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*Setting the Standard for Automation™***TECHNICAL REPORT****ISA-TR5.1.01/ISA-TR77.40.01-2012 (R2016)**

Functional Diagram Usage

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ISA-TR5.1.01/ISA-TR77.40.01-2012 (R2016)
Functional Diagram Usage

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Foreword

Functional diagrams were first employed when discrete and electric analog control systems were designed. Associations and professional societies, such as Scientific Apparatus Makers Association (SAMA), ISA, and ISO, provided guidelines as to industry use of functional diagrams. SAMA has ceased to exist, but its popular standard, PMC 22.1-1981, *Functional Diagramming of Instrument and Control Systems*, is currently available through The Measurement, Control and Automation Association as well as ISA. Current ISA standards available for industry use include ANSI/ISA-5.1-2009, *Instrument Symbols and Identification*, and ISA-5.2-1976 (R1992), *Binary Logic Diagrams for Process Operations*. Symbols from SAMA PMC 22.1-1981, *Functional Diagramming of Instrument and Control Systems*, have been incorporated into ANSI/ISA-5.1-2009. The work within this technical report maintains historical practices of the previous and current documents and expands on new algorithms and practices.

Abstract

This technical report is an extension of ANSI/ISA-5.1-2009. The intent of this report is to provide further information and practical examples on the usage of functional diagrams for documenting application software. It is hoped that this report will be a handy reference to design engineers who are directly involved in the generation or review of functional diagrams.

Keywords

functional diagram, function block symbols, application software, control algorithm, cascade controller, multiple input multiple output controller, symbol legend, PID controller

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1 Scope

The scope of this technical report is to expand on and illustrate usage of function block symbols and functions and to prepare examples in development of complex function block symbols and functions.

2 Purpose

The purpose of this technical report is to provide advice and guidance in documenting application software through functional diagrams.

3 Definitions

3.1 alarm:

an audible and/or visible means of indicating to the operator an equipment malfunction, process deviation, or abnormal condition requiring a response [ANSI/ISA-18.2-2016]

3.2 application software:

software specific to a user application that is configurable and in general contains logic sequences, permissive and limit expressions, control algorithms, and other codes required to control the appropriate input, output, calculations, and decisions

3.3 binary:

a term applied to a signal or device that has only two discrete positions or states. When used in its simplest form, as in binary signal (as opposed to analog signal), the term denotes an on-off or high-low state, i.e., one which does not represent continuously varying quantities.

3.4 controller:

any manual or automatic device or system of devices used to regulate a process within defined parameters. If automatic, the device or system responds to variations in a process variable.

3.5 control station:

a manual loading station that provides control-loop switching between manual and automatic control mode. It is also known as an auto-manual station. In addition, the operator interface of a distributed control system may be regarded as a control station.

3.6 converter:

a device that receives instrument signal information in one form and transmits an output signal in another form. An instrument that changes a sensor's output to a standard signal is properly designated as a transmitter, not a converter. Typically, a temperature element (TE) may connect to a transmitter (TT), not to a converter (TY).

3.7 digital:

a term applied to a signal or device that uses binary digits to represent continuous values or discrete states

3.8 distributed control system:

a system that, while being functionally integrated, consists of subsystems that may be physically separate and remotely located from one another

3.9 function:

the purpose of or an action performed by a device

3.10 functional diagram:

the practice of diagramming application software in its basic functional form, exclusive of its operating media or specific equipment detail

3.11 legend sheet:

a sheet of the individual symbols and identification with explanation

3.12 logic signal:

representation of information by a set of discrete values in accordance with a prescribed law. These values are represented by numbers. [ISA-51.1-1979 (R1993)]

3.13 logic system:

decision-making logic equipment with its associated power supplies, I/O hardware, and sensing devices.

3.14 macro:

a set of functions combined as a specific program to be run as a single task. The task is a subset of the controller's program but executes repeatedly for similar devices or applications with unique inputs and outputs.

3.15 measurement:

the determination of the existence or the magnitude of a variable [ISA-51.1-1979 (R1993)]

3.16 multiple input multiple output:

an algorithm/program, such as model predictive control, neural networks, etc., that computes one or more output demands, biases, or setpoints based on multiple inputs

3.17 process:

any operation or sequence of operations involving a change of energy, state, composition, dimension, or other properties that may be defined with respect to a datum [ISA-51.1-1979 (R1993)]

3.18 process measurement:

the acquisition of information that establishes the magnitude of process qualities [ISA-51.1-1979 (R1993)]

3.19 process variable:

any variable property of a process; used in this standard to apply to all variables other than instrument signals [ISA-51.1-1979 (R1993)]

3.20 program:

a repeatable sequence of actions that defines the status of outputs as a fixed relationship to a set of inputs

3.21 setpoint:

also called target value, reference, or desired value. This is the level at which the controller should attempt to maintain the process variable.

4 Abbreviations (Acronyms)

HMI – human machine interface

I/O – input/output

MIMO – multiple input multiple output

MOV – motor operated valve

PID - proportional integral derivative

5 Preparation of functional diagrams

This report is concerned with the functional diagrams normally prepared in the early stages of system conception from the mechanical or process flow sheet. Functional diagrams normally are revised and kept current over the complete system life cycle as system design progresses through the various stages of negotiations, quotation, contract award, reduction to final equipment, system checkout, installation, and ongoing system enhancements. They are also included as part of the system instructions.

The functional diagrams define functions of a control configuration that are independent of the hardware and firmware of the control system used for process automation. Functional diagrams are a method to document application software and transfer information for implementation into the selected control system.

A functional diagram may be more or less detailed, depending on its intended use. The amount of detail in a logic diagram depends on the degree of refinement of the logic and on whether auxiliary, essentially non-logic, information is included. Simplified diagrams can be drawn by omitting details that may be obvious.

This report is intended to provide sufficient information to enable anyone with a reasonable amount of process and instrumentation knowledge, who is reviewing documents depicting process measurement and control, to understand the means of measurement and control of the process.

This report is suitable for use whenever reference to measurement and/or control instrumentation, control devices and/or functions, or software applications and/or functions is required for the purposes of symbolizing and identification.

5.1 Basic symbols

A logic symbol comprises an outline or a combination of outlines together with one or more qualifying identifications and/or qualifying texts. Basic and complex logic symbols with minimum inputs need not specify input names. Logic symbols with multiple inputs can have input name identifiers to specify the signal functions within the algorithm. New function or algorithm symbols should represent an encapsulated software component (i.e., function block) that exists within a system's library.

5.2 Advanced symbols

With the introduction of microprocessor-based systems, suppliers have developed advanced algorithms that are not represented by previous PMC 22.1, the German Institute for Standardization (DIN), the International Electrotechnical Commission (IEC), or ISA-5.1 standards. While following the intent of these standards, suppliers either create a new symbol or group existing symbols to represent the new algorithm. The problem occurs in understanding what function that symbol really represents and the symbol's boundaries. Thus, advanced symbols depict new control algorithms via a combination of existing symbols, new control algorithms with multiple functions, and new control algorithms previously unavailable with electric analog systems.