

System Control Functions

SW09-501

**Implementation
Startup & Reconfiguration - 2**

System Control Functions

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Release 520
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About This Publication

This is a reference manual for process engineers, control system engineers, and application engineers who design and implement data acquisition and control strategies to be accomplished through a **TotalPlant** Solution (TPS) System with a Local Control Network.

This publication is part of family of publications that define control system functions. Other control functions publications are: *High-Performance Process Manager Control Functions and Algorithms*, *Advanced Process Manager Control Functions and Algorithms*, *Process Manager Control Functions and Algorithms*, *Application Module Control Functions*, *Hiway Gateway Control Functions*, *Programmable Logic Controller Gateway Control Functions*, and *Logic Manager Control Functions*, and *Safety Manager Control Functions*. See Section 1, *References*.

This publication supports **TotalPlant** Solution (TPS) System network Release 520. TPS is the evolution of TDC 3000^X.

Change bars are used to indicate paragraphs, tables, or illustrations containing changes that have been made to this manual effective with Release 520. Pages revised only to correct minor typographical errors contain no change bars.

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REFERENCES

Section 1

This section provides references to other publications that are useful or necessary in implementing control system functions.

1.1 REFERENCES

This manual describes the data acquisition and control functions that are independent of the modules or gateways that participate in these functions. The following publications describe the data acquisition and control functions that are accomplished through Advanced or High-Performance Process Managers, Programmable Logic Controller Gateways, Logic Managers, Safety Managers, Application Modules, and Hiway Gateways:

- *High-Performance Process Manager Control Functions and Algorithms* in the *Implementation/High-Performance Process Manager - 1* binder.
- *Advanced Process Manager Control Functions and Algorithms* in the *Implementation/Advanced Process Manager - 1* binder.
- *Process Manager Control Functions and Algorithms* in the *Implementation/Process Manager - 1* binder.
- *Logic Manager Control Functions* in the *Implementation/Logic Manager* binder.
- *Safety Manager Control Functions* in the *Implementation/Safety Manager* binder.
- *Application Module Control Functions* in the *Implementation/Application Module - 1* binder.
- *Application Module^X User Guide* in the *Implementation/Application Module^X - 1* binder.
- *Hiway Gateway Control Functions* in the *Implementation/Hiway Gateway - 1* binder.
- *Programmable Logic Controller Gateway Control Functions* in the *Implementation/PLC Gateway* binder.

Information about other topics related to the data acquisition and control functions are provided in these publications:

AM, PM, APM, and HPM Algorithms;

- *Application Module Algorithm Engineering Data* in the *Implementation/Application Module - 1* binder.
- *Process Manager Control Functions and Algorithms* in the *Implementation/Process Manager - 1* binder.
- *Advanced Process Manager Control Functions and Algorithms* in the *Implementation/Advanced Process Manager - 1* binder.
- *High-Performance Process Manager Control Functions and Algorithms* in the *Implementation/High-Performance Process Manager - 1* binder.

Algorithms in Data Hiway boxes (the following publications are in the *Basic Product Manual* binders);

- Basic Controller—*Algorithms Engineering Data, CB-09-01*.
- Multifunction Controller or A-MC—*Algorithms Engineering Data, BC-10-01*.
- Extended Controller—*Algorithms—Engineering Data, CB-09-01*.

Process Connected Box Functions. The functions of boxes on Data Hiways are described in the BASIC System bookset. The *Basic Product Manual* binders have a section for each type of box (CB, A/MC, MC, EC, DHP, and PIUs).

Control Language (CL) programs:

- *Control Language/Application Module Overview* in the *Implementation/Application Module* - 3 binder.
- *Control Language/Application Module Reference Manual* in the *Implementation/Application Module* - 3 binder.
- *Control Language/Application Module Data Entry* in the *Implementation/Application Module* - 3 binder.
- *Control Language/Process Manager Reference Manual* in the *Implementation/Process Manager* - 2 binder.
- *Control Language/Process Manager Data Entry* in the *Implementation/Process Manager* - 2 binder.
- *Control Language/Advanced Process Manager Reference Manual* in the *Implementation/Advanced Process Manager* - 2 binder.
- *Control Language/Advanced Process Manager Data Entry* in the *Implementation/Advanced Process Manager* - 2 binder.
- *Control Language/High-Performance Process Manager Reference Manual* in the *Implementation/High-Performance Process Manager* - 2 binder.
- *Control Language/High-Performance Process Manager Data Entry* in the *Implementation/High-Performance Process Manager* - 2 binder.
- *Control Language/MC Reference Manual* in the *Implementation/Hiway Gateway* - 2 binder.
- *Control Language/MC Data Entry* in the *Implementation/Hiway Gateway* - 2 binder.

Computer Gateway functions—refer to appropriate publications in these binders;

Implementation/Computer Gateway

Implementation/CM50S - 1 and - 2

Implementation/Processor Gateway

Parameter Reference Dictionaries—These dictionaries provide details on all data point parameters including: value types, ranges, default values, sources, and access levels (key levels).

- *High-Performance Process Manager Parameter Reference Dictionary* in the *Implementation/High-Performance Process Manager - 2* binder.
- *Advanced Process Manager Parameter Reference Dictionary* in the *Implementation/Advanced Process Manager - 2* binder.
- *Process Manager Parameter Reference Dictionary* in the *Implementation/Process Manager - 2* binder.
- *Logic Manager Parameter Reference Dictionary* in the *Implementation/Logic Manager* binder.
- *Safety Manager Parameter Reference Dictionary* in the *Implementation/Safety Manager* binder.
- *Hiway Gateway Parameter Reference Dictionary* in the *Implementation/Hiway Gateway - 1* binder.
- *Programmable Logic Controller Gateway Parameter Reference Dictionary* in the *Implementation/PLC Gateway* binder.
- *Application Module Parameter Reference Dictionary* in the *Implementation/Application Module - 2* binder.
- *Computer Gateway Parameter Reference Dictionary* in the *Implementation/Computer Gateway* binder.

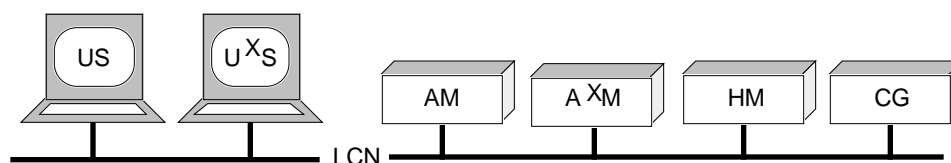
DEFINITIONS Section 2

Data acquisition and control system terms are defined under subsection 2.2. Frequently used acronyms are defined under subsection 2.3. The terms used to define parameter access levels are defined under subsection 2.4. Parameter value types are defined under subsection 2.5 and parameter arrays are explained under subsection 2.6.

2.1 CONTROL SUBSYSTEMS

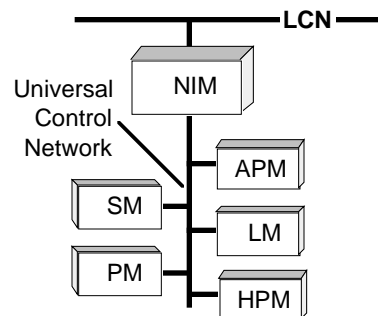
A **TotalPlant** Solution (TPS) System consists of these major subsystems:

- **The control room subsystem**—Based on the LCN, the control room subsystem includes Operator Consoles with Universal Stations (USs), Application Modules (AMs), and Computer Gateways (CGs) with the computers they serve. Universal Station^X (U^XS) and Application Module^X (A^XM) nodes provide X layer/UNIX functions as well as standard LCN functions.

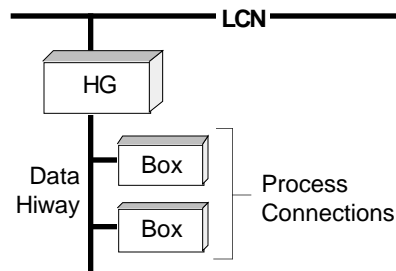


- **The process-connected subsystem or subsystems**—These process-connected subsystems are available on TPS Systems:

The UCN-based subsystem, which includes the Network Interface Module (NIM), Process Managers (PMs), Advanced Process Managers (APMs), High-Performance Process Managers (HPMs), Safety Managers (SMs) and Logic Managers (LMs).



The Data Hiway-based subsystem, which includes the Hiway Gateway (HG); a Data Hiway; and process-connected boxes, including Basic Controllers (CBs), Multifunction Controllers (A-MCs and MCs), Extended Controllers (ECs), and Data Hiway Ports (DHPs).



Programmable Logic Controller Gateways (PLCGs) appear to the system and the software to be an HG with its associated Data Hiway and up to eight DHPs. Therefore, all information in this publication applicable to HGs, Data Hiways, and DHPs also applies to PLCGs.

2.2 TERMINOLOGY

Abnormal Conditions—Condition(s) monitored by a sequence program. A true condition causes the execution of an Abnormal Condition Handler.

Abnormal Condition Handler—A CL sequence program section written by the user to respond to abnormal conditions. Abnormal Condition Handlers are optional. Three types are available: Hold, Shutdown, and Emergency.

Access Level—All data point parameters are assigned an access level that specifies what activities and tasks can change values in the parameter. See subsection 2.4.

Advanced Control Interface Data Point—A data point whose database represents an Advanced Control Program in a Computing Module.

Advanced Control Program—A program in a computing module that is represented by an Advanced Control Interface Data Point. Advanced Control Programs can be written in Fortran or Pascal.

Advanced Process Manager (APM)—A process-connected device on the UCN that provides regulatory control and sequence operations. The APM includes a powerful set of prebuilt data acquisition and control algorithms, plus additional and enhanced data points as compared to a PM.

Alias Point—An HG data point that uses the same box and slot on a Data Hiway as another point in the same HG, but has a different tag name (an alias). Alias points are created by building and loading only the HG-resident parameters (parameter LOADDEST contains Hg) for a point that already exists in the box and slot, and then loading the point in the HG. This new point in the HG then has access to the data in the designated box and slot. Alias points usually have virtually identical data, but different unit assignments. This allows alarms for such points to be generated for more than one unit.

Anti-Reset Windup—A function that prevents reset windup of PID points by inhibiting integral control action that is beyond the limits of the final control device (valve). See subsection 3.3.1.5.

Bad (Value Status)—The value of the PV is indeterminate. This might be caused by an unavailable input, a PV range violation with no clamping, an invalid PV constant, or a bad input-value status.

Batch—A result achieved or a product created by one or more sequence-program executions.

Batch Control Strategy—The control plan used to achieve an end result. The result can be an intermediate product or a product made from a complete recipe.

Binding—The process of replacing virtual references with actual references; also called linking.

Bound Data Point—A program in CL can execute only after it has been connected to a data point by the CL Linker. This data point is known as the program's Bound Data Point. The Bound Data Point of a Sequence Program is a Process Module Data Point; a CL Block is bound to a Continuous Data Point.

Build—To enter configuration data, picture information, reports, and logs into the system through one of the facilities of the Engineering Personality, such as the Data Entity Builder.

CL—Control Language, the process engineer's programming language. A subset of this language (CL/C) is applicable to continuous data points. Another subset of the full language (CL/MC) is used to create sequences that execute in the Multifunction Controller. CL/MC is functionally similar to SOPL. See CL.

CL Block—The unit of CL execution in continuous control. One or more CL Blocks can be attached to insertion points of any continuous data point. A CL Block can also be used in place of the PV algorithm or Control Algorithm of a regulatory data point.

CL Switch—A CL feature that allows changes in control strategies through the use of CL Blocks.

Composite Point—A data point that combines more than one process input or output in a single data point.

Condition Handler—See Abnormal Condition Handler.

Configure—For hardware, this means to select the mix and quantity of hardware devices needed to meet the user's needs. "To configure" also means to specify the information the data acquisition and control subsystem needs to cooperate in the management of a specific process or plant. "Configuration" can include filling out configuration forms and doing other paper work, plus entering configuration data through the Universal Station's Engineering Personality.

Continuous Data Point—A data point whose processing functions are the same at each processing cycle. Regulatory, timer, and custom data points are examples of continuous data points.

Custom Data Point—A continuous data point consisting of functions performed by CL Blocks, using Custom Data Segments.

Custom Data Segment—Data whose characteristics are defined to the system by the user and is incorporated into data points.

Custom Data Segment Description—The user-defined descriptions of the parameters of a Custom Data Segment. This definition is implemented through the CL Compiler.

Data Entity Builder—A facility in the Universal Station's Engineering Personality that is used in building data points. "Building" includes accepting configuration data, verifying that data, storing it in intermediate data files, and loading it in the destination module or gateway.

Data Owner—The software function that is the caretaker of a part of the system database, such as a data point. Data owners are responsible for validation of requests for the data they own, and for validating attempts by other functions to change the data they own.

Data Point—A named collection of data values called parameters. The data point forms the basis for a set of functions that operate on the collection of values.

Disable (Point/Unit Alarms)—A command that disables reporting of point alarms to the Universal Stations, on a point/unit basis, respectively.

Enable (Point/Unit Alarms)—A command that enables reporting of point alarms to the Universal Stations, on a point/unit basis, respectively.

Engineer—A process engineer, a control system engineer, or an application engineer. One who has a key that he or she can insert in the Universal Station key switch to gain access to engineer-accessible parameters.

Engineering Units—Units of measurement such as degrees, kilos, pounds, liters, gallons, hours, meters, feet, kPa, and PSIG. Engineering units for PVs are specified as part of the data-point configuration.

Entity—A named piece of the TPS database. There are two types of entities: data points and reserved entities. Data points are built and named by users. Reserved entities are built into the system by Honeywell. Reserved entity names begin with "\$." Data point names (tag names) cannot begin with "\$."

Enumeration Type—A data type consisting of two or more states that are stored in a parameter. These states are stored in the form of strings of up to eight characters, and are referred to in these publications as a mix of capital letters and lowercase letters, for example, InActive, Active, and NotConfig are the enumeration states for certain parameters. Also see "self-defining enumerations."

Event—An action that results in notification to some other function, for example, alarms.

Fetch—To acquire (read) a value from a parameter.

High-Performance Process Manager (HPM)—A process-connected device on the UCN that provides regulatory control and sequence operations. The HPM is faster than the APM yet includes all of the data acquisition and control algorithms in the APM, plus additional algorithms and features.

Inhibit (Point/Unit Alarm)—A command that suppresses detection of point alarms to the Universal Stations, on a point/unit basis, respectively.

Initializable Inputs—Input parameters of control algorithms through which initialization can be passed upstream if the control algorithm is configured for external initialization. The setpoint of a PID is an initializable input.

Initialization—Adjustment of values in a cascade strategy when the cascade is open, such that when the cascade is again closed, a process "bump" does not occur. See subsection 3.3.1.3.

Logic Manager (LM)—A process-connected device on a UCN that provides high-speed logic functions, including fast ladder logic program execution, extensive digital, boolean, or interlock logic, and ease of ladder logic programming by the user.

