Honeywell

Hiway Gateway Control Functions

HG09-501

TotalPlant

Honeywell

Implementation

Hiway Gateway - 1

Hiway Gateway Control Functions

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About This Publication

This publication supports **TotalPlant** Solution (TPS) System network Release 500 - 520. TPS is the evolution of TDC 3000X.

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 TPS System with a Local Control Network. This publication defines the control functions that reside in Hiway Gateways and the process-connected boxes that reside on the Data Hiways served by the HGs.

This publication is part of a set of five publications that define control-system functions. The other members of the set are *System Control Functions*, *Process Manager Control Functions and Algorithms*, *Advanced Process Manager Control Functions and Algorithms* and *Application Module Control Functions*.

NOTE

Two versions of the HG are available in Release 500 and later systems—one version (HGII) that uses a 68020 microprocessor and another (HGIV) that uses 68040 sortware. The information in this publication applies to both versions.

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.

Table of Contents

Table of Contents

Table of Contents

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 reside in HGs and the process-connected boxes that are on the Data Hiways connected to the HGs. These are four companion publications:

- *System Control Functions,* in the *Implementation/Startup & Reconfiguration - 2* binder—describes data-acquisition and control functions that are independent of the module or gateway they reside in.

- *Application Module Control Functions,* in the *Implementation/Application Module - 1* binder—describes data-acquisition and control functions in Application Modules.

- *Process Manager Control Functions and Algorithms*, in the *Implementation/Process Manager - 2* binder—describes data-acquisition and control functions in Process Managers.

- *Advanced Process Manager Control Functions and Algorithms*, in the *Implementation/Advanced Process Manager - 2* binder—describes data acquisition and control functions in Advanced Process Managers.

You should be familiar with the content of *System Control Functions* before using this publication, *Application Module Control Functions*, *Process Manager Control Functions and Algorithms* or *Advanced Process Manager Control Functions and Algorithms.*

Other topics related to data-acquisition and control functions are covered in these publications:

- **Algorithms in Application Modules**—*Application Module Algorithm Engineering Data* in the *Implementation/Application Module - 1* binder.

- **Algorithms in Basic Controllers**—*CB Algorithm Engineering Data* in the *Product Manual* binder in the BASIC System bookset.

- **Algorithms in Multifunction Controllers**—*MC Algorithm Engineering Data* in the *Product Manual* binder in the BASIC System bookset.

- **Algorithms in Extended Controllers**—*EC Algorithm Engineering Data* in the *Product Manual* binder in the BASIC System bookset.

- **Preparation of Control Language Programs—**First refer to the *Control Language/Application Module Overview,* in the *Implementation/Application Module - 3* binder. Then refer to the *Control Language/Application Module Reference Manual,* in the same binder. These manuals cover both continuous-control programs that run in AMs and CL/MC programs that run in MCs.

- **Computer Gateway Functions—**Refer to the publications in the *Implementation/Computer Gateway, Implementation/Processor Gateway*, or *Implementation/CM50S* Rel. 4.0 binders.

- **Parameters—**For details on all of the data point parameters, including value types, default values, and access levels (keys), refer to the following publications:

  Hiway Gateway Parameter Reference Dictionary in the *Implementation/Hiway Gateway - 1* binder.

  Application Module Parameter Reference Dictionary in the *Implementation/Application Module - 2* binder.

  Process Manager Parameter Reference Dictionary in the *Implementation/Process Manager - 2* binder.

  Advanced Process Manager Parameter Reference Dictionary in the *Implementation/Advanced Process Manager-2* binder.

  High-Performance Process Manager Parameter Reference Dictionary in the *Implementation/High-Performance Process Manager-2* binder.

  Computer Gateway Parameter Reference Dictionary in the *Implementation/Computer Gateway, Implementation/Processor Gateway*, or *Implementation/CM50S* Rel 4.0 binders.

HG CONTROL FUNCTIONS
Section 2

This section defines the data-acquisition and control functions, other than HG data point functions, that are accomplished in HGs. The data point functions are defined in Section 3.

2.1 HIWAY STATES

A Data Hiway is in one of these three states:

- Uncertain
- Running
- Failed

Initially, before Data Hiway security checks have been made, or when starting up a hiway without a database, the status of a Data Hiway is set to Uncertain.

