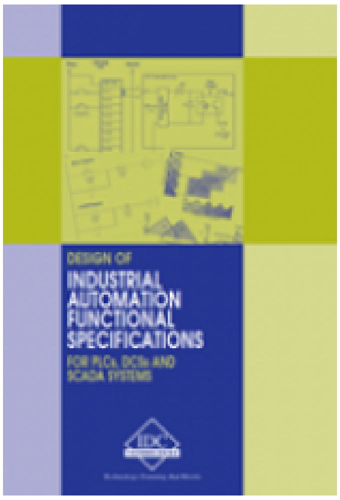
FC-E - Design of Industrial Automation Functional Specifications for PLCs, DCSs and SCADA Systems



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Short Description

This manual will be useful to both specifiers and implementers providing a theoretical grounding for preparing a control system functional specification for implementation on Industrial control systems consisting of PLC (Programmable Logic Controllers), HMI (Human Machine Interfaces / SCADA devices) or DCS (Distributed Control Systems).

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First Chapter
Design of Industrial Automation Functional Specifications for PLCs, DCSs and SCADA Systems - Function Design Specifications (FDS)

1 Functional Design Specifications (FDS)

In this chapter a brief overview of control system FDS is given. The important industrial terms and naming conventions are discussed and the standards are highlighted.

Learning objectives

You will learn about:

- Overview of control system FDS
- Essential industry terms and abbreviations used in the FDS
- Naming conventions and standards
- Control philosophy needed in guiding the FDS

1.1 Overview of control system FDS

Any Supervisory Control and Data Acquisition (SCADA) project will be successful if, and only if, the creating, understanding and execution of the functional specifications are executed perfectly. These technical specifications are important in the overall development and designing of control systems which contain the technical details that lead to the success of the project. These functions are as important as that of the mechanical sections.

For example, consider piping. The complete description of the valves, pumps, chillers, piping specialties and other components used to construct the piping system are given in piping specifications. Designers will not submit a project without this important information for the piping system. In general, this kind of thorough information is not included for control systems. The lack of proper technical specifications for control systems may lead to difficulty in meeting the project's design objectives. The design process is said to be successful if it contains descriptions of maintenance, operation and commissioning requirements. This leads to efficient building, and ensures the operation runs smoothly.

A functional specification defines what the system should do and what functions and facilities are to be provided. It provides a list of design objectives for the system.

A standard specification of the project should consider what is generally available in the market and what can reasonably be called upon for options. It is of no use to specify aspects which suppliers cannot provide at a reasonable cost and within a sensible time frame. The aim is to match what the manufacturer can offer, within their standard range of equipment. An efficient approach, by the purchaser, is to select standard equipment which is suitable for the manufacturer and then design the power system around the equipment to be purchased. In general, this approach will reduce the amount of time needed to design the power system.

Functional aspects of the specification should be considered carefully. The function of basic equipment such as generators, motors and switchgear will be understood easily. But, in order to gain an understanding of what is required, it is essential to pay attention to the design and performance details. Functionality implies a more interrelated type of existence, as is the case with systems of equipment rather than individual items of equipment.

Functional specifications in the area of process control systems cover the following:

- SCADA systems
- Power management control system
- System computer
- Measuring devices
- Controller set points
- Switchgear
- Rotating machines.

The entire system should be defined functionally and all the elements should be compatible from the conceptual stage of the specification.

Control System Engineers analyze the following, to develop the design and functional specifications of automation systems:

- User requirements
- Procedures
- Design process
- Mechanical equipment
- Problems to identify the system components.

The automation system helps the equipment to function in a required manner. The interface between the hardware and software development, for the automation system, is the responsibility of Control System Engineers.

A FDS is the most important stage in the design of any control system. It provides details of the solution to be implemented, to meet user requirements. It should be accepted by the user and should form the basis of the design for both hardware and software. An excellent FDS clearly specifies the following which are associated with the system:

- Functions
- Operator interactions control
-

Therefore, before the system is developed, the user must confirm whether the proposed solution fully meets the specified requirements or not. A FDS is considered as the basis for the design of the system. It is used during testing to verify and validate the system, to ensure whether all the required functions are present and that they operate correctly.

A FDS has all the information associated with the control system including:

- Details of how each area of the plant operates under automatic control (control philosophy)
- Details of the SCADA system i.e. screen layouts, navigation charts, alarm handling, trending and reporting
- Details of the Network architecture
- Details of any local operator interfaces.

Figure 1.1

Control system design

The FDS should cover:

- Control Modules such as PID Loops, indicators etc
- HMI Graphic displays
- Equipment Basic Control
- Phase Logic
- Operations
- Unit Procedures
- SCADA Recipes

- The Inputs and Outputs of the systems with cards and channels assigned to them.

1.1.1 Benefits of using a FDS

There are numerous benefits provided by a complete and coherent FDS which include time savings of approximately 50% of total time and a saving of resources and money of approximately 25%. These benefits are achieved only after everyone is involved in designing, developing, testing, approving of an application, signing the document containing an ordered list of all design and functional requirements.

By using a FDS (Functional Design Specification):

- The manufacturer knows exactly what to develop & deliver
- The system integrators know exactly what they are working with
- Quality Assurance knows exactly what to test
- The client knows exactly what they will be getting.

1.2 Essential industry terms and abbreviations used in the FDS

Technical terms and abbreviations are easily understood by professionals in one field whereas they may be confusing to others from another field, and may be misunderstood. Therefore, it is necessary to understand the abbreviations and some of the terms that are used in the text and elsewhere in the industry.

