

Interface for Micro Munition (IMM) Handbook

RATIONALE

This handbook provides information on the implementation of the Interface Standard, Interface for Micro Munitions (IMM), as defined in AS5726, into both current and future Micro Munition Hosts and Micro Munitions. This handbook provides guidance on design considerations, background information and rationale on AS5726 requirements, and other useful information for implementation of the IMM interface.

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1. SCOPE

1.1 Scope

This document was prepared by the SAE AS-1B1 IMM Task Group to explain and document background information and design decisions made during the development of AS5726. This handbook is published separately to preserve information that is not required or provided in the AS5726 but may be important to system designers to ensure interoperability between the Micro Munition Host and Micro Munition. As a handbook, it cannot be invoked as a requirement in a contract.

The structure and numbering of this document mirrors that of AS5726 for the convenience of readers. Headings such as "Requirements" in this handbook should not be interpreted as invoking requirements.

1.2 Background

The information contained in this handbook is intended to provide the Micro Munition system designer with the following types of information:

- A thorough understanding of the requirements imposed by AS5726.
- Identification of design problem areas that could contribute to an interface incompatibility.
- A presentation of design techniques, components and design practices that might be useful in implementing AS5726.
- Practical guidance and associated rationale for users of AS5726 in future applications.

1.3 Application

This handbook is applicable to AS5726, Revision A only.

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 General

The documents listed in this section are referenced in Sections 3, 4, and 5 of this handbook.

2.1.2 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AS5653	High Speed Network for MIL-STD-1760
AS5725	Interface Standard, Miniature Mission Store Interface
AS5726	Interface Standard, Interface for Micro Munitions

2.1.3 ANSI Publications

Copies of these documents are available online at <http://webstore.ansi.org/>.

FC-PI ANSI INCITS 352-2002 Fibre Channel – Physical interfaces

2.1.4 Government Publications

Copies of these documents are available online at <http://quicksearch.dla.mil>.

Specifications, Standards, and Handbooks

The following specifications, standards, and handbooks form a part of this document to the extent specified herein.

MIL-DTL-38999	Connectors, Electrical, Circular, Miniature, High Density, Quick Disconnect (Bayonet, Threaded, and Breech Coupling), Environment Resistant, Removable Crimp and Hermetic Solder Contacts, General Specification For
MIL-STD-704	Department of Defense Interface Standard for Aircraft Electrical Power Characteristics
MIL-HDBK-1760	Department of Defense Handbook for Aircraft/Store Electrical Interconnection System
MIL-STD-1760 Revision E	Department of Defense Interface Standard for Aircraft/Store Electrical Interconnection System
MIL-STD-8591	Department of Defense Design Criteria Standard for Airborne Stores, Suspension Equipment and Aircraft-Store Interface (Carriage Phase)
MIL-STD-1560	Department of Defense Standard: Insert Arrangements for MIL-DTL-38999, MIL-DTL-27599, and SAE-AS26900 Series A Electrical Circular Connectors

2.2 Definitions

Definitions applicable to this standard are as follows:

- 2.2.1 HOST: Any system capable of carrying, interfacing with, and employing Micro Munitions. The term includes Platforms such as aircraft, ground vehicle (armored vehicles, trucks), armed man portable, installations, nautical vehicle (boat, ship or submersible), and Micro Munition Carriage Systems.
- 2.2.2 ELECTRICAL INTERFACE TYPES: The two electrical interface types for the Host/Micro Munition electrical interconnection system are specified below.
 - 2.2.2.1 MICRO MUNITION HOST INTERFACE (MMH): The electrical interface on the Host structure where the Micro Munition is electrically connected either directly (blind mate) or via an interconnecting umbilical cable.
 - 2.2.2.2 INTERFACE FOR MICRO MUNITION (IMM): The electrical interface on the Micro Munition external structure or interconnecting umbilical cable that mates with an MMHI.
- 2.2.3 MICRO MUNITION: A Micro Munition is a weapon typically characterized by a mass up to 25 kilograms (55.12 pounds) and a minimum outer diameter of 38 mm (1.50 inches). Note that this does not prohibit other stores from using AS5726.
- 2.2.4 FIBRE CHANNEL (FC): Fibre Channel is the name for a high-speed network standard defined by a series of ANSI standards.