In the running state, interfaces to the hiway are operational and normal communication over the hiway is possible. The Hiway Status display for each Data Hiway shows which hiway (A or B) is active. Hiway swaps produce messages that require operator acknowledgment.

Restart of a backup HG does not cause a change in the hiway state. A failure in the HG (both redundant HGs) or the hiway (A and B out of service) changes the hiway status to "failed."

2.2 STATUS OF PROCESS-CONNECTED BOXES

The state of a process-connected box is determined by the HG, but only when the hiway is in the running state. If the hiway has failed, an access-error indication is returned when the HG tries to read from or write in the box. Table 2-1 lists the operational states for process-connected boxes.

2.2.1 Run State

The box is fully operational; the hiway-security check has qualified the box.

This state can be selected by the operator from the Reset state, if the box is operational and qualified. In addition, the MC must have gone through the Idle, Idle-SF, or the Idle-PF state.

2.2.2 Run-SF

The box is in Run and a soft failure has been detected.

2.2.3 Run-PF

The box detected a partial failure; some points are affected (their state is failed); unaffected slots operate normally.

Table 2-1 — Box States for Process-Connected Boxes

Box Op State	Applicable Box Types
* Run	CB,EC,MC,DHP,PIU
Run-SF	EC,MC, DHP
Run-PF	EC,DHP,MC,PIU
* Idle	MC
Idle-SF	MC
Idle-PF	MC
Fail-COM	CB,DHP,EC,HG,MC,PIU
Fail-HDW	CB,DHP,EC,HG,MC,PIU
Reset	CB,DHP,EC,MC,PIU
Uncertain	CB,DHP,EC,HG,MC,PIU

*Indicates a state that can be set by an operator

SF: soft failure
PF: partial failure
COM: Hiway Status diagnostic failure
HDW: hardware failure

2.2.4 Idle

The idle state applies to only the Multifunction Controller. This state can be selected by the operator from only the run or reset states. The box is fully operational, the hiway-security check has qualified the box, points are not being processed, and sequence programs can be downloaded.

2.2.5 Idle-SF, Idle-PF

The box is in the idle state and a soft failure (-SF) or a partial failure (-PF) has been detected.

2.2.6 Fail-COM

The box failed the hiway security check, or an addressing error was detected. All communication to the box, except for hiway security tests, are inhibited. The functional status is set to Basic Control.

2.2.7 Fail-HDW

The HG has determined that the box has failed; the functional state is set to Basic Control (read and write access from AMs and CMs is inhibited). This state can be set by only the HG.

Box HDW Failure Definition—A box failure is the inability of the HG to communicate with a specific box. This may be a result of communication errors other than those detected by the hiway-security check, including no response. In this situation, the HG changes the state of the box to "failed." In the absence of such a condition, the HG sets the state of the box to the one that is determined from the box-status words.

2.2.8 Reset

The box itself detected a fatal error and reset; the functional status is set to "basic control" and read or write access from an AM or CM is inhibited. A box can also be reset through the Box Commands function of the Hiway Status display.

2.2.9 Uncertain

The box has not yet been qualified by the hiway security check and communication with the box is inhibited. The functional status of the box is set to "out-of-service for control."

2.2.10 Box Control States

The control states are Basic, Read, Full, and Test. See 3.3.8 in *System Control Functions*.

When the control state for a box changes from Full to another state, the mode for all data points in that box that are in the Cas mode and are controlled from LCN-based modules is changed to the Shed mode, indicated by the point’s SHEDMODE parameter. Internal box cascades are not affected.

For a box to be in the Full control state both the “hiway control state” and individual “box control state” must be set to Full control. Consequently, by changing the hiway control state form Full to another state, an operator can simultaneously shed control for all points on the hiway in the event that the LCN-based primary becomes unreliable.

2.2.11 Box-State Transitions

The box states can change from one state to any other; however, changes from Fail-COM, -HDW, and Uncertain force the functional status to Basic Control.

2.3 DIGITAL ALARMS

Digital alarms are process alarms that are detected as the following types of HG points are processed:

- Digital input points
- Digital output points
- Digital I/O Composite points.