Network Interface Module (NIM)—The interface module between a Universal Control Network and the LCN.

Normal (Value Status)—The PV value status is normal if all input values for the PV are normal, the PV is calculated as a real number and within range, and the PV source is AUTO.

Normal Sequence—The portion of a sequence program that is executing under normal conditions.

Not a Number (NaN)—An indicator in a data point parameter that indicates that the parameter normally contains a number, but at present does not. At the Universal Station, a NaN data field appears as "-----" (six dashes).

Operator—Usually, a process operator at a Universal Station (someone who doesn't have a supervisor's key nor an engineer's key). See subsection 2.4.

Parameter—A named database item that contains a value (real, integer, logical, string, etc.) or an array of values. The parameter values are accessible through the data point name and parameter name.

Phase—A sequence program consists of a series of phases. A phase accomplishes a major process function or marks a major process milestone. Examples are a charging phase or heat-up phase. Phase boundaries are key points of synchronization in a sequence program. A phase is identified in the sequence program by the PHASE statement, and is divided into steps.

Programmable Logic Controller Gateway—An LCN node that functions and appears to the software and the rest of the system, as if it is an HG connected to a Data Hiway with up to eight Data Hiway Ports. The PLCG is a fast, cost-effective interface to PLCs from several manufacturers.

Point Type—Data points that accomplish a specific type of function. Regulatory, Timer, Numeric, Switch, and Custom are examples of point types.

Preemption Point—The point where suspension of a sequence program occurs to allow another program to run.

Prefetch—When a data point requires data from a data point in another module or gateway, that data is fetched (read and transferred) before the destination point is processed, hence the term "prefetch."

Primary Data Point—A data point in a cascade-control strategy that supplies an input to a secondary data point. The secondary data point is the closer of the two to the process.

Primary Module—A Process Module data point that represents a collection of equipment that is, in turn, represented by a collection of data points. The Primary Module is assigned to a batch for the collection of batch history. Most data points have a parameter that can name a Primary Module, and all data points that name a specific Primary Module are assigned to it.

Process Special on a Data Point—A condition that causes immediate processing of the data point. A process special may be requested by an operator, a CL block, or event-initiated processing, or any other mechanism that can store a value in the Process Special (PPS) parameter.

Processing Cycle—AM data points can be assigned to a predefined processing cycle within their assigned processing interval.

Process Manager (PM)—A process-connected device on the UCN that provides regulatory control and sequence operations. The PM includes a powerful set of prebuilt data acquisition and control algorithms.

Process Module Data Point—(1) A platform for the execution of a sequence, or (2) a data point that represents a specific group of other data points that, in turn, represent a specific set of process equipment. Either (1) or (2) or both may apply. If (1) applies, the Process Module data point is assigned to a sequence slot in an MC.

Product Path—The selection of process modules used to make a batch.

PV Tracking—Without PV tracking, when an open cascade loop is closed, unintended control action can occur. To prevent this, optional PV tracking causes the setpoint to track the PV value when the cascade is open, so that when the cascade is again closed the initial SP value is the same as the PV.

Read—To request and receive data from a data point parameter. Sometimes "fetch" is also used in this sense.

Regulatory Control—Regulatory control uses a predefined set of control and auxiliary algorithms to maintain a continuous process variable at a desired value by manipulating an output. Regulatory data points in the HG and the AM accomplish regulatory control.

Residence—The box, module, or gateway where a data point resides.

Safety Manager (SM)—A process-connected device on the UCN that uses three redundant modules to provide emergency shutdown functions through digital/analog I/O points. It can share data with other UCN nodes but isolates process control operation from safety or emergency shutdown functions.

Self-Defining Enumeration—A parameter value that consists of an enumeration that is defined by the user. These self-defining enumerations are the character strings that appear on displays, reports, and logs to represent the state of flag, digital, and logical variables. For example, for a digital input point, a PV value of 1 might represent the running state of a motor, so the self-defined enumeration for that value might be "Running." Self-defined enumerations are configured by the user in the STATE1 and STATE2 parameters of applicable data points.

Secondary Data Point—A data point in a cascade-control strategy that receives at least one input from a primary data point. The secondary data point is the closer of the two to the process.

Sequence Program—A program for discontinuous control, bound to a Process Module data point, written in CL, and consisting of four major parts: Data Declarations, normal sequence, (made up of one or more phases), abnormal condition handlers (optional), and user-defined subroutines (optional).

Sequence Slot—A Multifunction Controller location into which Sequence Programs are loaded and executed. Each is represented by a Process Module data point.

Statement—One CL or SOPL instruction (line of code). A statement performs an elementary action.

Step—A milestone in a Phase that executes a minor process function such as opening a valve with associated checks and verification, or measuring a temperature. Steps are recognizable on Universal Station displays. They are identified in a sequence program by the CL STEP statement.

Store—To write a new value into a parameter.

Supervisor—Often, the supervisor of two or more process operators. One who has a key that can be inserted in the Universal Station's key switch to gain access to supervisor-accessible parameters. See subsection 2.4.

Supervisory Sequence-Program—A sequence program that can initiate, monitor, and control other sequence programs that work together to make a batch.

Tag Name—The name of a data point. Configured by the user in data point parameter NAME. Consists of up to eight characters, identifies the data point on displays, logs and reports, and is used by the system to identify the data point and to access data in it.

Uncertain (Value Status)—The PV source is MANual or SUBstituted, or if it is Auto, some input to the PV calculation is uncertain.

Universal Control Network (UCN)—The network that interconnects Process Managers. The Network Interface Module is an interface module between a UCN and the LCN.

Upper Level Processor (ULP)—A computer or other device that is connected to the LCN through a Computer Gateway.

Value—The value(s) stored in a parameter. Can be a real number, a logical value, a data-point (tag) name, a character string, or an enumeration.

Value Status—A parameter whose value represents the "quality" of the PV parameter in a data point. The quality is specified as Normal, Uncertain, or Bad.

Write—To replace the value in a parameter with a new value.

2.3 ACRONYMS

ACIDP—Advanced Control Interface Data Point

ACP—Advanced Control Program

AM—Application Module

A-MC—Advanced Multifunction Controller

APM—Advanced Process Manager

APMM—Advanced Process Manager Module

ARW—Anti-Reset Windup

BHDP—Batch History Data Point (may be used in future releases)

BHPDP—Batch History Prototype Data Point (may be used in future releases)

BPL—BICEPS Programming Language

CB—Basic Controller

CDS—Custom Data Segment

CG—Computer Gateway

CI—Control Inputs

CIU—Computer Interface Unit (applies only to releases 135 and earlier)

CL—Control Language

CL/C—Control Language for Continuous Data Points

CL/MC—Control Language for the Multifunction Controller

CM—Computing Module

CRDP—Calculated Results Data Points

CV—Control Value

DDC—Direct Digital Control

DHP—Data Hiway Port

EC—Extended Controller

EU—Engineering Units

EIP—Event Initiated Processing

GI—General inputs

GO—General Outputs

HG—Hiway Gateway

HM—History Module

HPM—High-Performance Process Manager

HPMM—High-Performance Process Manager Module

I/OP or I/OM—Input/Output Processor Module

LCN—Local Control Network

LM—Logic Manager

MC—Multifunction Controller

MMI—Man Machine Interface

NaN—Not a Number

NIM—Network Interface Module

OV—Output value

PF—Partial Failure

PIU—Process Interface Unit

PLCG—Programmable Logic Controller Gateway

PM—Process Manager

PMM—Process Manager Module

PPS—Process Special on a Data Point

PV—Process Variable

PVP—Process Variable in Percent

SHDN—Shutdown

SOPL—Sequence-Oriented Procedural Language

SM—Safety Manager

SP—Setpoint

SPC—Supervisory Control

UCN—Universal Control Network

ULP—Upper Level Processor

US—Universal Station

2.4 PARAMETER ACCESS LEVELS

Each user-accessible data point parameter is assigned an access level that indicates the tasks or activities that can store (write) new values into the parameter. The available levels are defined below. They are listed in order, from the least restricted to the most restricted.

Most tasks and activities can read from any data point parameter (except a few internal parameters that have no meaning to users). Specific instances where a task, such as a CL program, doesn't have access to a parameter are noted in the reference publications listed under subsection 1.1.

- **Operator**—Indicates a parameter whose value can be changed by operators, supervisors, or engineers at a Universal Station; by an engineer using the Data Entity Builder; or by user-written programs.
- **Supervisor**—Indicates a parameter that can be changed only by someone with a supervisor's or an engineer's key, through a Universal Station; by an engineer using the Data Entity Builder; or by user-written programs.
- **Engineer**—Indicates a parameter that can be changed only by someone with an engineer's key, through a Universal Station, by an engineer using the Data Entity Builder, or by a user-written program.
- **EngOrDEB**—Indicates a parameter that can be changed by the Data Entity Builder or by someone with an engineer's key.
- **DEB**—Indicates a configured parameter that can be changed only in point building, through the Data Entity Builder.
- **Program**—Indicates a parameter that can be changed only by a user-written program (a CL program in an AM or a program in a CM), or by continuous-control general-input, control-output, and general-output connections.
- **View**—Indicates a "view-only" or a "read-only" parameter that can't be changed by an operator, supervisor, engineer, or a user-written program, but can be read to be seen at Universal Stations and can be printed in a log or report.

Some parameters have more than one access level. Except for parameters in Custom Data Segments, the user cannot change parameter-access level. Custom Data Segment (CDS) parameter-access levels are defined when the CDS is configured. These levels are available:

- **Operator**
- **Supervisor**
- **Engineer**
- **Program**

2.5 PARAMETER VALUE TYPES

Each data point can store only one type of value. The types of values are as follows:

- **Boolean**—a value that has only two possible states, such as On and Off or 1 and 0.
- **Integer**—a whole number with no fraction and no decimal point.
- **Entity ID**—an entity identifier that names an entity. Entities consist of data points and reserved entities. The entity ID for a data point is the tag name. The entity ID for a reserved (system) entity is an eight-character string that begins with a dollar sign (\$).
- **Enumeration**—a predefined value stored in another, enumeration-defining parameter. Enumerations are character strings that represent variable states on displays and printed logs and reports. Both system-defined and user-defined enumerations are available. See "Enumeration Type" and "Self-Defining Enumerations" under subsection 2.2.
- **Real**—a real number that has an integer part and a decimal-fraction part, separated by a decimal point.
- **String**—a string of characters consisting of the the alphabet, numbers 0 through 9, the tilde (~), and underbar (_).

2.6 PARAMETER ARRAYS

While most parameters have only a single value, some have an array of several values. For example, in AMs, general-input source connections are defined in parameter GISRC(n). Because the data point that uses this parameter can have up to eight general inputs, "(n)" in this example indicates that the parameter has an array of values, one for each of the inputs. In this case "n" represents an integer that names one of the eight values. In some documentation, "(n)" is written as "(1 . . . 8)," where the integers represent the first and last values in the array. The "n" value is often referred to as an "index."

OVERALL SYSTEM DESCRIPTION

Section 3

This section provides an overview of the data acquisition and control subsystem.

*The **TotalPlant** Solution (TPS) System LCN-based data acquisition and control subsystem integrates data acquisition, regulatory control, discontinuous control, and logic functions into a uniform, distributed system. These functions are distributed throughout the various modules, gateways, and boxes of the system in a way that allows the construction of hierarchical control systems, provides graceful degradation under failure conditions, and allows partitioning of the control system into unit operations, thereby simplifying control of the plant and process.*

3.1 DATA POINT

The basic element to which control functions are applied is the data point. A data point, identified by a tag name, is a named-collection of data values called parameters that are accessible by point name and parameter name, and to which specific sets of functions are assigned, for example:

Data Point (Tag) Name	Function
TT1200	Data Acquisition
FC248	Control

The main elements of a data point are these:

Tag Name
Parameters
Functions

The parameters in a data point can consist of input data (flow, temperature), tuning constants (gain, integral time, recipe data), output data (valve output, alarm state), etc. All, or a subset of, point parameters are accessible to other points or subsystems through a data-access mechanism.

The set of functions defines the operation of a data point. Functions can be selected from a set of preprogrammed algorithms, user-written algorithms, or user-defined procedures (sequences).

In addition to algorithms, AMs, HPMs, APMs, and PMs include other predefined functions such as PV processing, setpoint handling, output limiting, and alarming. These functions are processed in a predefined order. Process-connected boxes on Data Hiways have similar functions, but they occur as each point (slot) is processed and appear to the user as slot functions rather than as distinct functions.

In AMs, insertion points are provided between function blocks for the entry of short user-written routines, called CL blocks, that provide customized functions. You can also write your own AM algorithms in Honeywell's Control Language (CL).

If a point is to control a discontinuous process, a user-written sequence is considered to be the point's function. Sequences are written as CL/MC programs, which run in Multifunction Controllers (MCs) on Data Hiways.

The internal structure of a data point varies according to its assigned functions and its residence; however, the main elements, the tag name, the parameters, and the functions, remain.

To facilitate functions like point building, and point displays, data points are categorized according to their principal functions. For example:

- Analog Input Points
- Digital Output Points
- Counter Points
- Timer Points
- Regulatory Points

Each Process Manager/NIM data point is associated with a conceptual "slot" in the devices' Process Manager Module* (APMM, HPMM, etc.), and each slot's input and output connections to the process are made through the I/O Processor Modules (I/OMs).

To the user, the slot and subslot concept used in the process-connected boxes on the Data Hiway is generally the same as the data point concept used in LCN-based modules and gateways. The slots and subslots are represented by data points that reside in the HG, and are sometimes referred to as if the slot or subslot were the data point.

The type of module or gateway that a data point resides in may affect the set of functions that can be performed by that point. For example, a control point residing in an AM has a larger selection of alarm functions than a similar control point that resides in an HG that is representing a slot in a Basic Controller. Usually, the set of functions of a given type of data point in an AM is larger than the set of functions for the same type of point in a process-connected box on the Data Hiway.

Entering a data point into the TPS System is accomplished by using the Data Entity Builder, as described in the *Data Entity Builder Manual*. The initial information required by the builder is the point name (tag), the point type, and the point's residence. The Data Entity Builder presents the user sets of questions based on this initial information, and these questions must be answered in order to completely define a point.

*Hereafter, any reference to a Process Manager includes the HPM, APM, or PM, unless otherwise specified.

3.2 THE UNIT CONCEPT

A process or plant is generally partitioned into a number of process units that are assigned to specific operators. The TPS System supports the unit-partitioning concept by providing several unit-operation functions such as alarm reporting, alarm suppression, and message handling. Messages and alarm reports are directed to the responsible operator based on unit assignments. Unit partitioning requires that a point is assigned to only one unit. Units named by a unit ID (configured in Network Configuration, Unit Names) cannot be in more than one module (node) (you could have parts of a physical process unit represented by more than one named unit in more than one node), but points of a unit can be assigned partially to a module and partially to a lower-level box (CM, EC, MC, PIU, etc.).* Some functional enhancements apply to points within the same named unit in an AM, such as synchronized scheduling and propagation of initialization information. These are described under specific topics in subsection 3.3, *Formation of Strategies*, in this publication.