The following are the essential industry terms and relevant abbreviations used in functional design specifications:

Table 1.2

Industrial terms and their abbreviations

Industry terms	**Abbreviations**
AGC	Automatic Generation Control
API	Application Programming Interface
CORBA	Common Object Request Broker Architecture
C & I	Control and Instrumentation
CPU	Central Processing Unit
CRC16	16-bit Cyclic Redundancy Check
CSMA/CD	Carrier Sense Multiple Access/Collision Detection

CT	Current Transformer
DC	Direct Current
DCS	Distributed Control System
DMS	Distributed Management System
DNP	Distributed Network Protocol
DOD	Department of Defense
DOE	Department of Energy
DISCO	Distribution Company
DNP/DNP3	Distributed Network Protocol, version 3.0
DPI	Double-Point Information
EMS	Energy Management System
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EPROM	Erasable Programmable Read-Only Memory
FTP	File Transfer Protocol
FDS	Functional Design Specification
FS	Functional Specification
FAT	Factory Acceptance test
FMEA	Failure Modes and Effect Analysis
FPGA	Field Programmable Gate Array
GUI	Graphical User Interface
GAMP	Good Automated Manufacturing Practice
GAL	Generic Array Logic
GENCO	Generation Company
GPR	Ground Potential Rise
HMI	Human Machine Interface
HDS	Hardware Design Specifications
I/O	Input/Output
IED	Intelligent Electronic Devices
ICCP	Intercontrol Centre Communications Protocol
IEEE	Institute of Electrical and Electronics Engineers
INEEL	Idaho National Engineering and Environmental Laboratory
ISO	Independent System Operator or International Organization for Standardization
IRIG-B	Inter Range Instrumentation Group format B
ISA	Instrumentation Systems and Automation Society
IT	Information Technology
ITU	International Telecommunication Union
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LAN	Local Area Network
MMI	Man Machine Interface

MTBF	Mean Time Between Failure
MTTR	Mean Time To Repair
NIM	Network Interface Module
NISAC	National Infrastructure Simulation and Analysis Centre
NRC	Nuclear Regulatory Commission
NTP	Network Time Protocol
OASIS	Open Access Same - Time Information System
ODBC	Open Database Connectivity
PID	Proportional, Integral and derivative controller
POSIX	Portable Operating System Interface
PLC	Programmable logic Controller
P & ID	Process & Instrumentation Diagram
PSU	Power Supply Unit
PCS	Process Control System
PROM	Programmable Read-Only Memory
PSTN	Public Switched Telephone Network
PT	Potential Transformer
RTU	Remote Terminal Unit
REA	Rural Electric Association
RTO	Regional Transmission Organization
RAID	Redundant Array of Inexpensive Disks or Redundant Array of Independent Disks
ROM	Read-Only Memory
SCADA	Supervisory Control and Data Acquisition
SAT	Site acceptance test
SOE	Sequence of Events
SNTP	Simple Network Time Protocol
SPI	Single-Point Information
SQL	Structured Query Language
SWC	Surge Withstand Capability
TASE	Telecontrol Application Service Element
TRANSCO	Transmission Company
TCP/IP	Transmission Control Protocol/Internet Protocol
T&D	Transmission and Distribution
UHF	Ultra High Frequency
UPS	Uninterruptible Power Supply
UTP	Unshielded Twisted Pair
VDU	Video Display Unit
WAN	Wide Area Network

1.3 Naming conventions and standards

The General Design Principles (GDP) defines the number of conventions to be used.

For example, consider the standard color scheme. In one division of the plant a device is colored red, meaning 'stopped', and in another part of the plant the same type of motor is colored red, meaning 'dangerous condition'. This may lead to disaster, but by following naming conventions, such risks will be reduced.

Adopting a standardized reliable naming convention for devices controlled by the system, will be favorable for scalable and maintainable systems in the long run. In some cases, the naming conventions used are forced on the system by external influences. Therefore, they should be properly documented in the GDP.

Examples of tagging and naming conventions are:

- Graphic symbols
- Instrumentation naming.

Naming conventions and standards are explained in further detail in the next chapter.

1.4 Control philosophy in guiding FDS

Philosophy is a belief or a system of beliefs, accepted as authoritative by some groups. Control philosophy is a guideline for a FDS which describes the basic dos and don'ts and requirements of a FDS from the point of view of the end user. It should describe the following:

- Level of process automation
- Information handling needs
- Operational requirements
- Requirement of flexibility
- Level of control intervention
- Operators work and skill
- Management skills for both organization and data communication
- Level of management needed
- Extent of manual control required
- Extent of the physical area the system is covering
- Type of communication system
- Level of security needed for communication
- Type of control processing.

1.5 Summary

This chapter summarizes the following:

- A functional specification defines what the system should do and what functions and facilities are to be provided.
- An excellent FDS clearly specifies the following associated with the system:
- Functions
- Operator interactions control
-
- There are numerous benefits provided by a complete and coherent FDS, which include time savings of approximately 50% of total time and a saving of resources and money of approximately 25%.
- It is necessary to understand the abbreviations and some of the terms that are used in the text and elsewhere in the industry.
- Technical terms and abbreviations are easily understood by professionals in one field whereas it may be confusing to others and may be misunderstood
- Adopting a standardized reliable naming convention for devices, controlled by the system, will be favorable for scalable and maintainable systems in the long run
- Control philosophy is a guideline for a FDS, which describes the basic dos and don'ts and basic requirements of a FDS, from the point of view of the end user.