2.2.5 SAFETY CRITICAL: An interface operation (electrical, logical or a combination of both) at the MMHI or IMM is deemed safety critical when it causes the Micro Munition to perform functions that have the potential to generate Micro Munition behavior that may present a hazard to the Host, crew or ground handling personnel.

2.2.6 SAFETY SIGNIFICANT: This term identifies that object as having an impact on safety, whether determined through risk analysis or other means, that exceeds a predetermined significance criterion.

2.3 Acronyms and Abbreviations

The following acronyms and abbreviations are applicable.

A	Amperes
AC	Alternating Current
ANSI	American National Standards Institute
AWG	American Wire Gauge
COTS	Commercial off-the-shelf
CTSS	Commit to Store Separate
dBV	Decibel voltage relative to 1 Volt
DAPS	Document Automation and Production Services
DC	Direct Current
DFC	Down Fibre Channel
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
F	Frequency
FC	Fibre Channel
FC-PI	Fibre Channel – Physical Interfaces
Gbaud	Gigabaud
Gbps	Gigabit per second
GHz	Gigahertz
ICD	Interface Control Document
IMM	Interface for Micro Munitions
INCITS	International Committee for Information Technology Standards
Kohm	kiloohm
L	Inductance

Mbaud	Megabaud
Mbytes	Megabyte
MHz	Megahertz
MMHI	Micro Munition Host Interface
MMSI	Miniature Mission Store Interface
mA	Milliamperes
ms	Milliseconds
Mv	Millivolt
NT	Network Terminal
RD	Receive Data
SAE	Society of Automotive Engineers
SR&E	Suspension and Release Equipment
TD	Transmit Data
UFC	Up Fibre Channel
uH	Microhenry
V	Volt
W	Watt
Z	Impedance

3. GENERAL

3.1 Interface Set and Classes

The main objective in the selection of the AS5726 signal set was the reduction of the pin count in the interface connector, in order to produce a physically small interface that implemented all the fundamental functionality of the parent standard weapon interfaces (MIL-STD-1760 and AS5725) for a smaller class of store. The AS-1B1 task group considered and discarded a variety of approaches and signal sets, including connectorless (near field magnetic coupling) solutions, finally settling on a conventional pin/socket connector approach as an initial implementation, with the expectation that additional physical interconnection designs could be adopted at a later date. After a survey of industry and government entities involved with the development of Micro Munitions, the AS-1B1 developed a minimum set of performance requirements for the IMM interface, including data rates, power, and safety.

The selection of the signal set for IMM, represented in Figure 1 below, was based on fulfilling the identified performance requirements using the smallest feasible number of individual wires.

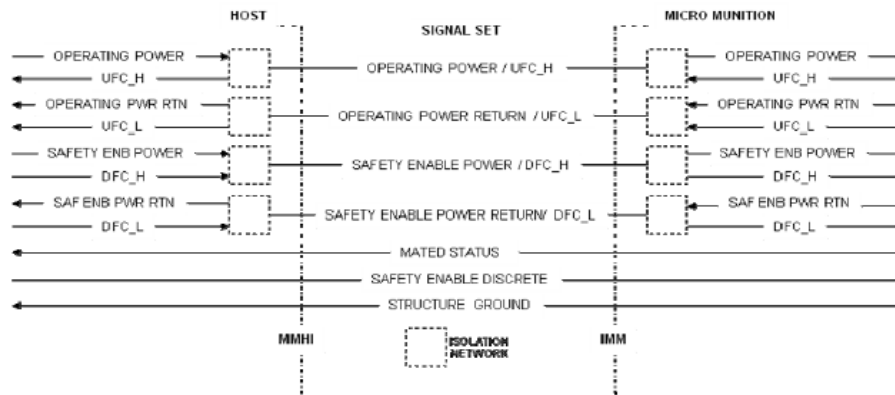


Figure 1 - IMM signal set from Figure 1 of AS5726

The Micro Munition interface was designed to ensure independence between power, communications, and mated status aspects of the interface. IMM also provides two separate DC power (supply/return) interfaces, one for general use by the Micro Munition and one specifically designated for powering circuits that implement safety significant functions within the Micro Munition (i.e., initiation of thermal batteries, ignition of launch motors or other irreversible functions that could compromise store safety). In addition, the data communication to the Micro Munition is implemented via the same physical wires that carry power to the Micro Munition, and is based on the AS5653 High Speed MIL-STD-1760 that uses the Fibre Channel digital data network. One unique aspect of the Micro Munition interface is that the standardization group chose to overlay serial data onto the power lines in an effort to reduce contact count to minimize the size of the connector for the Micro Munition.

