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Condition monitoring and diagnostics of machines — Data processing, communication and presentation —

Part 2:
Data processing

Surveillance et diagnostic d'état des machines — Traitement, échange et présentation des données —

Partie 2: Traitement des données

Reference number
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 13374-2 was prepared by Technical Committee ISO/TC 108, *Mechanical vibration, shock and condition monitoring*, Subcommittee SC 5, *Condition monitoring and diagnostics of machines*.

ISO 13374 consists of the following parts, under the general title *Condition monitoring and diagnostics of machines — Data processing, communication and presentation*:

— *Part 1: General guidelines*

— *Part 2: Data processing*

The following part is envisaged:

— Part 3: Communication requirements

This corrected version includes amendments to:

— Figure A.1 [deletion of "(see …)" references in the last four lines of the tabulated matter; deletion of "AGENT …" from the "Technology types" list];

— p. 25 (B.2.3, first line, deletion of "[30], [31]", insertion of "(see Reference [29], [30]");

— p. 29 (B.4.2, first line, deletion of "[21]", insertion of "[23]");

— throughout this part of ISO 1337, the format “see Reference [*x*]” has been adopted to cite references to publications other than standards.

Introduction

The various computer software systems written for condition monitoring and diagnostics (CM&D) of machines that are currently in use cannot easily exchange data or operate in a plug-and-play fashion without an extensive integration effort. This makes it difficult to integrate systems and provide a unified view of the condition of machinery to users. The intent of Parts 1 to 3 of ISO 13374 is to provide the basic requirements for open CM&D software architectures which will allow CM&D information to be processed, communicated, and displayed by various software packages without platform-specific or hardware-specific protocols.

Condition monitoring and diagnostics of machines — Data processing, communication and presentation —

Part 2: **Data processing**

1 Scope

This part of ISO 13374 details the requirements for a reference information model and a reference processing model to which an open condition monitoring and diagnostics (CM&D) architecture needs to conform. Software design professionals require both an information model and a processing model to adequately describe all data processing requirements. This part of ISO 13374 facilitates the interoperability of CM&D systems.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 13374-1:2003, *Condition monitoring and diagnostics of machines — Data processing, communication and presentation — Part 1: General guidelines*

ISO/IEC 14750:1999, *Information technology — Open Distributed Processing — Interface Definition Language*

3 CM&D information architecture requirements

3.1 Overview

An information architecture describes all the data objects and their properties (or attributes), property data types, data object relationships, reference data and data documents for a given system or application. An open CM&D information architecture specification shall describe their content for each of the five layers shown in Figure 1.

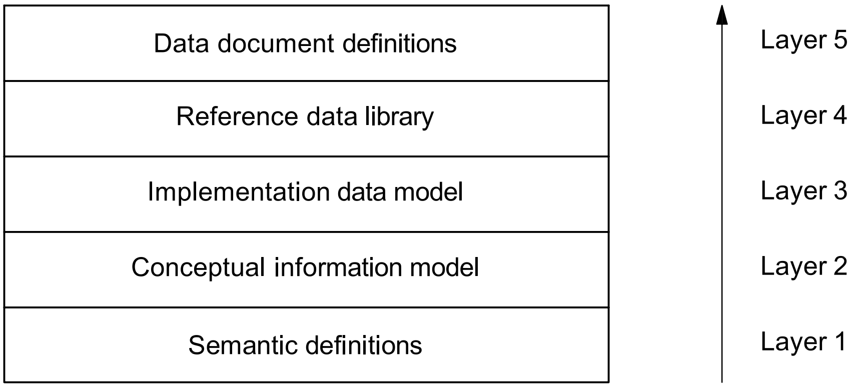

Figure 1 — CM&D information architecture layers

3.2 Semantic definition requirements

To ease understanding among various parties utilizing the information architecture, an open CM&D information architecture specification shall provide a set of semantic definitions for each major data object in the system. Non-formal description terminology, such as English language definitions of the data objects, may be used. Formal descriptions utilizing ontological schemas, such as the proposed Resource Description Format (RDF) of the World Wide Web Consortium (W3C), may also be utilized.