The types of digital alarms are:

- **Change-of-state alarms**—the alarm is detected when the state of a digital input point changes in either direction. This alarm is cleared from the Alarm Summary Display when the alarm is acknowledged.

- **State alarms**—the alarm is generated when the point is in the state contained in the DIGALFMT parameter. The states for this alarm are State 1, State 2, Input 1, Input 2, Either, and Both. This alarm remains on the Alarm Summary Display until the point is no longer in the alarm state.

- **Command-disagree alarms**—These alarms apply to only digital points with outputs. The alarm is generated when the point has been commanded to go to a state and, after a user-defined time, the input state does not agree with the commanded state.

For state, change-of-state, and command disagree alarms, the alarm descriptor that appears on the Alarm Summary Display is the actual state of the digital PV, which can be the string value (self-defined enumeration) in any of these parameters: STATE1, STATE2, ZZTEXT, or the complement of ZZTEXT. If DIGALFMT contains Either and both boxes for the point on the Group or Detail Display are lit, the state shown on the Alarm Summary Display is that of the first box lit.

You configure the types of alarms for these points in parameter DIGALFMT. Details of the alarm options, alarm conditions, and the effect on the Group and Detail displays for these points are provided under the listing for DIGALMFMT in the HG Parameter Reference Dictionary. The alarm formats that can be configured for each type of digital point are listed on the configuration forms and appear on the Data Entity Builder's parameter entry displays (PEDs). The formats are:

- `Noalm`—No alarm

- `State1`—State 1 alarm

- `State2`—State 2 alarm

- `Input1`—Input 1 alarm

- `Input2`—Input 2 alarm

- `Either`—Alarm in either state

- `Both`—Alarm in both states

- `Chngofst`—Change-of-state alarm

- `Cmmdis`—Command-disagree alarm

The following parameters are also related to digital alarms:

- INPTDIR—Input direction
- OUTIND—Output indication
- ZZTEXT—State 00 text (neither box lit)
- NCMPTXT1 and NCMPTXT2—Noncomplementary inputs text

2.3.1 Summary of Digital States and Alarms

The following chart shows which digital alarm types apply to single-input and dual-input points. The command disagree alarm applies only to digital I/O points.

Applicable Alarm Type	Single Input	Dual Input
Noalm (no alarm)	Yes	Yes
State1	Yes	
State2	Yes	
Input1		Yes
Input2		Yes
Either		Yes
Both		Yes (except MC)
Chngofst (change of state)	Yes (except MC)	Yes (except MC)
Cmmdis (command disagree)	Yes (except EC)	Yes (except EC)

In the chart on the next page,

Input states are given in input 1, input 2 order—input 1 is the subslot specified and input 2 is that subslot plus one.

These abbreviations are used for parameter names and values;

ST1 and ST2 mean STATE1 and STATE2. ZZT means ZZTEXT. CZZT means the complement of the value in ZZTEXT. Inp1, Inp2, Either, and both mean Input1, Input2, Either, and Both, respectively.

The integers in the "LCN Ordinals" column are values that can be accessed by CM60s and CGs to determine the input states of digital points.

For single digital inputs

State Presentation				State Description on Alarm Summary Display			
				State Alarm		Command Disagree	
Input State (PV)	State Text Parameter	Boxes Lit	LCN Ordinal	State 1	State 2	State 1	State 2
0 1	STATE1	Lower	0	STATE1	n/a	n/a	STATE1
1 0	STATE2	Upper	1	n/a	STATE2	STATE2	n/a

Input State: first column = Direct Indication; second column = Reverse Indication

For dual digital inputs

State Presentation				State Description on Alarm Summary Display					
				State Alarm				Commd Disagree	
Input State (PV)	State Text Parameter	Boxes Lit	LCN Ordinal	Input 1	Input 2	Either	Both	State 1	State 2
00 11	ZZTEXT	None	0	n/a	n/a	n/a	n/a	ZZTEXT	ZZTEXT
01 10	STATE1	Lower	1	n/a	ST1	ST1	n/a	n/a	STATE1
10 01	STATE2	Upper	2	ST2	n/a	ST2	n/a		
11 00	CZZT	Both	3	ST2	ST1	STx	CZZT	CZZT	CZZT