The choice of AS5653 Fibre Channel for the IMM data communication protocol was made to fulfill the data rate requirements of all identified Micro Munition with ample growth capability, and to ensure ease of integration of the IMM interface in complex systems implementing other interface standards that use the AS5653 Fibre Channel protocol including MIL-STD-1760 and AS5725 networks. Notwithstanding variation of the physical layers between the three interface standards (MIL-STD-1760, AS5725, and AS5726), AS5653 provides a uniform mechanism for directly addressing a very large number of munitions in a logically flat address space and thus enables direct store to store and Stores Management System (SMS) to store communication without constraints from the hierarchy of munitions, carriage systems, and platform switches that are conceivable within the three interface standards.

Finally, IMM provides a dedicated structure ground discrete interface as an electrical safety provision.

In order to supply the required power to the Micro Munition on 22 gauge wires, IMM defines two different power classes, corresponding to 28V ("Class I") or 56V ("Class II") DC operating power. By increasing the operating voltage for Class II, IMM can provide in excess of 200W of power to the Micro Munition without requiring auxiliary connectors or heavy gauge contacts. The 56V specification was chosen to ensure that the maximum voltage present on the interface would remain below 60V DC for human safety consideration. In addition, the 56V level is also a common voltage for commercial Power over Ethernet applications, and DC-DC converters able to produce 56V from 28V MIL-STD-704 power or to down-convert 56V to typical electronic power busses are therefore readily available.

AS5726 detailed requirements (e.g., voltage and timing) levied on each of the interface signals are designed to ensure functional performance and to ensure safety when any combination of Host and Micro Munition classes are inter-mated.

Initial implementations of IMM have been successful in using individual twisted shielded pairs for the Operating Power/Up Fibre Channel (UFC) and Safety Enable Power/Down Fibre Channel (DFC) signals, and individual 22 American Wire Gauge (AWG) discrete wiring for Safety Enable Discrete, Mated Status and Structure ground and overall shielding of the IMM umbilical bundle is highly recommended.

A notional schematic of the various circuit elements necessary at both end of the interface to overlay and separate the discrete interface functions over the signal set is represented in Figure 2 below.