3.3 Conceptual information model requirements

A conceptual information model is an integrated definition of all the primary data objects relevant to CM&D, along with their major properties (also called "attributes"), property data types, object interrelationships, and object or relationship constraints. An open CM&D information architecture specification shall provide a non-proprietary conceptual information model, sometimes referred to as a "schema", which is independent of how the data are physically stored or accessed. This conceptual information schema is a blueprint of the location of various data elements, which facilitates system integration and data integrity. Using a conceptual schema, an implementation data model can be verified.

The Unified Modelling Language (UML) has emerged as the software industry's dominant modelling language and is now an International Standard, ISO/IEC 19501. UML includes a standardized class diagram representation for information modelling (see Annex B for additional information about UML).

3.4 Implementation data model requirements

Based on the conceptual information model, an implementation data model provides the exact representation of data elements that shall be transferred or stored. An open CM&D information architecture specification shall provide an open implementation data model that conforms to its conceptual data model.

The open CM&D implementation data model shall allow for the integration of many sources of machinery information, support peer-to-peer databases, allow user-defined look-up entries, and utilize standardized timestamps and engineering units. The schema should support unique enterprise, site, and database or data source identifiers to differentiate data taken at different physical locations. The schema should also support unique, system-wide identifiers for plant segments containing machinery (service segment locations) in a parent-child hierarchy. Also, the schema should support a unique asset-specific identifier to allow individual component monitoring and tracking in a parts hierarchy.

The basic framework of storing enterprise, site, site database, process or machine segment information (such as physical orientation, drive type, mounting type and shaft coupling type), asset nameplate data (including entries such as rated speed, rated power, make and model, and bearing or other component information), measurement locations, data measurement sources, transducers, transducer orientation, engineering units, signal processing post-scaling types, ordered lists, and alarms should be specified in the schema. At a data level, the schema should support formats for communicating historical single-valued numeric data, Fast-Fourier Transform (FFT) spectra data, constant percentage band (CPB) spectra, time waveforms, sample-based test data, thermographic images and binary large objects. The schema should support a date/time notation that references back to a specific instance in time, using the Gregorian (common era, or CE) calendar, with a lexical representation based upon ISO 8601 (see Reference [1]) referenced to universal coordinated time (UTC) and that also stores the local time zone offset.

This specification can be specified using various schema definitions. The file description schema format has been used for years in the scientific programming community. It maps the format for ASCII or binary data files, which can be exported from a computer system or imported into a computer system. A complete record format description is published which specifies the data fields contained in the file, their exact location in relation to the other data fields, whether the fields are in ASCII or binary format, and the exact data format – real floating point, integer, character, varying character string – of each field.

The relational information schema format is the definition language for relational database management systems. The relational method is analogous to a blue-print drawing which defines the various “room names” or (tables) where data will be stored, the data “contents” or (columns) in the rooms, each data column's exact data format (scientific floating point, integer, varying character string, etc.), whether or not a data column can be empty or not (not null) and each data row's unique “key” (primary key) which uniquely identifies it. A table can be related to another table by including a “reference” (foreign key) to it.

An Extensible Markup Language (XML) schema definition (XSD) is a recommended definition language. XML is a project of the World Wide Web Consortium (W3C), and the development of the specification is being supervised by their XML Working Group. XML is a public format written in the Standard Generalized Markup Language (SGML), using ISO 8879, for defining descriptions of the structures of different types of electronic documents. The version 1.0 specification was accepted by the W3C as a recommendation on 10 February 1998. On 3 May 2001, the W3C issued an XML schema as a W3C recommendation. XML schemas define shared markup vocabularies, the structure of XML documents which use those vocabularies, and provide hooks to associate semantics with them. By bringing datatypes to XML, XML schemas increase the utility of XML to the developers of data interchange systems. XML schemas allow the author to determine which parts of a document may be validated, or identify parts of a document where a schema may apply. Further, as XML schemas are XML documents themselves, they may be managed by XML authoring tools (see Annex B for additional information about XML).