Input State: first column = Direct Indication; second column = Reverse Indication

For single digital outputs

State Presentation				
Output State (OP)	State Text Parameter	Boxes Lit	LCN Ordinal	**What Activates Output with Group or Detail Display**
0 1	STATE1	Lower	0	Down Arrow
1 0	STATE2	Upper	1	Up Arrow

Output State: first column = Direct Indication; second column = Reverse Indication

For dual digital outputs

State Presentation				
Output State (OP)	State Text Parameter	Boxes Lit	LCN Ordinal	**What Activates Output with Group or Detail Display**
00 11	"NONE"	None	0	(Not Possible)
01 10	STATE1	Lower	1	Down Arrow
10 01	STATE2	Upper	2	Up Arrow
11 00	"BOTH"	Both	3	(Not Possible)

Output State: first column = Direct Indication; second column = Reverse Indication

2.4 MODE AND ATTRIBUTE HANDLING BY HIWAY GATEWAYS

The Hiway Gateway handles mode-change requests and attributes for CBs, DHPs, ECs, MCs, and PIUs.

- **Attributes**—For data points in CBs, DHPs, ECs, and PIUs, the HG determines the attribute and provides the attribute functions described under 4.5.3, 4.5.5, and 4.5.6 in *System Control Functions*.

- **Normal Mode and Attribute**—The HG handles the normal-mode and normal-attribute functions for data points in CBs, DHPs, ECs, and PIUs (not for MCs). The HG also tracks mode and attribute changes that can occur within MCs.

- **Cascade Requests**—The HG handles cascade requests for data points in CBs, DHPs, MCs, and PIUs.

- **Comparison of Modes in Non-LCN Systems to Modes in LCN-Based Modules and Gateways:**

  For regulatory points in CBs and MCs;

Non-LCN Systems		LCN-Based Systems
MAN		MAN
AUTO		AUTO
CASC	(except algos. 5, 6, and 7)	CAS
CASC	(algos. 5, 6, and 7)	BCAS
COMP	(algos. 5, 6, and 7)	CAS

  Note: The sequence attribute in MCs appears as the Prog attribute in LCN-based modules and gateways.

  For regulatory points in ECs;

Non-LCN System		LCN-Based Systems
MAN		MAN
AUTO		AUTO
CASC	(no COMP function)	CAS
CASC	(with COMP function)	BCAS
COMP		CAS

  For analog I/O points in PIUs;

Non-LCN Systems	LCN-Based Systems
(None)	MAN
(None)	CAS

For analog I/O points in MCs;

Non-LCN Systems	LCN-Based Systems
MAN	MAN
COMP	CAS
SMAN	P-CAS
SCOMP	P-CAS

For analog I/O points in DHPs;

Non-LCN Systems	LCN-Based Systems
MAN	MAN
COMP	CAS

2.4.1 Handling of Cascade Requests and Shedding By HGs

Hiway Gateways provide consistent handling of modes and timers for many types of data points in process-connected boxes through the Cascade Request and Shedding functions. For CBs, DHPs, MCs, and PIUs, Cascade Requests are handled by the HG as follows, to assure consistency with mode handling for ECs:

- The HG maintains a record of the modes for all data points in all CBs, ECs, MCs, and PIUs on its hiway.
- Requests from a US for CAS mode for data points that use PIDCM, PIDCMA, PIDDDC, or PIDSPC algorithms don't immediately change the mode of the point in the box. Instead, the cascade-mode request flag in CASREQ is set. When continuous control in an AM determines that CASREQ contains Request, it requests that the value in MODE be changed to Cas, and changes the value in CASREQ to Notreq. Then this point's primary point in the AM takes over control.

NOTE: DHP and PIU output points in cascade (computer) mode stay in cascade mode after HG shutdown and reload. These points do not shed like CB, EC, and MC points. After HG reload the hiway is in basic control. Although the points are still in cascade mode the AM is unable to store.

2.5 HG BACKUP

2.5.1 HG Failover Scenario

Switching from an active HG to the backup is accomplished with as little disruption to control and data acquisition as is possible. These two factors are very important in failover processing:

- Timeout handling
- Time to restore communication on the Data Hiway.