3.2.1 Unit Operations

Unit-based operations are limited to:

- Alarm reporting
- Alarm suppression
- Event reporting

Specifically, alarms and events are reported and can be retrieved from the system on a unit basis. Alarm suppression, which consists of alarm enabling, disabling, and inhibiting, can be accomplished through the Unit Assignment display on a unit basis. Alarms can be suppressed on a per-point basis through the ALENBST parameter on the point's Detail display.

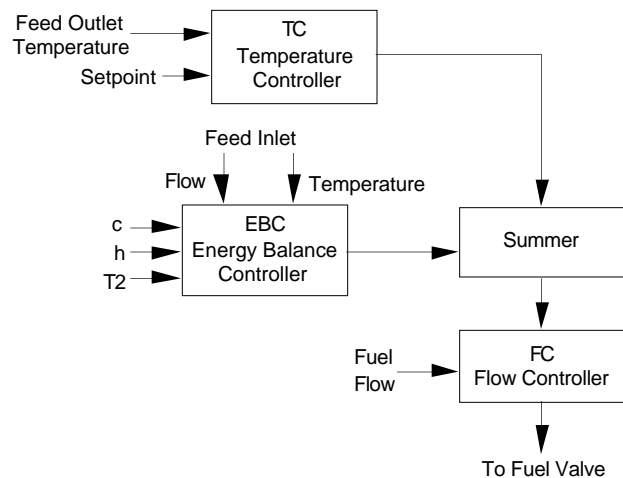
3.3 FORMATION OF STRATEGIES

Many processes require more complex control than one data point can provide; therefore, mechanisms are provided that allow the formation of complex strategies from simple data points.

*The Hiway Gateway provides an alias-point function that allows identical data points to be built, using the same slot or subslot in a box, but with different unit assignments. This allows alarms for such points to be generated for more than one unit.

3.3.1 Formation of Strategies Using Regulatory Data Points

A regulatory-control strategy that uses several data points should operate as a single, cohesive strategy, using the latest possible data. It should be undisturbed if mode changes occur, and primary points should not saturate if the path to the final control element (valve) is broken. Information on the current state of the strategy should be readily available to the operator. This sketch presents such a strategy.



To operate properly, the following requirements must be met:

- Each of the four data points needs access to the data in all other points.
- So that the points can operate on the most recent data, a processing order should be established. TC and EBC should be processed before Summer, and FC should be processed after Summer.
- To prevent windup, TC must know when the path to the valve is broken.
- TC must be initialized when EBC is introduced into the strategy and when Summer or FC are returned to Cascade mode from some other mode.

To achieve these requirements, these mechanisms are provided in the data acquisition and control subsystem:

- Point-parameter access
- Point scheduling
- Initialization
- Anti-Reset Windup (ARW)

These mechanisms meet the requirements for points in a single module. Control strategies may, however, be required to span across modules, gateways, the Process Managers, and boxes. For example, you might configure the control system so that all the points reside in a single AM, or that the TC and Summer reside in one module, the EBC in a another module, and the FC in a PM slot or in a box on a Data Hiway.

Synchronization of point processing in LCN-based modules, and in PM and process-connected boxes is not provided. Initialization and Anti-Reset Windup functions are designed to allow for connections of unsynchronized points; however, some functional restraints result. Initialization is discussed under subsection 3.3.1.3 and Anti-Reset Windup is discussed under subsection 3.3.1.5.

3.3.1.1 Point Parameter Access

Two mechanisms are provided for parameter access:

- Point-Interconnection Configuration
- CL Access

3.3.1.1.1 Configuration of Point Interconnections

Interconnections between data points are paths over which data is transferred to and from specific parameters in named data points. The interconnections between data points are specified in the configuration forms and when the configuration information is entered through the Data Entity Builder.

How the interconnections are Defined

For AM and Process Manager type points, the connections are defined by naming a point and a parameter in that point, in this form; TagName.Parameter. AM Regulatory and Counter points can have several types of input and output connections (see subsection 3.1.4 in *AM Control Functions*). PM points have one type of input connection and one type of output connection (for more information refer to the appropriate device Control Functions and Algorithms manual).

For HG points, the connections are defined in two of this point's parameters. One of these two parameters defines which parameter in the other point is to be accessed. The second of these two parameters defines the tag name of the other point.

Initializable Connections

For AM and Process Manager type points, control-output connections store data in input-variable parameters in another point and are initializable connections. That is, initialization values can be passed from secondary points to their primary points, to be used in establishing values to be provided over the control-output connections. An example of an initializable input acquired through a control-output connection is a setpoint (SP) for a point in a cascade connection. Typically, the value in the primary point's output (OP) is transferred to SP in the secondary.

Initialization information passes between HG points and between HG points and AM points in a similar manner. Here, initializable connections are not determined by a connection type, however, but by the function of the connection. Generally, a configured SP (setpoint) input for a process-connected box, which receives the OP (output) from its primary point, forms an initialization path. Where the SP of an HG point is to participate in initialization with an AM, the AM point must have a control-output connection to an appropriate destination parameter (usually SP) in the HG point.

3.3.1.1.2 CL Access

CL Access is built into the Control Language (CL) and is used in CL blocks and sequences. Control Language executing in the AM provides direct access to parameters of all process data-points in the system. Some access restrictions are enforced. For details refer to Section 4 in the *AM Control Functions* manual.

3.3.1.2 Processing Schedules

Application Modules

In AMs, processing schedules are configured, so they allow you to determine point-processing rates and order. Through judicious assignments of processing rates and order, good use of the AMs' resources can be attained. (For more information, refer to subsection 2.2.1 in the *AM Control Functions* manual)

Process Managers

Process Manager type points are related to slots in the PM and the slots are processed by a point-processing executive that runs four times (cycles) per second. The slots are configured on cycles and those on the same cycle are assigned an order within the cycle that is determined by the slot type (regulatory PV, process module, logic, digital composite, and regulatory control). (For more information, refer to the appropriate Control Functions and Algorithms manual).

Hiway Gateways

HG data points are not assigned to processing schedules—the associated slots and subslots are processed on fixed, slot-processing schedules in each box type, as follows:

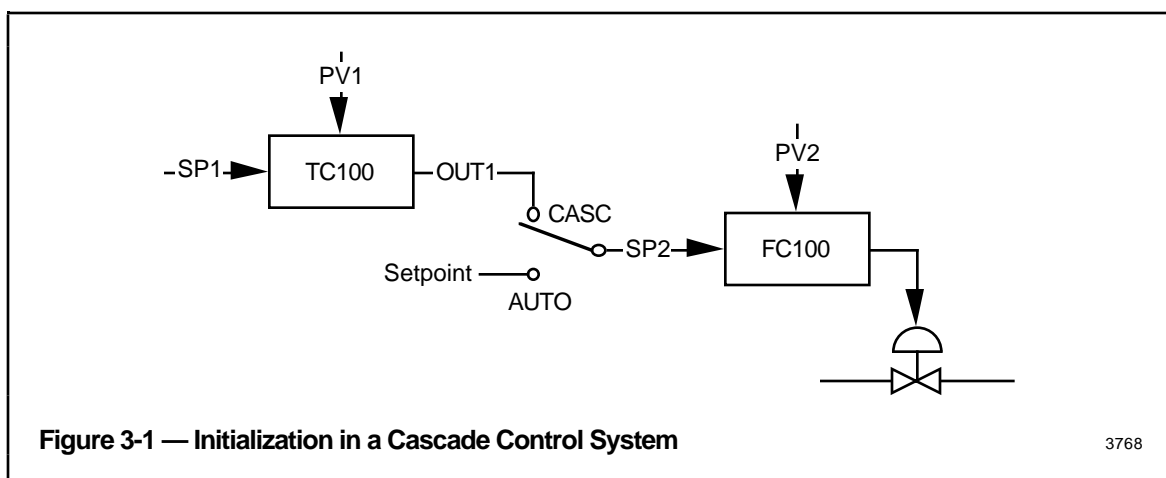
- Basic Controller (CB)—every one-third second, in descending slot-number order.
- Multifunction Controller (MC)—every second. A scheduling algorithm determines the slot-processing order.
- Extended Controller (EC)—every one-half second. A scheduling algorithm determines the slot-processing order.
- Process Interface Units (PIUs)—depends on the PIU type and the slot type. Often from 60 to 250 points per second.
- DHPs—depends on the configured scan interval, which can be free-running or from one to 15 seconds.

3.3.1.3 Initialization for Regulatory Data Points

Initialization assures "bumpless" outputs of final control variables during mode changes and strategy changes. This is accomplished by computing and adjusting initial conditions of data points in a way that doesn't disturb the final control variables.

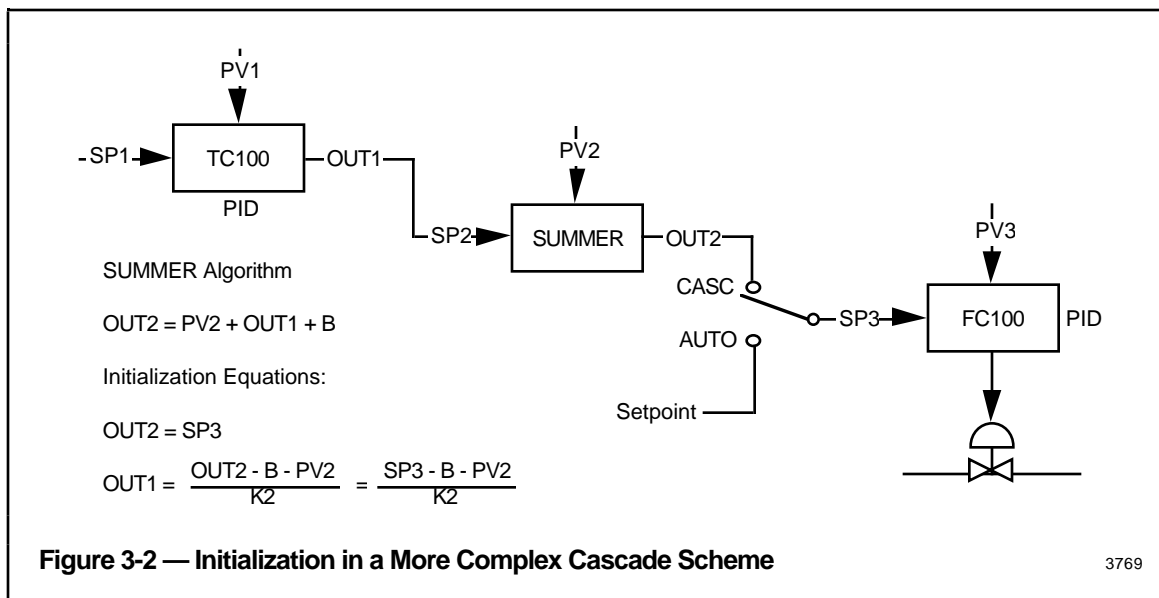
Initialization takes place when initializable connections are broken, when there is no path to the control element in the process (the valve), when a data point is switched in or out of a control strategy, and on demand. Initialization produces a calculated initialization value and, when so configured, requests the appropriate primary point to initialize using that value.

For example, in a cascade system like that shown in Figure 3-1, the output of the primary controller, TC100, must be set to the setpoint of the secondary controller, FC100, before the cascade can be closed.



A somewhat more complex initialization needs to be accomplished in a cascade system like the one shown in Figure 3-2.

In both examples the primary controller's output has been initialized because a PID controller can accept a new output value without affecting its dynamic operation. Summer, Multiplier, and other computational algorithms do not have floating output; however, for such algorithms in AMs, the bias (B) can be configured to absorb the bump.



Application Modules

In AMs, three initialization possibilities exist (parameter INITTYPE):

- No Initialization
- Internal Initialization
- External Initialization

When an AM regulatory data point is configured for no initialization, requests for initialization are ignored by the point. Internal initialization causes the point to adjust its initial condition parameter or B. External initialization causes the point to back-calculate one of its inputs and request initialization from the primary connected to that input. Most algorithms have one of their inputs dedicated for this purpose. That particular input is called the initializable input. To accomplish initialization, an output connection must be used to make the connection.

Process Managers

Initialization for Process Manager type regulatory data points is the same as for AM points except that there is no INITTYPE parameter, and only external initialization is used. If a secondary point is to participate in initialization, a control-output connection is configured from the primary point. If initialization is not desired for a point, its input is acquired over a control-input connection.

Hiway Gateways

Most HG-regulatory data points (each represents a slot or subslot in a process-connected box) can be configured for initialization or no initialization (parameter INITCONF). A few of the algorithms don't participate in initialization.

When initialization is configured for such HG points, a secondary point requests its primary point to initialize when the secondary is taken out of the cascade strategy. Then, when the secondary is again switched into the strategy (goes to CAS mode), the initial value from the primary does not cause a process "bump." A secondary that is in CAS mode passes any initialization request it receives from its own secondary, on to its primary, regardless of configuration.

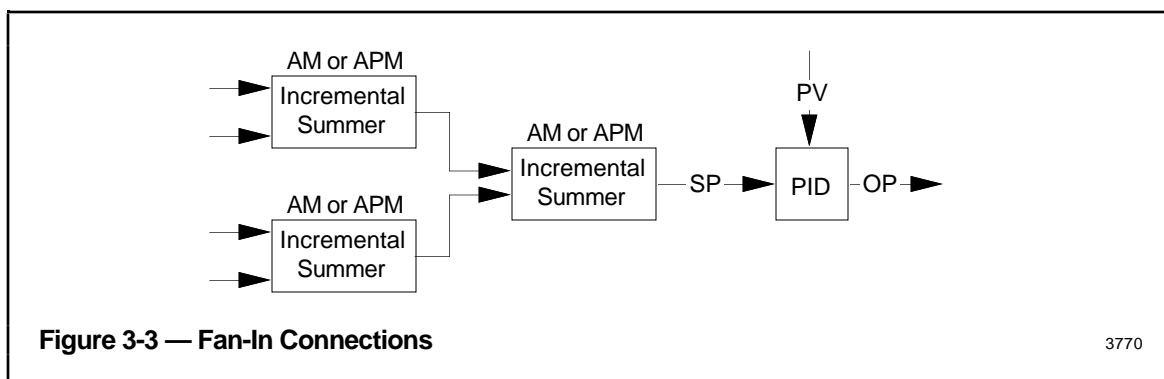
3.3.1.3.1 Cross-Unit/Hiway Connections

Initializable AM data points participating in the same strategy should all be assigned to the same module.

All strategies, however, require at least one connection to a point outside the AM that drives the final control element (valve) (a Process Manager type slot or a process-connected controller on the Data Hiway). Because the AM points and the processing in the Process Manager or box are not synchronized, the initialization functions are affected. This has an effect on what the operator sees, because mode changes in strategies that extend beyond the AM are not instantly propagated throughout the strategy. Propagation of mode changes starts when the point with the output connection to the process-connected controller is processed. The control aspect of initialization is not affected.