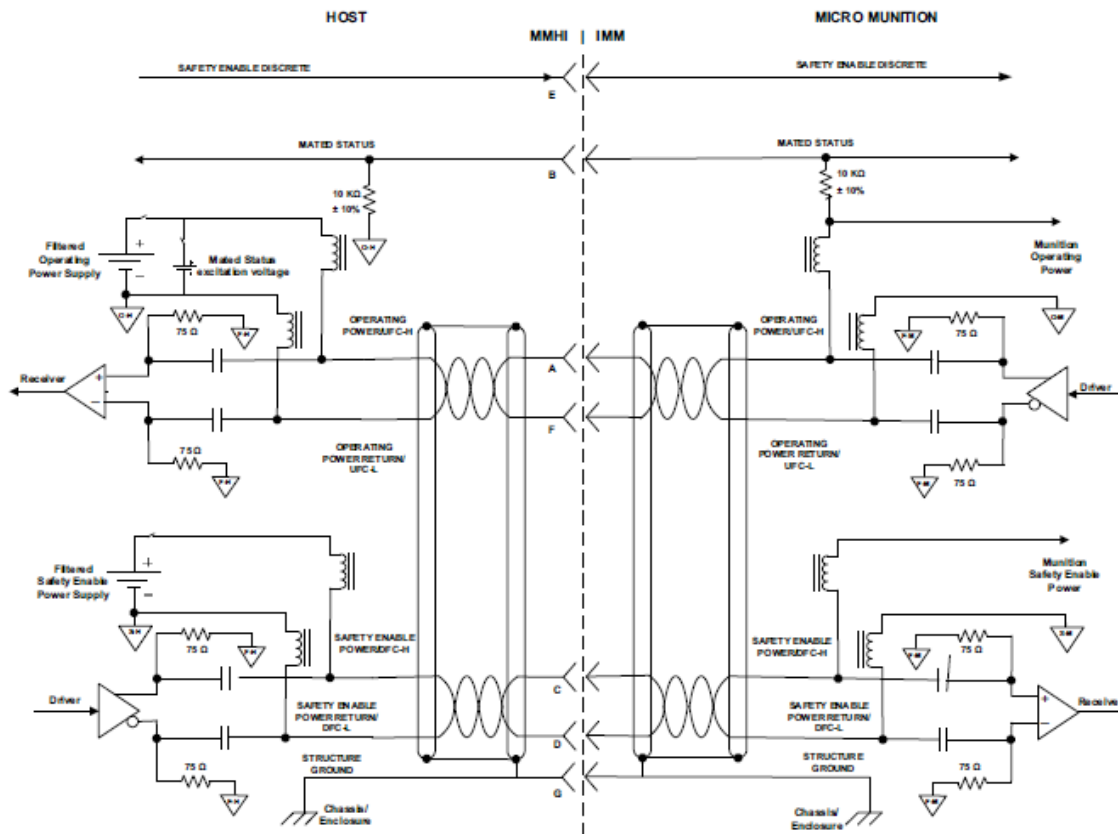


Figure 2 - Digital data and power interfaces schematic from Figure 2 of AS5726

3.1.1 Overlay of Digital Data and Power Interfaces

In order to minimize the number of contacts in the IMM signal set and the associated connector size, a decision was made to overlay digital data on the power interfaces. This is facilitated by the fact that the lowest significant spectral components of the UFC and DFC digital data link signals are widely separated in frequency from the direct current (DC) power interface signals including ripple. This enables a relatively straightforward combination and separation of the power and data signals at the source and sink ends of the power/data paths via frequency selective networks. The networks consist of a low pass filter on the DC path and a high pass filter on the data path. Using this approach as illustrated by the example represented in Figure 2 above, the DFC signal is transferred from Host to the Micro Munition over the Operating Power interface and the UFC signal is transferred from Micro Munition to Host over the Safety Enable Power interface.

3.1.2 Digital Data Interfaces

AS5726 uses the high speed network defined in AS5653 as modified by the requirements of Section 5 of AS5726. AS5653 addresses use of a coaxial physical layer whereas AS5726 implements a twisted pair physical layer with power overlay in order to fit into a smaller connector size. See 4.1.3 for Host requirements and 4.2.3 for Micro Munition requirements.

3.1.3 Mated Status Interface

The Mated Status Interface provides an indication of the electrical mated status at the connector interface between the Host and Micro Munition, similar to the “Interlock” interface used in MIL-STD-1760. One unique aspect of the Mated Status for IMM is that the Host interprets its status as mated when the voltage between Mated Status and Operating Power Return exceeds 20% of the voltage between Class I/II Operating Power and Class I/II Operating Power Return. This results in a different voltage level for determining Mated Status based on the class of operating power.

3.1.4 Safety Enable Discrete Interface

The Safety Enable Discrete Interface was included in AS5726, based on guidance from the Safety Community to provide an independent path for the authorization of safety critical messages that may be sent over the data bus to the Micro Munition.

This interface has direct equivalence to the Release Consent in MIL-STD-1760, and serves an exactly equivalent logical purpose in this interface.

The definition of the "SAFETY CRITICAL" Data entities that are authorized by the presence of this discrete are referenced in 5.1.2.

Safety Enable Discrete is one of three elements of the AS5726 standard that in combination enable the implementation of a safe system in a manner compatible with MIL-STD-1760 and AS5725. These three elements are:

- The active application of the Safety Enable Discrete prior to the store control message is being sent
- Store Control Message verification via the internal checksum and control authority data words in the store control message (Table B-II of MIL-STD-1760, Appendix B)
- The presence of the Safety Enable Power

The use of the Safety Enable Discrete, in conjunction with the checksums and coded checks included in the control authority data words, plus the provisions of the Safety Enable power, are intended to ensure safety critical actions be enabled only when the Host determines that the safety criteria for Micro Munition employment have been met.