It takes the backup one second to detect a failure in the active HG. When it does detect a failure, it attempts to directly communicate with the active HG. If this communication isn't re-established within two seconds, the backup requests the error-handling subsystem to determine whether to replace the active HG. While waiting for this replacement, the backup proceeds with the following two functions:

1. Hiway-security checking is started by the backup, and the scanning of the points with the 50 most critical (emergency priority) alarms begins.

2. The timeout gates in the boxes are updated so that control shedding doesn't occur.

When the system error handler determines that the formerly active HG has failed, failover processing continues. The total time to complete the failover is about five seconds.

As failover processing continues, the following takes place:

3. The backup (secondary) becomes active (primary).

4. All functions that receive event messages are notified that failover has occurred and the distribution of the highest-priority alarms begins.

5. Requests for data from the hiway are processed according to these priorities:

   - Control-function requests
   - Operator-initiated requests
   - Display updates.

6. Alarms other than the 50 critical alarms are processed.

7. Remaining requests for data from the hiway are processed.

8. All remaining functions resume, including checkpointing of HG data, history collection, and trending.

2.6 HG DATA POINT CAPACITY

The following are configuration limits and restrictions that apply to HG data points.

2.6.1 Total HG Point Capacity

The maximum number of data points that can be built for an HG (or HG pair) is 3,000.

2.6.2 Composite Points in One Box

Composite Analog I/O and Composite Digital I/O points must be configured for the same HG and the same process-connected box. The input and the output cannot be in different boxes. See 3.1 and 3.2.

2.6.3 Fifty Points With Critical Alarm Status

Effective with Release 301, up-to-50 data points can be configured for critical alarms (parameter CRITSCAN contains "ON" for such points). These points are specially checked on HG startup or failover to see if an alarm has been detected during the failover operation. During failover, alarms that have a status of CRITSCAN = OFF are not distributed. In normal operation, points with CRITSCAN = ON are scanned by the HG at one-half-second intervals.

The parameter ALPRIOR can still be configured with a value of "EMERGNCY." The number of these is unlimited.

2.6.4 Momentary ("Doorbell") Digital Points

HGs can have up to 500 momentary digital output points.

2.6.5 Analog Input Points

HGs can have up to 3,000 analog input points.

2.6.6 Calibration-Offset Points

Up to 250 data points can be configured for a calibration offset. This offset is configured in the CALIBOFF parameter. If CALIBOFF contains 0.0, there is no calibration offset.

2.6.7 Points With Event-Initiated Processing

HGs can have up to 600 EIP points. (4.2 in *System Control Functions*.)

2.6.8 Remote Variable (RV) Points

Alarm detection can be configured for up to 100 RV points in Basic Controllers. Alarm detection for up to 500 RV points can be configured for HGs.

2.6.9 Contact-Cutout Secondary Points

Up-to-500 points can be configured as secondary cutout points (4.3.1.7 in *System Control Functions*).

2.6.10 Control Counter Points

Up to 100 HG control counter points can be configured. (See 3.4.1.)

2.7 SPECIAL HG FUNCTIONS

This subsection defines specific control functions that are performed by the HGs. The purpose of the section is to clarify that though these functions may be covered elsewhere in the System, HG, and AM Control Functions publications, they are accomplished by the HG.

2.7.1 Functions Related to Process-Connected Boxes

2.7.1.1 Box Startups

The HG handles the necessary initialization for all process-connected boxes.

As PIUs are started, "garbage" alarms from the PIUs are suppressed.

After downloading the database to a CB, EC, MC, or if "past mode recall" is configured (PSTMODE = Pastmr), the HG restores the mode of the data points (slots) from a checkpoint file in a History Module, if one is available.

2.7.1.2 Control Timeout Function

For the CBs, DHPs, MCs, and PIUs the HG provides a timeout function similar to that of the EC. The box-level timeout gates are automatically updated by the HG as long as the box is in the "full control" state, secondary points in the box are in CAS mode, and their primary points in an AM continue to supply new SP or OP values to their secondary points. In addition, each slot can be assigned (parameter TOGINTSL) to one of two time intervals configured for its box (BOXTOGn). These intervals are the timeout periods for the slot. A write to the SP or OP parameter of a slot resets the timer.