3.3.1.4 Fan-In and Fan-Out Connections

"Fan-in" connections are two or more inputs that supply a value to a single parameter in a data point. It is possible for several devices with incremental outputs to output to a single parameter, but all outputs in the TPS System are full-value outputs, so direct fan-in connections are not possible. Fan-in connections in AMs and Process Managers can be made through one or more incremental-summer data points, as shown on Figure 3-3. The Incremental Summer algorithm adds all of the full-value inputs, and thus results in a single full-value input to the destination data point and parameter. Incremental Summer algorithms are available in AMs, the various Process Managers, and ECs, but fan-out connections can be configured for only AM and Process Manager type data points, not for HG points.



"Fan-out" connections consist of several connections from one parameter in an AM data point to several other parameters in one or more AM data points. Fan-out connections from one PM point to another PM point are also possible.

3.3.1.5 Anti-Reset Windup (ARW)

The Anti-Reset Windup function prevents reset windup in primary points that use PID control algorithms, by inhibiting integral action in a direction that cannot be reflected at the ultimate output because of output or setpoint limits. Points in a cascade chain compute the value for a windup-status parameter that indicates if the primary should have integral limiting, and if so, the direction of the limiting. The computed value of the windup status is based on output- and setpoint-limit violations and their relationship to input changes on the initializable input. Changes in windup status initiate propagation and recalculation of the status at each of the primary points. Propagation of windup status is along the initializable path, up through a cascade strategy, and occurs immediately after the detection of its change.

3.3.2 Alarming

Most data points detect several types of alarm conditions and initiate annunciation of the alarms and the display of alarm messages at the Universal Stations assigned to the process unit that the point belongs to. Specific alarm actions depend on the configured priority, and alarms can be inhibited on a unit or point basis. An alarm-cutout (contact-cutout) function is also available.

Alarm priority assignments allow important alarms to be brought to, and held for, the operator's attention, while alarms of lower priorities are routinely handled, and alarms of the lowest priority are merely recorded and printed. The alarm priorities are:

- Emergency
- High
- Low
- Journal Print
- Journal
- Printer
- No Action

The operator can disable or inhibit alarms to suppress nuisance alarms, such as alarms that may occur during startup or shutdown, or alarms that are secondary to some primary alarms condition that must receive attention first. The alarm-cutout feature is very useful in suppressing such secondary alarms.

For additional information on alarms, see subsection 4.3, *Alarming*.

3.3.3 Events

Event-handling functions report events (such as a change of state somewhere in the process) to the Universal Stations, to journals in History Modules, and to initiate special processing in an AM or a CM. The latter function is referred to as "event-initiated processing" or EIP. Events can occur almost anywhere in the TPS System or in the process. Additional EIP information is under subsection 4.2, *Event Initiated Processing*.

3.3.4 Sequences of Events

The sequence of events (SOE) function provides a high-resolution history of changes-of-states of digital inputs. The events are recorded on an HM and can be displayed or printed through the Event History Retrieval display in the Operator Personality. Each event is tagged with the time it occurred and is sent to an SOE file on the HM.

Process Manager digital input points are configured for SOE time tagging by entering Soe or EipSoe in the EVTOPT parameters. High-Performance Process Managers and Advanced Process Managers have a unique SOE digital input point.

SOEs from a Data Hiway are available only from HL PIUs with the SOE option and appropriate digital input cards. Such points must not be configured for critical alarm scanning (CRITSCAN = ON) because critical alarm scanning alters the time stamp value.

3.3.5 Messages

Operator messages, system messages, and operator comments are available. Operator messages are generated by sequence program in MCs and are displayed in the Message Summary Display. System messages and operator comments are part of the collection of event history.

3.3.6 History Collection

The system can be configured to collect history of process variables, events, and batch data. Process variable history is collected by History Modules and batch history is collected by Application Modules. Additional information about continuous history functions is under subsection 7.4, *Continuous History Configuration*, in the *Engineer's Reference Manual* in the *Implementation/Startup and Reconfiguration* binder.

3.3.7 Advanced Functions

The TPS System provides a number of functions that augment and enhance the control functions. All advanced functions reside in AMs and CMs. These functions include:

- CL blocks and insertion points (Section 4 in *AM Control Functions*)
- CL Switches (see subsection 4.1.5 in *AM Control Functions*)
- Custom Data Segments (see subsection 4.4 in the *Control Language/Application Module Reference Manual*, and refer to the Index in the appropriate *Computer Gateway* or *Computing Module 60 User Manual*.)
- Advanced Control Programs (see the appropriate *Computer Gateway* or *Computing Module User Manual*.)

3.3.7.1 CL Blocks and Insertion Points

The processing of an AM-Regulatory data point is accomplished by processing a number of function blocks in a predetermined order. See subsection 3.1.3 in *Application Module Control Functions*. An insertion point is provided after several of these blocks. You can insert custom routines (CL blocks) at each of these points, and customize the standard control functions.

The objective here is to allow you to modify the standard functions but still take advantage of such complex system functions as initialization, Anti-Reset Windup, range checking, and alarming. Such modifications are generally limited to the modification of existing standard parameters and don't modify standard functions.

CL blocks can be unconditionally processed every time the data point is processed, or under conditions specified by the user.

A CL block can store (write) data in most parameters in the data point it is bound (linked) to and in parameters in other data points, subject to standard control subsystem constraints, which are explained in Section 4 of *Application Module Control Functions*.

3.3.7.2 Custom Data Segments

Custom data segments (CDSs) are user-defined, named segments, consisting of named parameters that are attached to a data point. CDSs allow the user to define custom parameters for an AM data point, or an ACIDP or CRDP (see subsection 3.3.7.4).

For more CDS information, refer to subsection 4.4 in the *CL Reference Manual*.

3.3.7.3 CL Switches

CL Switches are entities that contain several predefined parameters that are used in conjunction with CL Blocks for strategy switching. The two main parameters of the CL Switch are current state and requested state. By writing CL Blocks that are executed when specific values of the requested state parameter are true (e.g., mode, activity status, tuning parameters, etc.) a control strategy can be automatically switched. CL switches are actually predefined custom data segments that can be configured to be attached to an AM data point, and their state can be changed by writing into the requested state parameter. Custom data segments are used in conjunction with CL blocks, CL switches, and CL PV or control algorithms.

For more CL Switch information, refer to subsection 4.2 in *Application Module Control Functions*.

3.3.7.4 Advanced Control Programs

Advanced Control Programs (ACPs) are custom programs, written in FORTRAN or Pascal by the user, or they may be application packages supplied by Honeywell. ACPs are executed in Upper Level Processors (ULPs) connected to Computer Gateways. They have access to the general file system in the ULP and they can acquire data from any data point parameter in the system. ACPs' ability to store values in data point parameters is restricted by mode selection, and ACP scheduling is controlled through Advanced Control Interface Data Points (ACIDPs).

Custom data segments can be assigned to ACIDPs and CRDPs to facilitate operator communications (for more information, refer to subsection 4.4 in the *Control Language/Application Module Reference Manual*, and refer to the index in the appropriate *Computer Gateway* or *Computing Module User Manual*).

3.3.8 Data Hiway Control States

The Hiway Status Display in the Universal Station's operator personality is used to select one of the following four hiway-control states:

- Basic Control
- Read Control
- Full Control
- Test

A similar but lower control level is available for each hiway box (box control) through the Box Status Display. The Hiway control level can simultaneously change the state of all hiway boxes when full control is selected at the box level.

3.3.8.1 Full Control

This is the normal control state. In this state, LCN-based modules and gateways can change parameter values in the process-connected boxes, including MODE, SP, and OP. This state is selected when there is reason to believe that all modules and gateways, including the HG, that are configured to participate in control with the boxes, are properly operating.

When a Data Hiway is in the Full Control state, one of the following types of controls may be in effect:

- Supervisory Control (SPC)
- Direct Digital Control (DDC)

In Supervisory Control (SPC), an LCN-based module provides the setpoint to a data point in a process-connected box. The data point (slot) in the box has a control function that is dependent on the setpoint from the module.

Process-connected points used in SPC control have a time-out feature that switches the point into a configured mode (usually BCAs, see Section 4) when the setpoint has not been updated for a period greater than the time-out period.

Supervisory Control applies only to regulatory points in process-connected boxes. Through mode changes the operator can request SPC control and can remove a point from SPC control.

In direct-digital control, an LCN-based module produces the output to the final control element and a regulatory data point or an analog output data point in a process-connected box provides a holding amplifier that actually applies the 4-20 mA output to the final control element (valve).

The process-connected point backs up the module, should the module's output become unavailable. A time-out function is provided for DDC points in process-connected boxes that switches the point to the configured mode (usually BCas, see Section 4) when the output from the module has not been updated before the time-out period expires.

The operator at a Universal Station can use DDC or the backup mode by changing the mode of the process-connected data point.

If the box control state changes from Full to Basic, Read, or Test, and if supported by the algorithm, for all points in that box that are in the Cas mode (MODE = Cas), the mode changes to the **shed** mode (the mode represented by the value in parameter SHEDMODE).

NOTE

Points cannot be loaded to a box that is in Full Control. The box must be put in Basic Control, to be loaded. Then it can be returned to Full control.

3.3.8.2 Basic Control

This state might be selected if it is known that LCN-based modules or gateways are not available to participate in the control strategies, or if there is doubt that they are operating properly. In this state, control can independently operate in the process-connected boxes on the hiway, if they are so configured; LCN-based modules and gateways can read parameter values from the process-connected boxes on the hiway but cannot change values in those parameters.

There is one exception: if a box is assigned for control from a 4500 or 45000 process computer (PMC or PMX System, for more information, refer to Section 4 in *Hiway Gateway Implementation Guidelines* in the *Implementation/Hiway Gateway - 1* binder), an operator at a US can change the MODE parameter of a point in that box to Cas [this allows control directly from the PMC or PMX System while automatic control from the LCN (AMs) is still prohibited because the box is not in the Full control state].

Process-connected boxes that have failed are placed in the Basic control state to ensure that the operator reconnects automatic control after the failure.

3.3.8.3 Read Control

The Read control state is provided as a separate box state, but is functionally equivalent to Basic control.

NOTE

To support calibration and loop tuning from an AM, when the hiway-control state is Full or Read but the box-control state is Read, if the BOXASSN parameter for the box contains H4500 (for more information, refer to Section 4 in *Hiway Gateway Implementation Guidelines*), a discontinuous program in an AM can read from and write to parameters in a process-connected box.

3.3.8.4 US Access to Process-Connected Boxes (Test Mode)

Universal Stations on the LCN can read and change parameter values in process-connected boxes on the hiway in the Full, Basic, or Read modes. In the Test mode, only the SMCC/Maintenance activity in the Universal Station's Engineering Personality can communicate with the Data Hiway.

3.3.9 Restarting Control

Restarting is restoring the AM, HG, or NIM databases, as applicable, and reestablishing control from the LCN, after one or more of these modules or gateways has been out of service.

3.3.9.1 AM Restarts

A copy (checkpoint) of each AM's database must be available. In systems with an HM, module and gateway databases are periodically stored for use in restarting. This is called "checkpointing." In systems with no HM, the user must maintain a copy of the AM data base on one or more cartridges or floppy diskettes. Process-connected points operating as SPC- or DDC-types go to a backup mode when the setpoint or output supplied to them from the LCN is not updated. Because SPC and DDC points have generally switched to their backup mode, control over these points from the LCN must also be reestablished as part of the restart procedure. Depending on the desired control class to be established after a restart, and the length of downtime, the operator or engineer can select one of three types of restart procedures (see subsection 2.7 in *Application Module Control Functions*):

- Cold Restart
- Fast Restart
- Warm Restart
- No Point Processing

3.3.9.2 NIM and HG Restarts

An NIM or HG is restarted by reloading its checkpointed database from an HM or by reloading it from removable media. Cold, warm, and fast restarts (see subsection 3.3.9.1) don't directly apply to NIMs or HGs, but of course, if the module has been out of service and not backed up, a similar procedure must be applied to get the process-connected devices (Process Manager devices, LMs, or hiway boxes) back in control, with the UCN or Data Hiway in the Full Control state (see subsection 3.3.8.1).

3.3.10 Redundancy

Backup techniques provide virtually uninterrupted automatic control, should a module, gateway, or box go out of service.

3.3.10.1 NIM or HG Redundancy

Each NIM and HG is intended to use a one-on-one backup technique. Each NIM or HG is backed up by another NIM or HG and the database in the inactive one tracks that of the active NIM or HG. Transfer from a primary NIM or HG to its backup ("failover") occurs in five seconds or less.

3.3.10.2 Process Manager and Logic Manager Redundancy

In Process Manager devices, the Process Manager Modules (PMMs, APMMs, or HPMMs) can be configured as redundant pairs, as can High Level Analog Input I/O Processors and Analog Output I/O Processors (for more information, refer to the appropriate Process Manager Implementation Guidelines manual).

Logic Managers can also be configured as redundant pairs where one LM operates as an on-line primary and its partner backs it up (for more information, refer to *Logic Manager Implementation Guidelines* in the *Implementation/Logic Manager* binder).

3.3.10.3 Backup of Process-Connected Boxes on Data Hiways

The Uninterrupted Automatic Control (UAC) Subsystem is available to back up Basic Controllers, Multifunction Controllers, and Extended Controllers.

DETAILED FUNCTIONAL DESCRIPTION Section 4

This section provides a detailed description of the data-acquisition and control functions that are independent of the modules or gateways (nodes) that participate in these functions.

NOTE

The information in this section applies to data points in Application Modules, the various Process Manager devices, PLCGs, and boxes on Data Hiways. Information in this section that applies to HGs, Data Hiways, and DHPs also applies to PLCGs. For similar information on the Safety Manager and Logic Manager, refer to the appropriate Control Functions manuals.

Table 4-1 lists the types of data points available in Application Modules, Process Manager devices*, and process-connected boxes on Data Hiways. The center column in this table provides references to the publications where each point type is described in detail. These references indicate the appropriate paragraph number in the following publications:

- HPM *High-Performance Process Manager Control Functions and Algorithms*
- APM *Advanced Process Manager Control Functions and Algorithms*
- PM *Process Manager Control Functions and Algorithms*
- HG *HG Control Functions*
- PLCG *PLCG Control Functions*
- AM *AM Control Functions*

Advanced Control Interface Data Points (ACIDPs) and Calculated Results Data Points (CRDPS) are defined in the *Computer Gateway* or *Computing Module User Manuals* in the following binders:

- *Implementation/Computer Gateway*
- *Implementation/CM50S*

Table 4-2 indicates the modules and boxes each point type resides in.

Table 4-3 indicates where algorithms for regulatory data points can reside.

*Except where otherwise noted, in this manual the term Process Manager refers to any of the three Process Manager type devices: PM, APM, or HPM.