Regardless of which information schema format is chosen, the implementation data model shall define a minimum set of data elements that should be included in the schema for conformance. In addition, a list of optional elements may be included.

3.5 Reference data library requirements

To effectively utilize an implementation data model, standard entries for various look-ups need to be stored in a reference data library. An open CM&D information architecture specification shall provide an open reference data library which conforms to its implementation data model. The specification should support populating and maintaining industry-standard taxonomies and codes for the reference data and allow both suppliers and end-users to add industry-specific and customer-specific entries to the library using database-unique entries. The specification shall also support the creation of a standard set of reference codes in various languages as required.

The reference data library specifies all code tables for segment (machine/component) type codes, asset type codes, measurement location type codes, engineering unit type codes, sampling test codes, diagnostic/prognostic event codes, health codes, failure codes and root cause codes. The library also houses engineering unit codes, measurement location type codes and mounting orientation codes.

3.6 Data document definition requirements

An open CM&D information architecture specification shall also specify the format for the publication of a data document. The specification allows the reference data library to be read or written in a standardized way and supports applications which need data import/export capability.

Specifications which utilize the file description schema format as their implementation data model will probably utilize the same specification for the publication of an ASCII or binary data document. The complete record format description shall be published, specifying the data fields contained in the file, their exact location in relation to the other data fields, whether the fields are in ASCII or binary format, and the exact data format – real floating point, integer, character, varying character string – of each field.

Specifications which utilize the XML schema format as their implementation data model will probably utilize the same format for the publication of an XML data document. An XML schema provides the definition of the XML document and XML parsers and validation tools can verify the syntax of the document's content.

3.7 Compliant specifications

An open CM&D information architecture specification shall utilize the information architecture as described in subclauses 3.1 to 3.6. MIMOSA, a non-profit association, publishes an open CM&D information specification which is compliant with the above requirements. The specification is known as the MIMOSA Open Systems Architecture for Enterprise Application Integration (OSA-EAI™) specification. Annex A describes this specification in more detail.

4 CM&D processing architecture requirements

4.1 Overview

A processing architecture describes all the interactions or transactions which are between modules internal to the software system itself, external from end-user interactions, or external from other software system interactions. An open CM&D processing architecture specification shall utilize the processing architecture shown in Figure 2. This architecture is defined as blocks of data processing functionality. After each block in the system has been properly configured, the basic data are converted into digital form in Data Acquisition (DA) and are processed in various ways as they are transformed into actionable information, resulting in Advisory Generation (AG). As the processing progresses from DA to AG, data from preceding blocks need to be transferred to subsequent blocks and additional information acquired from or sent to external systems. Similarly, as the data evolve into information, both standard technical displays and graphical presentation formats are required. In many applications, data archiving is required in order to maintain a history of the output of each block. The DA, DM and SD blocks are responsible for assessing data quality. Output should be identified as good, bad or undetermined.

This part of ISO 13374 does not address the impact of errors and their propagation within and across the various CM&D processing blocks. Sources of such errors include instrumentation calibration, environmental noise, signal conditioning and processing, computational rounding, human-induced inputs, and their combined effects.