2.7.1.3 General Parameter Access

The HG provides access to all accessible parameters in the boxes on its hiway. The HG returns an error indication if an invalid access request is made.

2.7.1.4 PV Source Selection

The HG provides selection of PV sources for all analog input, digital input and regulatory data points, that is similar to that described for AM Regulatory points, under 7.5.5.4. For regulatory points, PV source changes are permitted only when the data point is in the MAN mode. While the PV source is manual or substituted, mode changes are inhibited. Access to the PV Auto value is available when the PV source is manual or substituted. Values of PV MAN and PV SUB are limited to the PV range. While the PV source is manual or substituted, PV alarms are inhibited. A bump in the PV can occur when changing from SUB to AUTO.

When PVSOURCE equals MAN or SUB, the manually entered or substituted PV value is held in the HG, while the PV in the box (visible at the LCN as PVAUTO) is unaffected. Alarm checking continues on the PV in the box. Note that any access of the PV that does not go through the HG, (e.g., CL/MC or SOPL programs, Operator Stations) views the box PV value, not the manually entered or substituted value.

2.7.1.5 Clamping

If PV clamping is configured for a data point in a box (PVCLAMP = Clmp), clamping is handled by the HG. For the full-range clamp option, the PV is clamped at -2.9% of the range when the variable goes below that value, and it is clamped at 102.9% if the variable goes above that value. A zero-clamp option is also available where the PV is clamped at 0% of the range if the variable goes below that value.

2.7.1.6 Reverse-Acting Transmitter Handling

The HG accommodates reverse-acting transmitters (see parameters CTLACTN and OUTIND in the *Hiway Gateway Parameter Reference Dictionary*).

2.7.1.7 PV Value Status

Value status is assigned to all analog PVs by the HG. A bad value status is assigned if the PV is outside the range and the extension and clamping is not configured, or if the PV is not available from the box. The value status is uncertain when the PV is clamped or the PV source is other than auto. When the PV status is bad, the PV value is NaN (not a number).

2.7.1.8 Mode Handling After Downloading

After downloading a box, the HG restores the modes of all points in the box as follows:

- Past-Mode Recall Configured (PSTMODE = Pastmr)—to the checkpointed mode, if a checkpoint file is available in an HM.
- Past-Mode Recall Not Configured (PSTMODE = Nopastmr), or a checkpoint file not available—to MAN mode.

2.7.1.9 C-Link Support

The HG maintains the C-Link database. An HG can handle up-to-16 C-Links.

2.7.2 RV Inputs to Basic Controllers

RV inputs to Basic Controllers (CBs) can be configured as analog input data points.

2.7.3 Regulatory Data Points

2.7.3.1 Raw PV Access

The HG permits read access to raw PV in CBs, MCs, and ECs, as it is after input filtering and, if configured, after square-root extraction. The raw PV is available only in percentage of full scale.

2.7.4 Process Modules

The HG maintains the Process Module database.

DETAILED DATA POINT DESCRIPTIONS
Section 3

This section provides a definition of the functions of the ten types of HG data points. The algorithms for HG regulatory data points are defined in the Algorithm Engineering Data publications. See Section 1, "References."

3.1 HG ANALOG I/O DATA POINTS

Analog I/O data points represent analog inputs from the process and analog outputs to the process. The inputs and outputs are connected to process-connected boxes on a Data Hiway.

3.1.1 Analog I/O Point Types

There are three types of analog I/O data points:

- Analog Input—one input from the process.

- Analog Output—one output to the process.

- Analog I/O Composite—one input and one output with the same tag name. The input slot (and subslot) and the output slot (and subslot) must be in the same process-connected box (DHP, HLPIU, or MC).

3.1.2 Analog I/O Point Residences

An analog input point is an HG point whose input slot is in one of the following process-connected boxes:

- Basic Controller
- Multifunction Controller
- High Level, Low Level, and Low Energy PIUs
- Programmable controllers interfaced by DHP

The input and output slots for analog I/O composite data points must be in the same process-connected box.

3.1.3 Functional Structure of Analog I/O Points

- Analog input points have one wired input and produce a PV with point status and PV status.

- Analog output points have one output (OP) with related status and mode parameters. OP produces one wired output to the process.