4.1 ENGINEERING-UNITS HANDLING

Nearly all parameters that contain analog values contain real (floating point) numbers in engineering units (EUs). For the following parameters, both engineering-units values and values as a percentage of EU range are available:

- PV of an analog input point
- PV of a regulatory data point
- PV of counter data point
- PV of numeric data point
- Initializable inputs of a regulatory data point
- Output of a regulatory data point
- Accumulation value (AV) of an AM counter point

4.1.1 EU-Range and Percentage-of-Range Conversion

You configure the EU range for each regulatory data point in the following two parameters:

- xxEULO = engineering unit value corresponding to 0% of range
- xxEUHI = engineering unit value corresponding to 100% of range

where xx means PV, SP, X, or CV.

For HG points, you can configure a cross-over of EU limits; that is, xxEULO can be higher than xxEUHI, if necessary.

The value as a percentage of range is converted as follows:

$$\% \text{ Value} = \frac{\text{EU Value} - \text{xxEULO}}{\text{xxEUHI} - \text{xxEULO}} * 100.0$$

and, a percentage-of-range value can be converted to EUs as:

$$\text{EU Value} = \frac{\% \text{ Value} * (\text{xxEUHI} - \text{xxEULO})}{100.0} + \text{xxEULO}$$

4.1.2 Range Extension

An extension can be added to the high and low EU limits, and the PV is considered good if it is within the range plus the extension. A PV outside the range plus extension is considered bad, unless the clamping option is selected.

For data points in AMs and Process Manager devices, you can configure a PV range extension of any size. OPs have a fixed extension range of +6.9% and -6.9%.

The values of parameters related to PV and OP (limits, alarms) are limited to their respective range extensions.

Table 4-1 — Data Point Types

Point Type	Refer to Paragraph No.	Description
Advanced Control Interface Calculated Results D.P.	(See CG or CM User Manual)	Interface to ULP programs
Analog Input	HG, PLCG, 3.1 PM, APM, or HPM, 2.2	Process-connected input
Analog Output	HG, 3.1, PLCG, 3.1 PM, APM, or HPM, 2.4	Single process-connected output
Analog I/O Composite	HG, 3.1	One analog input and one analog output
Array	APM or HPM, Section 10 (N/A for PM)	Reference to arrays of APM/HPM box variables or serial input data.
Box/Slot Data Point	HG, 3.10; PLCG, 3.4	Contains box and slot parameters
CL Switch	AM, 3.7	Supports CL strategy switching
Counter	HG, 3.4; PLCG, 3.3 AM, 3.3	Accepts counter inputs from DHP, MC, and PIUs
Custom	AM, 3.6	Supports Custom Data Segments
Device Control Point	APM or HPM, Section 11 (N/A for PM)	Typically for motor control strategies.
Digital Input	HG, PLCG, 3.2 PM, APM, or HPM, 2.5	One or two process-connected Boolean inputs
Digital Output	HG, PLCG, 3.2 PM, APM, or HPM, 2.6	One or two process-connected Boolean outputs
Digital I/O Composite	HG, 3.2 PM, APM, or HPM, Section 4	Up to two Boolean inputs and two Boolean outputs
Flag	HG, 3.6 PM, APM, or HPM, 9.2	Boolean variable
Logic Block	HG, 3.9	Multiple Boolean outputs
Logic	PM, Section 5 APM, or HPM, Section 9	Logical functions in APM
Node Specific	Sec. 4 of <i>PM Implementation Guidelines</i>	Defines APM and ALM internal configuration and functions.
Numeric	HG, 3.7 AM, 3.2; PM, Section 5 APM, or HPM, Section 9.3	Numeric variable
Processor Status	Sec. 22 of <i>Engr. Ref. Man.</i>	Contains performance and memory-use information
Process Module	HG, 3.8 PM, APM, or HPM, Section 6	Basis for sequence execution
Regulatory	HG, 3.3 AM, 3	OP controlled per SP
Regulatory PV	PM, APM, or HPM, Section 7	PV processing for PM, APM, HPM slots
Regulatory Control	PM, APM, or HPM, Section 8	OP controlled per SP for PM, APM, HPM slots
Serial Device Interface	PM, APM, HPM, Section 2	Serial I/O
Serial Interface	APM/HPM, Section 2 and 10 (N/A for PM)	Serial I/O Array Point
Time	APM/HPM, Section 9 (N/A for PM)	Stores date/time data
Timer	HG, 3.5 AM, 3.5 PM, APM, or HPM, Section 9	Timing functions
UCN Node	Sec. 4 of PM, APM, or HPM - <i>Implementation Guidelines</i>	Defines NIMs, PMs, APMs, HPMs, and SMs on a UCN

Table 4-2 — Data Point Residences

<p>Application Module</p> <ul style="list-style-type: none"> Counter Custom Flag Numeric Regulatory Switch Timer Processor Status
<p>Process Managers (PM/APM/HPM)</p> <ul style="list-style-type: none"> Analog Input Analog Output Array (APM/HPM only) Counter (Digital Input with accumulation) Device Control (APM/HPM only) Digital Composite Digital Input Digital Output Logic Slot Numeric Process Module Regulatory PV Regulatory Control Serial Interface (APM only) Time (APM only) Timer
<p>Basic Controller*</p> <ul style="list-style-type: none"> Analog Input Regulatory Box/Slot
<p>Computer Gateway</p> <ul style="list-style-type: none"> Advanced Control Interface Calculated Results Processor Status
<p>Data Hiway Port*</p> <ul style="list-style-type: none"> Analog Input Analog Output Counter Digital Input Digital Output Timer Box/Slot
<p>*These are actually HG points that use resources in these process-connected boxes.</p>

(Continued)

Table 4-2 — Data Point Residences (Continued)

<p>Extended Controller*</p> <p>Regulatory Digital Input Box/Slot</p>
<p>Multifunction Controller*</p> <p>Analog Input Analog Output Counter Digital Input Digital Output Flag Logic Block Process Module Numeric Regulatory Timer Box/Slot</p>
<p>Process Interface Unit*</p> <p>Analog Input Analog Output (HLPIU) Counter (HLPIU) Digital Input (HLPIU) Digital Output (HLPIU) Control Counter (HLPIU) Box/Slot</p>
<p>*These are actually HG points that use resources in these process-connected boxes.</p>

Table 4-3 — Algorithm Residences

Algorithm Type	NIM/PMs	CB	MC	EC	AM
PIDs	Yes	Yes	Yes	Yes	Yes
Arithmetic					
Summer	Yes ⁵	Yes	Yes	Yes	Yes
Multiplier	Part ⁴	Yes	Yes	Yes	Yes
Calculator	Yes	No	No	No	No
Divider	Part ⁴	Yes	Yes	Yes	Yes
Square Root Extraction	No ⁶	Yes	Yes	Yes	No
Selectors	Yes	Yes	Yes	Yes	Yes
Dead Time	Yes	No	No	Yes	Yes
Lead/Lag	Yes	No	No	Yes	Yes
Flow Compensation	Yes	No	No	Yes	Yes
Switch	Yes	Yes	Yes	Yes	Yes
Logic	No ³	No	Yes ¹	Yes	No
Characterization	Yes	No	No	Yes	Yes
Auto-Manual Station	Yes	Yes	Yes	Yes	Yes
Data Acquisition	Yes	Yes	Yes	Yes	Yes
Override Selector	Yes	Yes	Yes	Yes	Yes
Position Proportional Cont.	Yes	No	No	No	No
Position Proportional PID Cont.	Yes ⁵	No	No	No	No
Ratio Control ²	Yes	Yes	Yes	Yes	Yes
Time-Scaled Accumulation	Yes	No	No	No	Yes
Totalizer	Yes	No	No	No	Yes
Ramp and Soak Sequences	Yes	No	No	Yes	Yes

¹ Logical operations are available through Logic Blocks, rather than through regulatory-point algorithms.

² Ratio control is a PID option in CBs, MCs, ECs, and AMs. It is also available as separate Ratio Control algorithms in ECs and AMs.

³ Logical functions are available through the Logic data point.

⁴ These functions are available through the Calculator algorithm or the HPMs MUL/DIV algorithm.

⁵ N/A for PM.

⁶ These functions are available through the Calculator algorithm.

4.1.3 EU Range for PVs

Configure the PV range for every regulatory data point in the following two parameters:

- PVEUHI
- PVEULO

4.1.4 EU Range for Analog Output Points

No EU range can be configured for analog output points.

4.1.5 EU Range for Regulatory Data Points in AMs and PMs

When an AM or PM type Regulatory data point uses PV processing, you must configure the EU range in PVEUHI and PVEULO. EU ranges are also required for initializable inputs to, and outputs from, control processing; however, these do not always have to be configured by the user. In some cases, they are derived.

4.1.5.1 EU Range for PV Algorithms in AMs and PMs

You must configure the EU range for the PV that is the outcome of a PV-algorithm calculation. The PV-algorithm calculation typically yields a PV in EUs that can be converted to percentage of range.

4.1.5.2 EU Range and Control Algorithms in AMs and PMs

You must configure the EU range for every initializable input. It is defined by parameters SPEULO and SPEUHI. If there is more than one initializable input, the same EU range applies to all of them. For some control algorithms (e.g., PID), the EU range of the initializable input is forced to be the same as the EU range of the PV. The target value for an SP uses the same range as is specified for the SP.

The EU Range for the output of a control algorithm is defined by these parameters:

- CVEULO
- CVEUHI

NOTE

If no control-output connections are configured, CVEUHI and CVEULO must be specified by the user; however, if at least one control-output connection is configured, CVEUHI and CVEULO are derived from the EU range of the secondary that receives the first active control-output connection, and they cannot be specified by the user. For DDC outputs, the range of the secondary is assumed to be 0 to 100.

4.2 EVENT-INITIATED PROCESSING

Event-initiated processing (EIP) is the initiation of the processing of a data point when an event occurs. Processing of points and programs in AMs and in CGs can be initiated when certain events occur, such a change in the PV value of a digital point or an alarm.

4.2.1 Application Modules

When it detects an event, a CL block in an AM can request special processing of a point by placing Normal in parameter PPSREQ, or it can request special processing at some later time by placing a delay time in seconds in parameter PPSCYCLE. For more information, refer to subsection 2.2.1.2 in *Application Module Control Functions*.

4.2.2 Process Managers

EIP is enabled by configuring Eip or EipSoe in parameter EVTOPT of the event-detecting PM point, which must be a digital input point or a digital composite point. The tag name of a target AM or CG point is contained in EIPCODE. When a PV change occurs, On is placed in PPS of the target point.

Process Managers have a dedicated digital input point for sequence of events. For more information, refer to subsection 2.9 in the appropriate Control Functions and Algorithms manual.

4.2.3 Hiway Gateway

EIP can be configured for all HG point types except timer, numeric, logic block, and process module points. There can be up to 600 points with EIP in each HG. EIP from an HG point is enabled by placing Enable in parameter EVENTPRC. Further control over EIP is provided by parameter EIPENB, whose value can be changed from Disable to Enable, or vice versa, by an engineer or supervisor at a US. The tag name of the target AM or CG point is placed in EIPCODE.

HG points can be configured to specify the types of events that are reported to the target point through parameter EIPEVENT. IF EIPEVENT contains Any, any change in alarm state, from normal to alarm or from alarm to normal, is reported; and for digital points, any change in the PV value is reported. When an event is reported, On is placed in the target point's PPS parameter. Other values in EIPEVENT define certain types of events to be reported (see the *Hiway Gateway Parameter Reference Dictionary* for a list of the event types).

4.3 ALARMING

This section describes alarm functions related to alarms detected in Application Modules and in, or through, NIMs and HGs.

The two major types of alarms detected in this system are as follows:

- Process Alarms—These are typically caused by some process condition or some improper situation encountered by the control subsystem.
- System Alarms—These are caused by system-related events, such as hardware or software failures.

4.3.1 Process Alarms

4.3.1.1 Process Alarm Detection

Process-Alarm detection occurs as individual data points are processed in normal point processing.

Each appropriate, process-related parameter is checked to determine if it is within user-configured alarm trip-points, and the corresponding alarm flag is set or reset as the result of the test.

In Regulatory points in AMs only, a 3-state alarm-transition parameter value is derived for most analog variables that are subject to alarm checking. The three states are: Alarm, Rtn, and NoChange. This alarm-transition parameter is meaningful only for the duration of the point's execution and is intended specifically for use by CL blocks on the point.

Points in APMs and HGs can be configured to trigger point processing in an AM when an alarm occurs (see subsection 4.2).

4.3.1.2 Alarm Trip Points

Alarm trip points are user-configured values. When a monitored variable exceeds the trip point, an alarm is generated.

In Process Managers and AMs, you can configure the trip point as NaN—not a number. When an alarm trip point is defined as NaN, the trip-point test is not performed, the corresponding alarm flag is changed to false, and the alarm-transition flag is changed to "no transition."

A deadband affects the return-to-normal. Alarms are generated when the PV increases through the trip point and the return-to-normal indication occurs when the PV returns through the trip point and the deadband. In AMs and PMs, deadband values in parameter PVADLDB have a value of 0.5% to 5.0%. HG deadband values default to 1.0%.

4.3.1.3 Alarm Priorities

Alarms with different priority levels cause different types of annunciation at the Universal Stations, or none at all. In software prior to Release 500, each alarm for a data point had the same priority and this priority was specified through the parameter ALPRIOR. When building R500 points you may choose individual priorities for each type of alarm.

The ALPRIOR function is retained for compatibility with existing AM\CL programs and schematics, but is no longer displayed on the point build displays. The value fetched for ALPRIOR is the highest alarm priority configured for any of the individual alarm priority parameters for that point. If a schematic or CL program stores to ALPRIOR, the value stored will be written to all the alarm priority parameters for that point. Also, the parameter HIGHAL will contain the parameter with the highest alarm priority that is currently in alarm. If more than one parameter in alarm contains the highest alarm priority, then the parameter is the highest as determined by a preset order. Refer to HIGHAL in the appropriate parameter reference dictionary for more information.

To ensure consistency of the alarm-priority states displayed on the Alarm Display and the current alarm priority state, reconfiguration of alarm priority in AMs is restricted to Inactive points only.

The following are the five priorities and the annunciation and reporting for each:

Priority	Action
Emergency	Display message, print message, store in journal
High	Display message, print message, store in journal
Low	Display message, print message, store in journal
JnlPrint	Print message, store in journal.
Printer	Print message
Journal	Store in journal
No action	None

Alarms in the top three priorities can be set up to sound a user-supplied device.

The "journal" referred to here is an alarm journal (file) in a History Module.

