industry wide participation and cooperation to ensure interface commonality, reliability, and early reduction to practice. To facilitate such participation, this document provides potential users of the technology a balanced consensus on its present state of development, the prospects for demonstration of production readiness, and a discussion of problem areas within this technology. The intent is to inform the user/designer of the options available for interfacing photonics (optics) to hydraulic power control actuators used in aerospace applications. Specifically, power and signal interfaces such as control, status and BIT (built in test) are considered. Mechanical interfaces such as optical connectors and fibers are also discussed. Other issues covered include the benefits of optics, reliability of components, and system architectures.

The document draws on the expertise of numerous investigators who develop demonstration hardware, are familiar with photonics and specialize in hydraulic actuation, or are cognizant of aerospace fluid control systems. Contributions and suggestions have been supplied by members and attendees of the A-6D Committee.

2. REFERENCES:

2.1 Applicable Documents:

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

ARP490	Aerospace Recommended Practice on Servovalves
ARP1281A	Servoactuators: Aircraft Flight Controls, Power Operated, Hydraulic, General Specification for
AS1773	Fiberoptics Mechanization of a Digital Time Division Command/Response Multiplex Data Bus
ARP4386	Terminology and Definitions for Aerospace Fluid Power, Actuation and Control Technologies
ARD50020	Fiber Optic Interconnection Systems for Aerospace Applications
ARD50024	Fiber Optic Coupled Sensors for Aerospace Applications

- 2.1.2 U.S. Government Publications: Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-F-9490 Flight Control Systems, General Specification for Design Installation and Test of Piloted Aircraft

MIL-STD-461 Requirements for Control of Electromagnetic Interference Emissions and Susceptability

MIL-STD-1773 Fiber Optics Mechanization of an Aircraft Internal Time Division Command/Response Multiplexing Data Bus

FDA Regulation 21 CFR Subchapter "J"

DO-160 Environmental Conditions and Test Procedures for Airframe Equipment

- 2.1.3 ANSI Publications: Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

ANSI Standard Z136.2

- 2.1.4 ARINC Publications: Available from Aeronautical Radio Inc., 2551 Riva Road, Annapolis, MD 21401.

ARINC429

ARINC629

2.2 Definitions:

APPLICATION SPECIFIC INTEGRATED CIRCUIT (ASIC): An integrated circuit designed and built for a specific application, rather than for general use.

BUILT-IN-TEST (BIT): A testing routine capable of diagnosing a suspected system fault. In some cases it is an intrusive operation that places the system outside its normal, fully operational state. There are also monitor BIT functions which are non-intrusive and are used to monitor and fault isolate system operation.

CABLE, FIBER-OPTIC: That portion of an interconnection scheme carrying photonic signals between two sub-systems, that consists of the signal carrying medium plus one or more mechanical protective members such as a sheath plus strength member and scuff jacket. A fiber or multiple fibers in a structure fabricated to meet optical, mechanical and environmental specifications.

CONTROL POWER-BY-LIGHT: Involves the conversion of optical power into electrical power for use as the primary power source for otherwise electrically isolated circuits. This power is used to activate the control elements of an actuator.

2.2 (Continued):

DETECTOR: A transduction device that transforms photonic energy into electrical form (typically a photodiode).

EMITTER: A transduction device that creates and launches optical radiation; an optical source; typically a light emitting diode (LED) or laser.

FLY-BY-LIGHT: The broad term used to generally describe the use of optics to communicate with the control elements of a flight control system.

FLY-BY-WIRE: A flight control system wherein vehicle control input is transmitted completely by electrical means.

NUMERIC APERTURE: The sine of the half-angle of light acceptance and emittance of an optical fiber.

SMART ACTUATOR: A servoactuator that carries on board all its necessary loop closures and the capability to report status. Many different command signal formats are possible and are discussed in 4.3.2. A smart actuator differs from a conventional actuator where information is fed back to a remote location for summing with a command and the actuator receives only the error signal. Figure 1 shows a conceptual approach for smart actuation.

TRANSDUCER, FIBER-OPTIC: That portion of a fiber-optic based sensing system that responds to the measurand based on some defined physical law; also known as the “sensing element”. Any such mechanism, internal or external to the fiber, that causes a change to the characteristic parameters of light injected into or propagated by an optical fiber (phase, intensity, wavelength, polarization) in accord with the measurand (pressure, temperature, acceleration, displacement, velocity, etc.). It is part of a sensor mechanism; not a stand-alone device.

Additional definitions for actuation and control technology that relate to the general subject of fly-by-light may be found in ARP4386.