- Analog I/O composite points combine one analog input and one analog output in one data point with one tag name. They are intended to support displays and applications that use an output with position feedback. They have an output value with its status and an input PV with its status.

Table 3-1 — Point Types Applicable to Each Box

Point type	CB	MC	HLPIU	LLPIU	DHP LEPIU	HG
Analog Input	RVs	x	x	x	x	-
Analog Output	-	x	x	-	x	-
Analog Composite	-	-	-	-	-	x
Where: x means point type is available for that box type - means point type is not defined for this box type						

3.1.4 Function Residences for Analog I/O Points

The analog data point functions reside both in process-connected boxes and in the HG. The place where each function resides depends on the type of the box configured to handle the input or the output. To the user, these functions are not significantly different whether they reside in the box or in the HG.

The following chart shows where each major analog output function resides.

Analog Output Function	Box
• Mode Translation	PIU,MC,DHP
- Normal Mode	PIU,MC,DHP
- Cascade Request	PIU,MC,DHP
• Timeout Gate	PIU,MC,DHP
• Red Tag	PIU,MC,DHP

The following chart shows where each major analog input function resides.

Analog Input Function	For these boxes, resides in HG	For these boxes, resides in the box
• Data Acquisition		
- PV		PIU,CB,MC,DHP
- Input Accumulation		MC
• Alarm Type		
- Bad PV	PIU, MC,DHP	
- Deviation Hi/Lo		PIU,CB,MC*,DHP
- PV Hi/Lo		PIU,CB,MC,DHP
- PV Rate of Change		PIU
- RV Hi/Lo	CB (100 points, only)	
- Open Thermocouple		

* except AI accumulation

(Analog input chart continued)

Analog Input Function	For these boxes, resides in HG	For these boxes, resides in the box
• Alarm States		
- Alarm Cutout	PIU,CB,MC,DHP	
- Alarm Enable, Disable, Inhibit	PIU,CB,MC,DHP	
• Unit Alarm States		
- Alarm Enable, Disable, Inhibit	PIU,CB,MC,DHP	
• Alarm Level	PIU,CB,MC,DHP	
• Alarm Priority	PIU,CB,MC	
• Digital Filtering		CB,MC,DHP
• EU Conversion	PIU,CB,MC,DHP	
• Linearization & Characterization	PIU,CB,MC,DHP	
• Execution State	PIU,CB,MC,DHP	
• Input Calibration Correction	PIU,CB,MC,DHP**	
• PV Source Selection	PIU,CB,MC,DHP	
• PV Value Status	PIU,CB,MC,DHP	
• PV Clamping Option	PIU,CB,MC,DHP	
• PV Target Value	PIU,CB,MC,DHP	
• EIP	PIU,CB,MC,DHP	

** For only 250 points

3.1.5 Processing Order for Analog I/O Points

Because individual analog I/O data-point functions reside in different physical locations and the functions are distributed between the boxes and the HG, there is no apparent processing order.

3.1.6 PV Linearization and Characterization for Analog I/O Points

PVs received from nonlinear transmitters in the process can be characterized by configuring an appropriate value in parameter PVCHAR, which can have one of the following values:

- For Thermocouple Inputs;

Value	Thermocouple Type	Temp. Range, CB, MC, HLPIU, Deg. C
JTherm	Type J	-73.3 to 1093.3
KTherm	Type K	371.1 to 1371.1
TTherm	Type T	-184.4 to 389.9
STherm	Type S	-17.8 to 1760.0
ETherm	Type E (MC and EC only)	-200.0 to 1000.0
RTherm	Type R (MC and EC only)	-50.0 to 1760.0
RPTherm	Type R' (MC and EC only)	0.0 to 1770.0
BTherm	Type B (MC and EC only)	800.0 to 1700.0

- For RTD Inputs;

Value	RTD Type	Temperature Range		
CopprRTD	Copper			
NICKLRTD	Nickel			
BURNSRTD	Burns	-184.4	to	648.9
RADIAMAT	Radiamatic	593.3	to	1760.0
JISRTD	JIS RTD Curve	-200.0	to	630.0
DINRTD	DIN RTD Curve	-212.2	to	648.9

For linear PV inputs, PVCHAR is configured with Linear and INPTCOND also contains Linear. For square law inputs, such as from differential-pressure flow transmitters, INPTCOND is configured to contain SqrRoot, and PVCHAR to contain Linear.