4.3.1.4 Alarm Levels

Each type data point can be configured to detect appropriate alarm types. Each of the alarm types is assigned a relative (fixed, nonconfigurable) alarm level. If more than one alarm occurs for a data point at the same time, only the alarm at the highest level appears on the point's Group and Detail displays. For alarms that are configured at the same alarm priority, the levels are used to determine which alarm will be displayed. The levels are:

	Highest	Offset 1	Lower
Bad PV		Mark 2	
Bad Control		Mark 1	
CL Error		S4 Logic	
CL Failure		S3 Logic	
Switch Alarm 3		S1 Logic	
Switch Alarm 2		Computer Shed	
Switch Alarm 1		Manual	
Overrun		Auto	
PFPS Overrun		Cascade	
CVB Overrun		Back-up Cascade	
CVB Warning		Command Disagree	
Configuration Error		Unreasonable	
PVHHH or PVLLL Alarm		Change-of-State	
PVHH or PVLL Alarm		Counter	
PV Significant-Change Alarm		Flag	
PV High or PV Low Alarm		Open Thermocouple	
Deviation HHH or LLL Alarm		Timeout	
Deviation HH or LL Alarm		Off Normal	
Deviation High or Low Alarm		Preset Alarm	
PV Rate-of-Change		Pre-Preset Alarm	
PV Rate-of-Change Positive or Negative		Pre-Pre-Preset Alarm	
Advisory Deviation		Invalid	
Offset 3			
Offset 2	Lower		Lowest

4.3.1.5 Alarm Inhibition

An alarm that is inhibited is not reported. Alarms can be inhibited for a data point through the Detail display, or for all the points in a process unit through the Unit Assignment display. When alarms for a point are inhibited, all alarm flags for the point are changed to false and the transition flags are changed to "no transition." A "point in inhibit" message is sent to the appropriate Universal Station and alarm journal.

Any alarm messages for a point with alarms inhibited are removed from the list used to produce alarm displays if they have been acknowledged, or when they are acknowledged. When the alarms for a process unit are inhibited, all alarm flags for all points in the unit are changed to false and all transition flags in AMs are changed to "no transition." A "point in inhibit" message is sent to the appropriate Universal Station and alarm journal.

Any alarm messages for a unit with alarms inhibited are removed from the list used to produce alarm displays if they have been acknowledged, or when they are acknowledged.

In AMs and PMs, alarms can be effectively inhibited by setting the alarm trip points to NaN, if the trip point is a real number (that is, if the PV represents an analog value).

4.3.1.6 Primary Module Points

Primary Module (PRIMMOD) Points provide a mechanism for grouping related points; it is used to collect alarms and events from points that are related for some purpose. The PRIMMOD parameter contains the name of a single point that is linked to other related points. All points with matching PRIMMOD parameters are considered to be in the same group.

PRIMMOD parameters can be used in the following ways:

- Create alarm groups—the composite alarm status is maintained for a PRIMMOD group and can be used to support more flexible and customized alarm annunciation through button LEDs, custom schematics, and the Area Annunciator Display.
- Retrieve events—from the Event History Retrieval Display, you can enter the primary module point name to retrieve events related to points with the same PRIMMOD parameter.
- Identify a set of points—as belonging to a batch equipment unit or batch ID.
- Identify the Process Module Point—that is responsible for manipulating a group of points.

Any type of LCN point can be used as a Primary Module Point. All LCN points have a PRIMMOD parameter except for UCN component and CG points. There is no limit to the number of points that can be grouped under a primary module point.

Use the following guidelines when assigning points to a Primary Module:

- The PRIMMOD default is null (underscores “_” or dashes “-”).
- The PRIMMOD value of an AM point can be any valid local LCN point.
- The PRIMMOD value of a UCN point must be a point in the local NIM.
- The PRIMMOD value of a Hiway point must be a point in the local HG.

4.3.1.7 AM Multiple PRIMMOD Alarming Option

With R520, a new NCF option allows a single alarm on an AM point to be reflected in four new PRIMMOD alarm groups in addition to the standard PRIMMOD parameter group, which is used for alarm displays and event history. This accommodates the sharing of a common piece of equipment by up to five processes; e.g. batches or oil movements, simultaneously.

These new PRIMMOD alarm groups are identified by four 16-character string-type parameters; \$MPROD1, \$MPROD2, \$MPROD3, and \$MPROD4. These strings will take the place of the PRIMMOD parameter strings in LCN alarm events. The PRIMMOD and \$MPROD groups can be referenced from displays and button LEDs, and used for event history retrieval.

The NCF Configurator has an option parameter that controls whether the Multiple PRIMMOD functionality is enabled or not. This option has three modes:

- Multiple PRIMMOD Option Disabled — Alarms are reflected only in PRIMMOD parameter alarm groups (not \$MPROD).
- Multiple PRIMMOD Option Enabled Exclusive—Alarming on PRIMMOD and \$MPROD is mutually exclusive (e.g., if a point is in an alarm state and at least one \$MPROD parameter on that point has a value, that alarm will be reflected in the alarm groups for those \$MPROD parameters which have values and will not be in the alarm group for the PRIMMOD parameter. If none of the \$MPRODs have values, the alarm will be reflected in the PRIMMOD group).
- Multiple PRIMMOD Option Enabled Inclusive—An alarm on a point will be reflected in the alarm groups for all the point's \$MPROD parameters which have values and also on the alarm group for the PRIMMOD parameter.

All alarmable AM points have these new \$MPROD parameters. This functionality does not apply to the HG, NIM, or CG.

4.3.1.8 Auxiliary Unit

In R520, all alarmable points have a new parameter called Auxiliary Unit (\$AUXUNIT). This new parameter is in the Data Entity Builder (DEB) and on the Configuration Page of the point's Detail Display. It allows all process alarms on a point to be dynamically redirected from the point's primary unit to an alternate unit for alarm displays.

Process alarm events, that are generated from points whose \$AUXUNIT has been configured, will be accepted only by Universal Stations having an Area Database in which both the Primary Unit and the Auxiliary Unit are configured. If the \$AUXUNIT parameter is set to null (--), alarms and messages on that point go to the primary unit. If a valid Unit ID is specified, alarms and messages from that point go to the Auxiliary Unit.

A point's \$AUXUNIT parameter can be modified by Schematic, Detail display, DEB, Alter Parameters, Computing Modules, and CL. The key level for changes from the operator stations is configurable in the NCF. As long as there is no key level violation, the \$AUXUNIT parameter can be modified at any time even if the point is active.

An Auxiliary Unit on the Alarm Summary and on the Alarm Annunciator displays will appear in the unit column in reverse video, half-intensity green. If an Auxiliary Unit does not exist, the unit column will contain the primary unit number and will not be back-lit.

If you do not want to use this feature, leave the new parameter \$AUXUNIT at its default value, "--".

4.3.1.9 Alarm Disabling and Enabling

Disabling alarms eliminates reporting to Universal Stations but does not eliminate alarm detecting, initiating of user-written programs and storage in an alarm journal. If it has been acknowledged or when it is acknowledged, the alarm message for a disabled alarm is removed from the list used to generate alarm displays.

All alarms for an individual point can be disabled, and all the alarms for all the points in a process unit can be disabled.

When alarms for a point or a unit are enabled after being disabled, all existing alarms for the point or unit are reported to the Universal Station(s) and normal alarm reporting is resumed as the points are processed.

When a formerly inhibited point or unit is again enabled, alarming and reporting resume as the data points are processed next. All newly detected alarms are treated as new alarms. When HG alarms are enabled, all alarms for all points in the unit are reported.

4.3.1.10 Contact Cutout

The concept of the contact cutout function is to prevent a proliferation of alarms from being reported to the operator. This can occur when a critical failure causes a number of related alarms in other points.

Contact cutout is used to automatically prevent alarms on a point, called the secondary cutout point, from being reported when a certain condition occurs on another point, the primary cutout point. The occurrence of any alarm on a primary cutout point is used to force the contact-cutout state on the secondary point; however, any logical parameter of the primary can be used to cutout alarms in the secondary.

In HGs, contact cutout is accomplished by the configuration of parameters CCPRIPT and CCRANK. CCRANK has three possible states:

- NEITHER This point is not part of a contact cutout chain
- PRIMARY This point is a primary in a contact cutout chain
- SECNDARY This point is a secondary in a contact cutout chain

In AMs and Process Managers, the contact-cutout function is implemented using a configured contact-cutout input connection to the secondary point's CONTCUT parameter. The use of an contact-cutout input connection allows an unlimited number of cutout secondaries and provides a pointer in each secondary's database to the cutout primary. In this case, however, the primary point has no information of the cutout secondaries and the actual contact cutout is done as the secondary point is processed.

Contact-cutout secondaries continue to detect alarms even in the cutout state. New alarms are not reported. Only returns-to-normal are reported. If a cutout secondary has detected an alarm when the cutout event occurs, the alarm is not removed from the alarm-message list until it returns to normal. If the secondary is holding a detected alarm when the cutout state is removed, the alarm(s) is not reported until it returns to normal and occurs again.

4.3.1.11 Process-Alarm Types

Each type of data point can be configured to detect appropriate types of alarms, so all of the alarm types defined here may not apply to a given point type.

4.3.1.11.1 Deviation-High Alarm

A deviation-high alarm is generated when the difference between the PV and SP is greater than the deviation-high trip point. This trip point (engineering units for AM and PM points, % of range for HG points) must be a positive number. A deviation-high return-to-normal is issued when the difference falls below the trip point, minus the deadband value, which is fixed at 10% of the value of the trip point itself.

4.3.1.11.2 Deviation-Low Alarm

A deviation-low alarm is generated when the difference between the SP and PV is greater than the deviation-low trip point. This trip point (engineering units for AM and PM points, % of range for HG points) must be a positive number. A deviation-high return-to-normal is issued when the difference goes below the trip point, minus the deadband value, which is fixed at 10% of the value of the trip point itself.

The deviation-high and -low alarms are available only for control algorithms that use a setpoint.

4.3.1.11.3 PV-High Alarm

A PV-high alarm is generated when the PV exceeds the PV high-alarm trip point. The PV-high trip point must be equal to or greater than the PV-low trip point, and less than or equal to the PV high-range plus overrange.

A return-to-Normal is generated when PV falls below the PV high-alarm trip point minus the deadband value.

4.3.1.11.4 PV High-High Alarm

A PV high-high alarm is generated when the PV exceeds the PV high-high-alarm trip point. The PV high-high trip point must be equal to or greater than the PV-high trip point, but less than or equal to the PV-high range plus overrange. A configuration error (mismatch) is detected if a user tries to enter a PV high-high trip-point value while the PV-high trip-point value is NaN.

A return-to-normal is generated when the PV falls below the PV high-high trip point, minus the deadband value.

No crossover of the PV high-high and PV-high trip points is allowed.

4.3.1.11.5 PV-Low Alarm

A PV-low alarm is generated when the PV is less than the PV-low trip point. The trip point must be less than or equal to the PV-high trip point, and greater than or equal to the PV low range minus overrange. A return-to-normal is generated when PV exceeds the PV-low trip point plus the deadband value.

4.3.1.11.6 PV Low-Low Alarm

A PV low-low alarm is issued when PV is less than the PV low-low alarm trip point. The trip point must be less than or equal to the PV-low trip point and greater than or equal to the PV-low range minus overrange. A configuration error (mismatch) is detected if a user tries to enter a PV low-low trip point if the PV high-high trip point is NaN.

A return-to-normal is generated when PV exceeds the PV low-low alarm trip point plus the deadband value. No crossover of the PV-low and PV low-low trip points is allowed.

4.3.1.11.7 Significant PV-Change Alarm

PV significant-change alarms annunciate a PVHI or PVLO alarm when the PV continues to move further beyond the alarm trip point. This alarm is generated only when the PV is between PVHI and PVHH or between PVLO and PVLL trip points. If PVHI occurs and PVHH is configured, the first time the PV crosses one of the boundaries defined by PVHITP plus ($n \cdot \text{PVSGCHTP}$, where n equals the number of times the significant change alarm has been annunciated), the PVHI alarm is reannunciated. This continues until the PVHH alarm occurs. At that point, reannunciation of the PVHI alarm stops.

Similarly, if a PVLO alarm occurs, the first time the PV crosses one of the boundaries defined by PVLOTP minus ($n \cdot \text{PVSGCHTP}$), the PVLO alarm is reannunciated. This continues until the PVLL alarm occurs. At that point, reannunciation of the PVLO alarm stops.

A fixed deadband equal to 10% of the value in PVSGCHTP is applied to each significant-change alarm.

A configuration error (mismatch) is detected if a user enters a value in PVSGCHTP while both PVHH and PVLL contain NaN.

4.3.1.11.8 PV Increasing-Rate-of-Change Alarm

A PV increasing-rate-of-change alarm trip point is specified in parameter PVROCPTP as a increasing rate per minute, in % for HG points and in engineering units for APM and AM points. There is no deadband provided for this alarm, but to protect from alarms caused by noise on the PV value, the following mechanism is used:

For the alarm to occur, the change in the PV value (present PV minus previous PV) must exceed the PVROCPTP divided by TS (the processing interval in minutes) for two consecutive processing passes. Similarly, for a return-to-normal, the change in the PV value must be less than PVROCPTP divided by TS, for two consecutive processing passes.

4.3.1.11.9 PV Decreasing-Rate-of-Change Alarm

A PV decreasing-rate-of-change alarm trip point is specified in parameter PVROCNTP as a decreasing rate per minute, in % for HG points and in engineering units for APM and AM points (for points in MCs, enter a minus sign with the value in %). There is no deadband provided for this alarm, but to protect from alarms caused by noise on the PV value, the following mechanism is used:

For the alarm to occur, the change in the PV value (present PV minus previous PV) must exceed the PVROCNTP divided by TS (the processing interval in minutes) for two consecutive processing passes. Similarly, for a return-to-normal, the change in the PV value must be less than PVROCNTP divided by TS, for two consecutive processing passes.

4.3.1.11.10 Time-out Alarm

This alarm applies only to timer points. A time-out alarm is set when the current time (PV) equals or exceeds the preset time (SP).

4.3.1.11.11 Preset Alarm

This alarm applies only to AM and MC counter data points. The preset alarm is generated when the accumulation value is equal to the preset (accumulation target) value.

4.3.1.11.12 Digital Alarms

There are several types of alarms for digital data points. They are:

- Change of State Alarms
- State Alarms
- Command Disagreement Alarms
- Command Fail Alarms (Process Managers only)

Digital points are in PMs/NIMs and HGs. Refer to the following publications for more information:

- The appropriate Control Functions and Algorithms manual and parameters ALMOPT, UNCMDFL, CMDFALFL, CMDDISFL, and UNCMDFL in the appropriate Parameter Reference Dictionary
- Section 2 of *Hiway Gateway Control Functions* and parameter DIGALFMT in the *Hiway Gateway Parameter Reference Dictionary*.

4.3.1.11.13 Controller Output Alarms

For Release 510 and later systems, most PM, APM, and HPM Regulatory Control algorithms have configurable output high and output low alarms. The exceptions are the Position Proportional, PID Position Proportional, and Rampsoak algorithms.

4.3.2 System Alarms

System alarms are generated when a significant system event such as a hardware failure or an unrecoverable software error occurs. System alarms may result in a node failure and may be accompanied by a maintenance recommendation. If a node that is involved in a control strategy fails, control continues as far as the redundancy, backup, and shed modes built into or configured into the system allow.

4.4 MODES AND ATTRIBUTES

NOTE

The control mode and interlock descriptions provided here apply only to control strategies implemented in AMs through process-connected devices on UCNs and Data Hiways. While AM control functions can automatically and independently sense output changes, ULPS connected through Computer Gateways cannot.