AS5726 expects that the three elements (Safety Enable Power; Safety Enable Discrete and Store Control Message verification) will be controlled by independent mechanisms so that common mode faults can be avoided.

3.1.5 Power Interfaces

The Host supplies and controls both Operating Power and Safety Enable Power (including associated dedicated returns) to each MMHI. These are independent power sources intended for different purposes, with separation maintained on both sides of the interface to simplify system safety analysis and certification. In contrast to MIL-STD-1760 and AS5725, the power that the IMM Host must supply is specified as highly conditioned with relatively tight regulation and power quality requirements. This places most of the cost and complexity burden of providing acceptable quality power to the Micro Munition electronics on the Host, as opposed to the expendable Micro Munition. Micro Munitions also likely to be manufactured in much larger quantities than Host platforms or carriage devices, further justifying the case for allocating most of the cost and complexity to the Host.

3.1.5.1 Operating Power

Operating Power is supplied to the Micro Munition by the Host for the purpose of powering internal electronics for basic operation in conjunction with non-safety-critical functions. A lower level excitation voltage may also be applied to the Operating Power interface by the Host for sensing the presence (or absence) of an attached Micro Munition (serves same function as MIL-STD-1760 interlock), prior to application of full Operating Power.

Two classes of Host are supported by the standard from an Operating Power perspective, as follows:

- Class I Host supplies 28V DC $\pm 5\%$ on the Operating Power interface.
- Class II Host supplies 28V DC followed by 56V DC $\pm 5\%$ on the Operating Power interface.

Note that the Class II Operating Power capability is optional, and is intended for use with Micro Munitions which require higher power than available via the 28V DC Class I capability. The higher Class II Operating Power voltage supports higher power transfer at lower current levels compatible with smaller wire and connector contact sizes than would be feasible with 28V DC, yet is still below levels which would present a potential personnel shock hazard. It also avoids the need for a separate higher power interface in the signal set like the Auxiliary Connector in MIL-STD-1760, which would require additional wiring and increase the interface footprint and required connector size. The Class I 28V DC level was retained for compatibility with the significant inventory of legacy platforms which may eventually carry Micro Munitions. Host procedures for initial power application and class determination of an attached Micro Munition are described in Section 4.1.1.

Micro Munition designers should be cognizant of the fact that maximum compatibility with various platforms will be achieved if Micro Munition Operating Power requirements can be maintained within the Class I capability level. Where feasible and when determined to be of operational value, Micro Munitions requiring Class II level Operating Power capability for full functionality should be designed with a more limited functionality option that permits operation within the Class I capability limits.

3.1.5.2 Safety Enable Power

The Safety Enable Power supply must be controlled separately from the Operating Power. The precise implementation is left to the designer in order to match the system requirements at hand. The duration is limited to two seconds in order to limit the requirements on the Host power supply. Two seconds also allows the Host to sequence Safety Enable signals so as to limit the number of simultaneous safety enable power signals that must be supported. This allows the Host to limit the overall power draw at the system level if desired.

3.1.6 Structure Ground Interface

The structure ground interface provides a ground path for dissipation of static buildup as well as a current path for abnormal situations or fault conditions. It is essentially a safety feature that prevents external voltage differentials from building up between a store and the Host. It is not to be used as a normal return path.

4. COMMENTARY ON THE REQUIREMENTS OF AS5726

4.1 Host Requirements

4.1.1 Host: Mated Status Interface

The Mated Status Interface provides an indication of the electrical mated status at the connector interface between the Host and Micro Munition. The Host Mated Status interface, as represented in Figure 3 below, consists of a single discrete signal that is used by both the Host and the Micro Munition as opposed to a two signal continuity loop approach used by other interfaces such as MIL-STD-1760 (i.e., Interlock and Interlock Return for the ASI and RT Address lines and RT Address Return for the MSI) and by AS5725 (i.e., Store Mated and Operating Power Return for Miniature Mission Store Interface Carriage System and Carriage Mated and Operating Power Return for the Miniature Mission Store Interface).