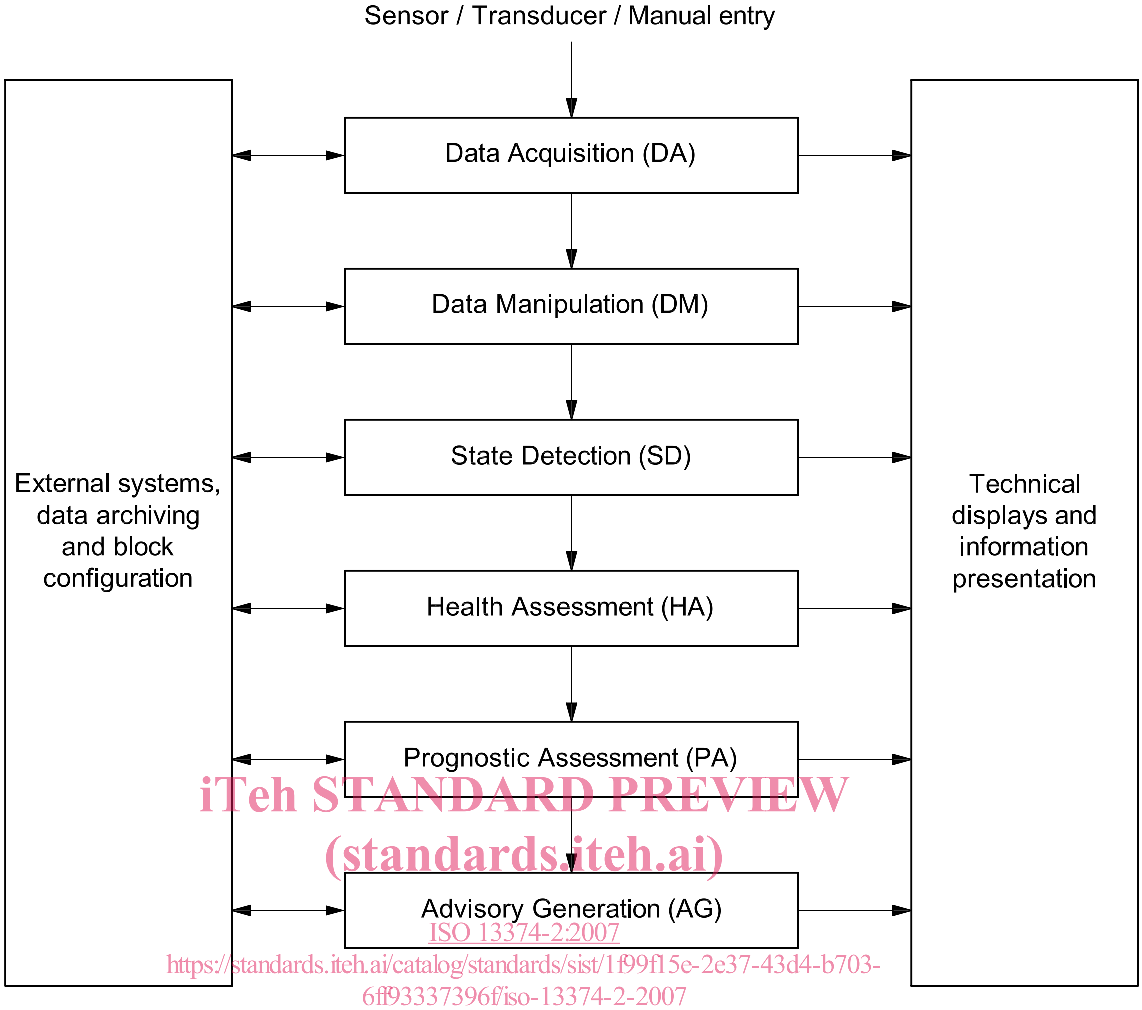

Figure 2 — Data processing block diagram

4.2 Data Acquisition (DA) blocks

As detailed in Figure 3, the DA block has been generalized to represent the software module that provides system access to digitized data entered automatically or manually. The DA module may represent a specialized data acquisition module that has analog feeds from legacy sensors, or it may collect and consolidate sensor signals from a data bus. Alternatively, it might represent the software interface to a smart sensor. The DA module is basically a server of calibrated digitized sensor data records.