Automatic control mechanisms require interlocks with the operator so that he or she can intervene in a clear and orderly way when necessary. In **TotalPlant** Solution (TPS) Systems these interlocks are based on the division of the automatic control mechanisms into the following two categories:

- **Continuous control** functions tend to execute periodically, often frequently. Closed-loop control is usually assumed. These functions are provided by the standard regulatory data points, and other data point types, in AMs, APMs, and in process-connected boxes, and by continuous-control CL blocks executing in AMs.
- **Discontinuous control** functions are at a conceptually higher level than continuous control. They tend to function as an "automated operator" with one-time changes that may depend on the state of the process, or of periodic functions, such as optimizations that run infrequently and may not assume closed-loop feedback. In TPS Systems these functions are provided by sequence programs in MCs (SOPL programs or CL/MC programs), user-written programs in CM60s, and optionally (per block option) CL blocks in AMs. The program attribute is the primary identifier of discontinuous control.

Continuous and discontinuous control are simply two different levels of control that can and often do, simultaneously execute in the same strategies.

- The MODE parameter provides an interlock between continuous-control mechanisms and the operator.
- The MODEATTR (mode attribute) parameter provides an interlock between discontinuous-control mechanisms and the operator. This concept was introduced for SOPL programs in MCs as the Sequence Attribute of the Mode. In LCN-based TPS Systems, this function applies to all data points used in control.

NOTE

The information under subsection 4.4 defines the functions of modes and attributes for regulatory data-points and analog-output data-points, only.

4.4.1 Modes

The current mode of a data point is indicated by the MODE parameter. A regulatory point, an HG digital point with one or more outputs, and an HG analog point with one or more outputs can be in one of the following modes (APM analog output points can be in Man or Cas modes only, and APM digital output points are in Man mode):

- **Manual**—An operator or discontinuous-control program is directly controlling the output. In each of the other modes (below), the continuous-control algorithm used by the data point determines the output value.
- **Automatic**—The setpoint or first initializable control-input is received from an operator or a discontinuous-control program.
- **Cascade**—In setpoint control (SPC), the setpoint or first initializable control-input is received from a primary data point. In direct-digital control (DDC) the output value, OP, is received from a primary data point. The source of the SP or OP value may be either a configured control output from a regulatory point or a continuous-control program.
- **Backup Cascade (BCas)**—A regulatory point (slot) in an PM or a process-connected box may be in this mode if an SP or OP value is not available from an LCN-based control module. The setpoint is received from a primary point in the APM or in the process-connected box. For PM points, the remote-cascade option parameter, RCASOPT, must contain Spc, Ddc, or DccRs. For HG points, the remote-cascade enable parameter, RCASCENB, must contain On.

In addition, some HG points can be in local-manual mode, where the output value is directly controlled from an analog display through the controller (box) on the Data Hiway.

4.4.1.1 MANual Mode

Typically, Man mode is used on an ultimate-secondary data point to allow an operator or a discontinuous program to override continuous control and to directly manipulate the valve.

4.4.1.2 AUTOMATIC Mode

Auto mode is the principal mode for a data point that is the ultimate primary in a cascade-control strategy. If the data point is configured as a secondary, Auto mode is used by an operator or a program to intervene in the cascade to manipulate the SP of the secondary.

The following are important characteristics of data points in Auto mode:

- If the mode attribute value in MODATTR is Oper, only a Universal Station operator or a DEP operator can change the setpoint (SP), provided the SP is not being initialized.
- If the value in MODATTR is Prog, only a user-written, discontinuous-control program can change the setpoint (SP), provided the SP is not being initialized.
- In AMs and PMs, Auto mode is not available for data points that use control algorithms that don't have a setpoint.
- For HG regulatory data points in a CB, MC, or EC, if the algorithm has an SP, Auto mode is as defined here; however, for those algorithms that don't have an SP, Auto mode works more like Cascade mode.

4.4.1.3 CAScade Mode

Cas mode is the normal operating mode of a regulatory data point, an HG digital point, or an analog point that is a secondary data point in a cascade-control strategy.

- Regardless of the mode or mode attribute, neither the operator nor a discontinuous-control program can change the output (OP) or the setpoint (SP).
- In an AM, when a data point is in Cas mode, it receives its setpoint (SP) from a control-output connection from another regulatory data point, or from a continuous program.
- When in Cas mode, data points that are not SPC types nor DDC types receive SP from the local primary in the same APM or process-connected box. In this case; for APM points, parameter RCASOPT contains None; and for HG points, parameter RCASENB contains Off.
- For PM and HG points in Cas mode that are SPC types or DCC types, the SP value (SPC) or the OP value (DDC) is received from a regulatory point in an AM or from a continuous-control program. For PM points, parameter RCASOPT contains Spc, Ddc, DdcRsp, or Rsp; and for HG points, parameter RCASCNB contains On.
- For HG analog or digital points in a DHP, MC, or PIU, the output (OP) is received from a control-output connection on a regulatory data point in an AM or from a continuous-control program.

4.4.1.4 Back-up Cascade Mode (BCas)

A Process Manager or HG regulatory data point that is an SPC type or a DDC type can have these alternate cascade inputs:

- In Cas mode, the setpoint input (SPC) or the output value (DDC) is received from a data point in an AM or a CG (see subsection 4.4.1.3).
- In BCas mode, the setpoint is received from a data point in the same APM or the same process-connected box.

BCas mode is not available for analog nor digital points. It is also not available in PM points where RCASOPT = None, nor in HG regulatory points where RCASENB = Off.

4.4.1.5 Local-Manual Mode

The operator at an analog display that is connected to a CB, EC, or MC can force the mode of an HG regulatory data point to local-manual mode, and thereby manipulate the output value directly from the display module.

If the data point is configured for initialization, local-manual mode causes the data point and its primaries to be initialized.

- Local-manual mode can be turned on only from an analog display, from a DEP, or by a special connection to the JYS05 termination panel. In local-manual mode, the output can be manipulated from one of these three sources.
- At a Universal Station or as seen by a user-written program, local-manual mode appears as the initialization of the affected data point from a secondary. At the Universal Station(s), the mode appears as Man.

For example, if the data point is in Auto mode with the program (Prog) attribute, and local-manual mode is forced from an analog display, the data point goes to Manual mode, with the Prog attribute, and the mode is indicated as P-Man on the displays. The output from the controller slot is controlled from the analog display.

4.4.2 Additional SPC/DDC Control Features

The Cascade Request, Time-Out Alarm, and Cascade Shed functions described in the following paragraphs apply to APM and HG data points.

4.4.2.1 CAScade Mode Requests

For a PM or HG regulatory data point that is an SPC or DDC type, the mode can't be changed directly to Cas. Instead, when a US operator or a program selects Cas mode, it requests Cas mode, which indicates that the primary in an LCN-based device can take over control of the setpoint (SPC) or of the output (DDC). The primary, which is typically a regulatory point in an AM or a user-written continuous-control program, can then change the value in MODE to Cas. Until it does, the secondary point remains in its present mode.

For PM points the mode-change request parameter is RCASREQ and for HG points it is the CASREQ parameter.

4.4.2.2 Time-out Alarm

For Process Module and HG regulatory points that are SPC or DDC types, the setpoint or the output value is periodically updated from the primary. If the time interval between two consecutive updates exceeds a predefined time interval, the slot reverts (sheds) to the mode configured in parameter SHEDMODE, and if the point is an HG point associated with an EC, a time-out alarm is generated.

- For PM points, the time interval is configured in the SHEDTIME parameter.
- For HG points associated with an EC, two time-out intervals are configured, in seconds. The first of these intervals applies to all SPC-type and DDC-type data points in the box and the other can be a different interval for each point. The time-out alarm is independently generated for each point. For CBs, DHPs, MCs, and PIUs, two time-out intervals are configured for each box (BOXTOG1 and BOXTOG2), and each point (slot) in each box is configured for one of the two intervals (TOGINTSL).
- For HG points associated with CBs, DHPs, MCs, and PIUs, the HG provides the time-out function. It is similar to that provided by the EC.

4.4.2.3 Cascade Shedding

When a time out occurs, the data point (slot) sheds from Cas to the mode indicated by SHEDMODE, with the attribute unchanged. At the same time a cascade request is sent to the primary data point so that it can pick up control after recovery, without intervention by an operator.

- For Process Manager points, the backup modes that can be in SHEDMODE depend on the algorithm configured for the point. Refer to the appropriate Parameter Reference Dictionary for more detail.
- For regulatory data points in an EC, the backup mode can be configured in the SHEDMODE parameter as Man, Auto, Cas, or BCas. If it is Cas, there really is no backup mode; only the time-out alarm is generated.
- For regulatory data points in a CB or MC, the backup mode depends on the algorithm used and whether initialization is configured for the point. Refer to the algorithm engineering data publications for more detail.
- For analog output and digital output points, the shed mode is Man.

CG Shed—The Computer Gateway was designed for advanced control and is not intended for continuous control. Advanced Control is less of a time critical process because it gathers and analyzes information over several minutes. Although not recommended, if a CG is used for continuous control, please note the following:

Automatic shedding to a lower level of control does not occur between the CG and controllers in process connected boxes. You can implement a watchdog timer function for Process Manager systems by writing a program in the CG that sets a flag = ON in affected Process Managers at a predefined interval (such as 20 seconds). Then write a CL program that reads that flag and resets it if it set, or changes the modes of the affected controllers to their backup mode if it is not set.

Bumpless transfer and antireset windup are not automatically handled by the TPS System when cascades are formed between the CG and a controller in a process connected box. These functions must be incorporated into an Advanced Control program in the CG.

4.4.2.4 APM/HPM Bad PV/Mode Shed

On detection of a bad PV (or bad CV for algorithms that do not have a meaningful PV), most APM and HPM regulatory control points shed to a mode determined by parameter BADCTLOP. This function is not applicable for PMs. Refer to subsection 8 in the *Advanced Process Manager Control Functions & Algorithms* manual or *High-Performance Process Manager Control Functions & Algorithms* manual for more information.

4.4.3 Mode Attributes and Control Interlocks

See Tables 4.4 and 4.5 for summaries of the mode attributes and control interlocks.

The mode attribute parameter, MODATTR, is in one of these two states:

- Operator (Oper)
- Program (Prog)

MODATTR provides an interlock between the operator and discontinuous-control programs for changes to the key parameters of the data point that direct the continuous-control functions: SP, OP, MODE, and for PID/Ratio/Bias algorithms, the RATIO and BIAS parameters.

- When MODATTR = Oper, an operator, supervisor, or engineer at a Universal Station is permitted to change the SP, OP, MODE, RATIO, and BIAS parameters (SP and OP are also subject to the mode checks specified under subsection 4.4.1), and discontinuous-control programs are prevented from changing them.
- When MODATTR = Prog, a discontinuous-control program is permitted to take the role of the operator and to change the SP, OP, MODE, RATIO, and BIAS parameters (SP and OP are also subject to the mode checks specified under subsection 4.4.1), and users of the Universal Stations are prevented from changing them.

The discontinuous-control interlock is extended to continuous control for the special case of the RATIO and BIAS parameters of PID Ratio/Bias algorithms, to provide a useful interlock where one would otherwise not exist. That is, changes by both continuous control and discontinuous control to RATIO and BIAS are prevented when MODATTR = Oper.

Changes to the MODE parameter by continuous control, including external mode switching (see subsection 2.5 in AM Control Functions), are not affected by the value in MODATTR.

Note that except for the impact on RATIO and BIAS just described, the MODATTR (and NMODATTR) parameter does not apply in continuous-only strategies, nor in continuous-only portions of discontinuous strategies.

4.4.4 Normal Mode and Normal Mode Attribute

A normal mode (NMODE) and a normal mode attribute (NMODATTR) are configured for each regulatory, analog-output, analog-I/O composite, HG digital output data point, and HG digital-I/O composite data point. This allows Universal Station operators to call for a return to the normal mode and attribute with a single keystroke (see Figure 4-1). The normal mode and the normal attribute are as intended by the engineer when a data point is normally operating.

You can define the normal mode (NMODE) to be Auto, Cas, BCas, Man, or None. The normal mode (NMODATTR) attribute is either Oper or Prog or None. If None is chosen for either or both of these parameters, the NORM key on the operator's keyboard has no effect on the corresponding parameter.

If the normal mode is None, the NORM key won't change the mode.

An engineer at a Universal Station, or a continuous-control or discontinuous-control program, can change the normal mode and the normal-mode attribute by changing the values in the NMODE and NMODATTR parameters.

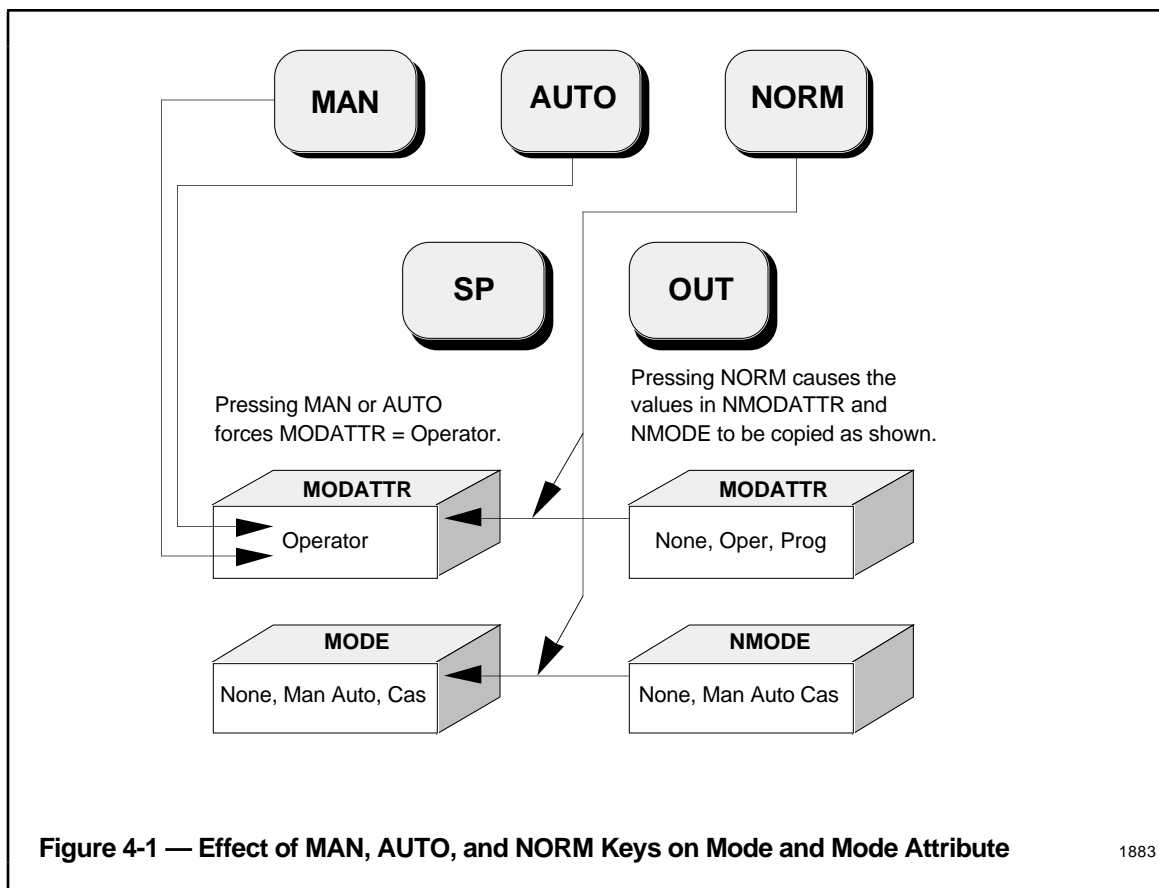


Table 4-4 — Control Interlocks, Analog Output and Regulatory Points

Parameters	Parameter Values	Agents Who Change Values
MODE	Man, Auto, Cas, Bcas, Normal	Operator (MODATTR = Operator) Disc. Control (MODATTR = Program) NORM key stores the content of NMODE into this parameter. Changes to MODE while in discontinuous control are written to NMODE and to NMODATTR. (Notes 1, 2, 4, 9, and 10)
NMODE (Normal Mode)	None, Man, Auto, Cas	Continuous Control (AM) Disc. Control (MODATTR = Program) Operator (MODATTR = Operator) Changes to MODATTR by discontinuous control are copied into this parameter and into MODATTR. Also, changes to MODE while in discontinuous control are written to NMODE and to NMODATTR (Notes 3, 4, and 10)
MODEATTR (Mode Attribute)	None, Operator, Program	NORM key stores content of NMODATTR in this parameter. Operator (MODPERM = Permit) Discontinuous Control Continuous Control (AM) MAN and AUTO keys force MODATTR = Operator (Notes 2, 4, and 10)
NMODATTR (Normal Mode Attribute)	None, Operator, Program	Changes to MODATTR by discontinuous control are copied into this parameter and into MODE. Also, changes to MODE while in discontinuous control are written to NMODE and to NMODATTR (Notes 3, and 10)
RCASENB (Remote Cascade Enable)	On, Off	Engineer at a US (Note 10)
OP (Output Value)	Real number	Operator (MODATTR = Oper, MODE = Man) Disc. Cont. (MODATTR = Prog, MODE = Man) Cont. Cont. (AM) (MODE = Cas, RCASENB = On) Cont. Cont. (Box) (MODE = Cas, RCASENB = Off) Cont. Cont. (APM) (MODE = Bcas, RCASOPT ≠ None) (Notes 5, 6, 7, and 10)
SP (Setpoint)	Real number	Operator (MODATTR = Oper, MODE = Man) Disc. Cont. (MODATTR = Prog, MODE = Man) Cont. Cont. (AM) (MODE = Cas, RCASENB = On) Cont. Cont. (Box) (MODE = Cas, RCASENB = Off) Cont. Cont. (APM) (MODE = Bcas, RCASOPT ≠ None) (Notes 5, 6, 7, 8, and 10)
RATIO (Ratio Value, Ratio/Bias Algorithm)	Real number	Operator (MODATTR = Operator) Disc. Control (MODATTR = Program) Continuous Control (MODATTR = Program) (Note 10)
BIAS (Bias Value, Ratio/Bias Algorithm)	Real number	Operator (MODATTR = Operator) Disc. Control (MODATTR = Program) Continuous Control (MODATTR = Program) (Note 10)

(Continued)

Table 4-4 — Control Interlocks, Analog Output and Regulatory Points (Continued)**Notes for Table 4-4**

1. If configured, external mode switching (permissive) can prevent changes in MODE.
2. If MODPERM = NotPerm, changes to MODE and MODEATTR are not permitted if the keyswitch is in the OPER position.
3. NMODE and NMODATTR can be disabled by configuring them with None.
4. Pressing the NORM key copies the values in NMODATTR and MODEATTR into NMODE and MODE.
5. Continuous control in an APM or box changes OP only in a remote cascade to a DDC algorithm in a APM or box. In this case, writes by continuous control to SP are also allowed, but not with SP as an initializable parameter.
6. Point initialization, and PV tracking for PIDs, may still prevent writing to SP and OP.
7. For cascades from an AM to an APM, RCASOPT for the APM point must contain Spc, Ddc, DdcRsp, or Rsp. For cascades from an AM to a box, RCASENB for the HG point must contain On.
8. For non-PID points without external initialization (this is rare), when MODE = Man, operators cannot change SP, and continuous control is allowed to write to SP (for internal initialization).
9. For APM points and HG points, if REDTAG = On, MODE is forced to contain Man, and changed to OP by LCN nodes is prevented; if PVSOURCE ≠ Auto (=Man or Sub), MODE contains Man; and Loop Manual from a Data Entry Panel (DEP) overrides all other modes and prevents changes to OP.
10. For APM points, none of the values of parameters in this table can be changed by continuous or discontinuous control unless the UCN and APM states are FULL CONTROL. For HG points, none of the values of parameters in this table can be changed by continuous or discontinuous control in LCN nodes, unless the Hiway and box states are FULL CONTROL.

Table 4-5 — Control Interlocks, HG Digital Output Points

Parameters	Parameter Values	Agents who Change Values
MODE	Man, Cas, BCas, Normal	Operator (MODATTR = Operator) Disc. Control (MODATTR = Program) NORM key stores the content of NMODE into this parameter. (Notes 2,7, 9, and 10)
NMODE (Normal Mode)	None, Man, Cas	Continuous Control (AM) Disc. Control (MODATTR = Program) Operator (MODATTR = Operator) Changes to MODATTR by disc. control are copied into NMODATTR. (Notes 3 and 10)
MODEATTR (Mode Attribute)	None, Operator, Program	NORM key stores content of NMODATTR in this parameter. Operator (MODPERM) = Permit Discontinuous Control Continuous Control (AM) MAN and AUTO keys force MODATTR = Operator (Notes 2 and 10)
NMODATTR (Normal Mode Attribute)	None, Operator, Program (Notes 3 and 10)	Changes to MODATTR by disc. control are copied into this parameter and into MODE.
OP (Output Value)	0, 1, 2, 3	Operator (MODATTR = Oper, MODE = Man) Disc. Control (MODATTR = Prog, MODE = Man) Cont Cont. (AM) (MODE = Cas, RCASENB = Off) (Note 10)
<p>Notes:</p> <ol style="list-style-type: none"> 2. If MODPERM = NotPerm, changes to MODE and MODATTR are not permitted if the keyswitch is in the OPER position. 3. NMODE and NMODATTR can be disabled by configuring them with None. 7. To change MODE to Cas, RCASENB for the HG point must contain On. 9. For HG points, if REDTAG = On, MODE is forced to contain Man and changes to OP by LCN nodes are prevented; if PVSOURCE ≠ Auto, (= Man or Sub), MODE contains Man; and Loop Manual from a DEP overrides all other modes and prevents changes to OP. 10. For HG points, none of the values of parameters in this table can be changes by continuous or discontinuous control in LCN nodes, unless the hiway and box states are FULL CONTROL. 		

Changes by discontinuous-control programs to the mode and the mode attribute are presumed to be changes in "normal operation" and are, therefore, automatically copied into the NMODE and NMODATTR parameters. This applies to changes by (SOPL or CL/MC) sequence programs in MCs and to changes by discontinuous-control programs in AMs or Computing Modules. This "normal mode tracking" doesn't occur for continuous-control changes, including any by continuous-control CL blocks and External Mode Switching in AMs (see Section 2 in *Application Module Control Functions*).

Though not an expected operation, a CL block or a Computing Module program can store the value Normal in MODE or in MODATTR. This changes the values in NMODE or NMODATTR, respectively, to be stored in MODE and MODATTR. Though possible, this is generally considered to be an operator function. CL blocks, Computing Module programs, and picture-editor-display logic should not include conditional expressions such as IF MODE = Normal, because Normal is not actually one of the states of the MODE parameter. Its states are Man, Auto, Cas, or BCas.

On a restart of a data point, the normal mode and normal-mode attribute are reestablished from a checkpointed file in an HM or they are reloaded from a cartridge or floppy diskette, as are the mode and mode attribute.

4.4.5 Use of Modes and Attributes

4.4.5.1 Operator Handling of Modes and Attributes

An operator at a Universal Station can directly change the mode and attribute of a data point or make the change as defined by the parameters described under subsection 4.4.5.1.1 and subsection 4.4.5.1.2.

4.4.5.1.1 Direct Mode and Attribute Changes by an Operator

An operator does direct mode and attribute changes to intervene in normal control by the system and to take over control of the mode and attribute.

- When an operator changes the mode, the selected data point goes to that mode with the Oper attribute. This lets the operator take over control through the point with a single keystroke or by touching a single target on the screen. For example, if in an urgent situation the operator needs to change the mode of the selected data point to Man, he or she presses only the MAN key. On the Group Display and the Detail Display, the mode indicator has no "P-" prefix for data points with the Oper attribute.
- Usually an operator changes the mode attribute by using the NORM key, which reestablishes the mode attribute from the NMODATTR parameter; however, it is possible for an operator to directly change the mode attribute, should he or she choose to. When a mode change is selected on a Group or Detail Display, a "Prog" target appears, as if it were another possible state of the MODE parameter. Selecting that target and pressing <ENTER> causes the MODATTR parameter for the point to toggle—if it contained Oper, it becomes Prog, and if it contained Prog, it becomes Oper.

The current attribute is indicated by the Mode indicator in the Group and Detail Displays. When the attribute is Oper, the mode indicator for a point in Man mode appears as in this example:

MAN.

When the attribute changes to Prog, the indicator changes as in this example:

P-MAN.

4.4.5.1.2 Mode and Attribute Changes as Specified by the NMODE and NMODATTR Parameters

Normal operation of the control system is with the mode that is defined in NMODE and the attribute that is defined in NMODATTR. When the operator is starting normal control by a data point for the first time or is restarting the point after an interruption in normal control, he or she typically uses the Normal key to set up the normal mode and attribute as defined in these parameters.

- With a data point selected, the operator presses the NORM key (or touches a target on the screen) and the selected point goes to the normal mode and attribute.
- If the engineer has configured a normal mode and attribute for all the points in a control strategy, the operator can start all the points in that strategy in the intended modes and attributes, merely by pushing the Normal key, so it isn't necessary to remember the modes and attributes of all of the points in the strategy.

4.4.5.2 Handling of Modes and Attributes by the Engineer

In AMs, user-written CL blocks can accomplish functions similar to those of PV algorithms and of control algorithms (continuous control), and they can accomplish operator-like actions (discontinuous control). The role a CL block takes is defined in the access clause in the block header, in the CL source file (see subsection 4.1.4.1 in *Application Module Control Functions*).

Also, when user-written programs are performing operator-like control actions, some sort of disciplined arbitration is required to allow the operator and the programs to work together. The control engineer should separately handle the continuous and discontinuous cases so that the operators' responsibilities can be easily understood. While developing a control strategy, you can significantly simplify the operators' tasks by appropriate selection of modes and proper use of the NMODE and NMODATTR parameters.

4.4.5.2.1 Disciplined Arbitration for Discontinuous Programs

A user-written, discontinuous-control program can act as an "automatic operator." It can perform operator-like functions such as setting proper modes for all data points, manipulating valves, and adjusting setpoints.

In such a situation, it useful for the operator to know that a control program is doing things that an operator might otherwise do. It is also best if the program doesn't alter actions that the operator can take if he or she takes control away from the program. It is usually best if the operator has the final discretion in control.

When a discontinuous program is started (usually by the operator), it is reasonable to assume that the operator has turned control over to the program. Therefore, near the beginning of the program, you can establish the Prog attribute and proper modes for all the data points in strategy. For the remainder of the program, only mode changes should be made—not attribute changes.

Once the program is running, if the operator takes control away, the attribute for the point will probably be Oper. Avoiding attribute changes in the program prevents program changes of the mode and attribute. This could cause the discontinuous control program to fail, unless the program always checks for the Prog attribute before changing the SP, OP, or the mode and takes appropriate action if it finds the Oper attribute. Because the NMODE parameter remembers the last mode set by the program, to turn control back to the program, the operator simply presses the Normal key. If the program expected the operator to return control in a different mode, it can redefine the the value in NMODE, as appropriate.

4.5 SYSTEM EVENTS

There are several types of events and alarms that are "broadcast" on the LCN by the modules, gateways, and boxes. Most of these events are visible to users of the system as alarm messages and other messages that appear on the Universal Stations. These events, their sources, and their causes are summarized here.

System events are detected by the following modules and gateways:

- Application Modules
- Network Interface Modules
- Hiway Gateways
- Programmable Logic Controller Gateways
- Computing Modules

The following types of events are broadcast on the Local Control Network:

- Process Alarms
- Sequence Events
- Messages generated by the NIMs, HGs, AMs, and CGs
- Operator Changes
- System Events and Alarms
- Software-Detected Events

System events are reported to all Universal Stations and they are recorded in an event journal in an HM.

4.6 DIFFERENCES IN CB, MC, AND EC ALGORITHMS

If you are familiar with the operation of the CB, MC, or EC algorithms as they appear at Basic or Enhanced Operator Stations that are connected to a Data Hiway, you will see that they appear to have slightly different modes and some different parameter names when seen through a Universal Station that is connected to a Local Control Network. Further, there are a few additional parameters that are visible to the user at a Universal Station.

The functions within the controller boxes are identical. The modes and parameters have been made to appear as a subset of modes and parameters of the Application Module algorithms, so that operators, supervisors, and engineers can use the algorithms in the same manner, no matter where they reside.

4.6.1 Comparison of Modes

The modes as seen at the Operator Station and the corresponding modes as seen at Universal Stations are as follows:

<u>Operator Station</u>	<u>Universal Station</u>
Man	Man
Auto	Auto
CasC	Cas, BCas*
COMP*	Cas*

*For the following algorithms only:

05 PID CMA
06 PID CM
07 PID SPC

BCas is the backup cascade mode, which is the mode the data point (slot) goes to when the output or setpoint from the LCN-based module is unavailable for more than the time-out period. In BCas mode, the slot takes over control, using a setpoint or output value from within the box.

4.6.2 Comparison of Parameter Names

Most tuning constants, such as K, B, T1, and T2 have the same names. Setpoints, process variables, and output values differ as follows:

Operator Station	Universal Station
PV/X	PV
SP/Y	SP
OUT	OP

Other parameters that appear on the displays, particularly the detail displays for data points and on point-building displays, differ from the way they appear on Operator Stations. The following are some examples:

Operator Station	Universal Station
OUT HI%	OPHILM
OUT LO%	OPLOLM
INT HI%	ITHILM
INT LO%	ITLOLM
DEV HI%	DEVHITP
DEV LO%	DEVLOTP

If you need information about an unfamiliar parameter, you can find it in the following publication:

- *Hiway Gateway Parameter Reference Dictionary*, in the *Implementation/Hiway Gateway* binder.

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