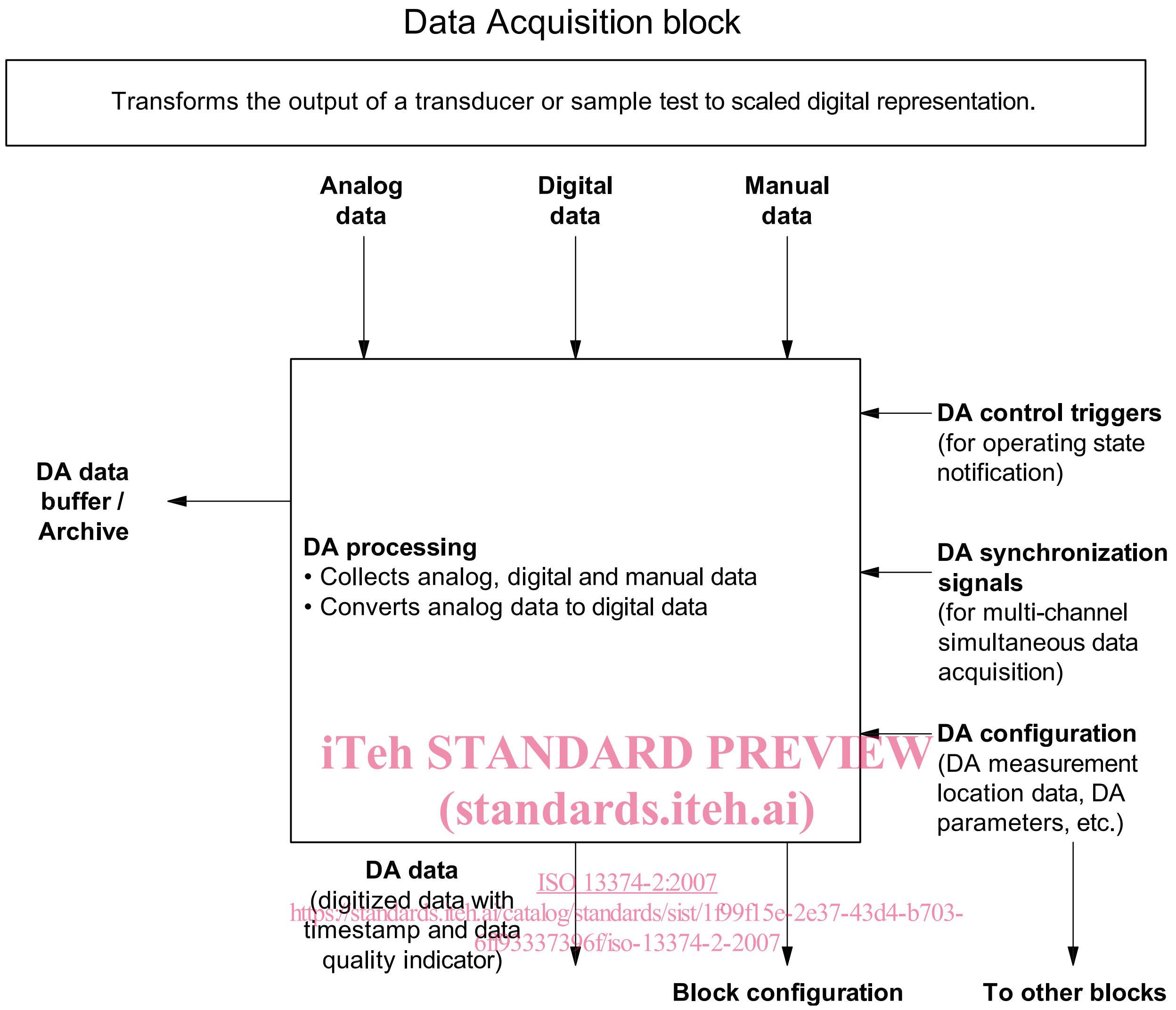

Figure 3 — Data Acquisition block

The output of all DA blocks shall contain the following:

— digitized data;

— time-order/time-reference data, normally referenced with UTC and local time zone;

— data quality indicator (e.g. “bad”, “good”, “unknown”, “under review”, etc.).

Examples of digitized data include:

— floating point values for scalar data;

— magnitude and time series for dynamic data;

— thermal radiation data with digitized image for thermographic data;

— sample test results for lubricating fluid/air/water sample data.

4.3 Data Manipulation (DM) blocks

As detailed in Figure 4, the DM block processes the digital data from the DA block to convert it to a desired form which characterizes specific descriptors (features) of interest in the machine condition monitoring and diagnostic process. Often the functionality within this layer consists of some signal processing algorithms.

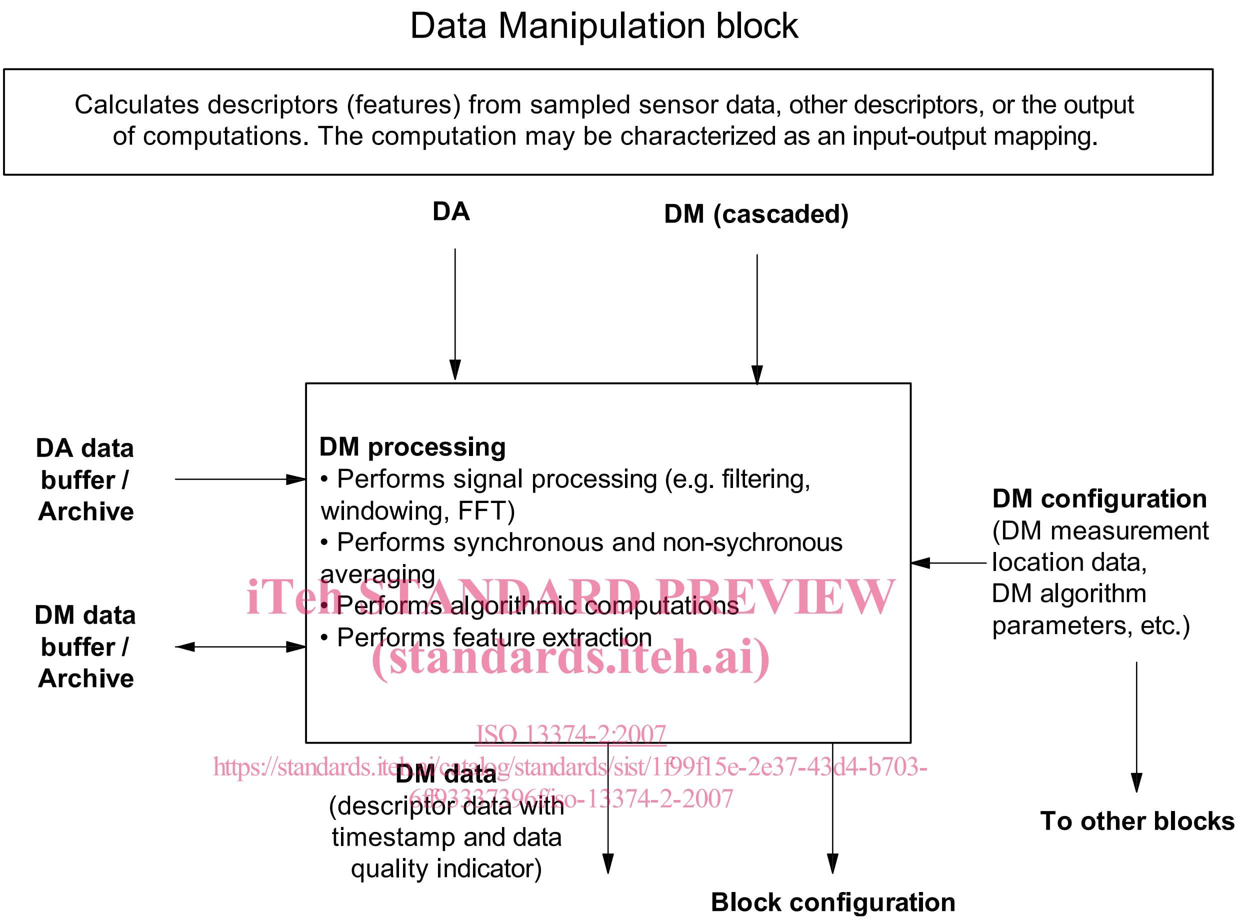

Figure 4 — Data Manipulation block

This block may contain speciality processing functions such as Fast Fourier Transforms, wavelets or simple average values over a time interval.

Examples of the descriptor outputs of the DM block include:

— extracted feature;

— conversion from time domain to frequency domain and vice versa;

— calculated, non-interpretative values;

— virtual sensor (differential pressure from inlet and outlet pressures);

— integrating acceleration to velocity/double integration to displacement;

— filtering;

— normalization;

— time series including sample rate.