NOTE

For revision 1C Basic Controllers, if INPCOND contains SqrRoot, PVRNGOP must contain ClmpZero (see 3.1.8).

3.1.7 PV Source Selection for Analog I/O Points

Parameter PVSOURCE indicates one of three sources for the PV. It can contain Auto, Man, or Sub. These values indicate which source is in effect, as follows:

- Auto—The PV is obtained from its configured source, as indicated by PVSLTSRC and PVSIGNAL. In this case, other points and user programs can't change the PV value.

- Man—The PV is a value entered by a Universal Station operator. The operator-entered value is checked against its configured limits and if the PV exceeds one of those limits, the value is clamped at the limit. Either an operator or a user-written program can change the PV source to Man. The operator can't change the Man value while the source is Auto. No alarm checks are made on the Man value; however, alarm checking on the PV continues.

- Sub—The PV value is entered by a user-written program. The program-entered value is checked against the configured range limits and if the PV exceeds one of those limits, the value is clamped at the limit. Either an operator or a user-written program can change the PV source to Sub. The Sub value can't be changed while the PV source is Auto. No alarm checks are made on the Sub value.

There are no interlocks to prevent switching from Auto to Man or Sub PV sources at any time. When the PV source is switched from Auto to Man, the initial Man value is made equal to the Auto value, so there is no initial bump in the value. Likewise, when the PV source is switched from Auto to Sub, the initial Sub value is made equal to Auto. A bump in the PV can occur when switching from Man or from Sub to Auto.

The current PV source for each data point is available in data point parameter PVSOURCE for displays or printing.

NOTE

For more information on the parameters mentioned in the following paragraphs, including value types, value ranges, default values, and access levels, refer to the *HG Parameter Reference Dictionary*.

3.1.8 PV Range, PV Clamping Options, and PV Value Status

The following parameters specify PV processing options:

- PVCLAMP—PV Clamping Option. Values are NoClamp and Clamp. Access level is Engineer.
- PVRNGOP—PV Range Option. Values are None, FullRng, and ClmpZero. Access level is Engineer.
- PVSOURCE—The source of the PV. Values are Auto, Man, and Sub. Access level is Supervisor.

These parameters indicate the results of PV processing:

- PV—The Process Variable. Value range is specified in PVRNGOP.
- PVSTS—PV Value Status. Values are Normal, Uncertn, and Bad.
- PVEXHIFL—PV Extended High Range Flag. Values are True and False.
- PVEXLOFL—PV Extended Low Range Flag. Values are True and False.

The functions of these parameters are as follows:

- PVCLAMP

  If PVCLAMP = NoClamp, and the PV is outside the range indicated by PVRNGOP, PVSTS = Bad.

  If PVCLAMP = Clamp, and the PV is outside the range indicated by PVRNGOP, PVSTS = Uncertn.

  The value in PVCLAMP affects the status indicated by PVSTS.

- PVRNGOP

  If PVRNGOP = None, the extended range of the PV value is from -6.9% to 106.9%.

  If PVRNGOP = FullRng, the extended range of the PV value is from -2.9% to 102.9%.

  If PVRNGOP = ClmpZero, the extended range of the PV value is from 0 to 102.9%.

- PVSOURCE

  If PVSOURCE = Auto, the PV is obtained from its configured source, as indicated by PVSLTSRC and PVSIGNAL.

  If PVSOURCE = Man, the PV value is entered by a Universal Station operator.

  If PVSOURCE = Sub, the PV value is entered by a user-written program.

- PVEXHIFL—If the PV is above the high end of the extended range, as specified in PVRNGOP, PVEXHIFL = True. Otherwise it is False.

- PVEXLOFL—If the PV is below the low end of the extended range, as specified in PVRNGOP, PVEXLOFL = True. Otherwise it is False.

- PV—Normally the value in PV represents the magnitude of the process variable. For range checking and clamping, the PV value in percentage-of-range is used, but the PV can be represented in engineering units on the Universal Station displays. The PVRNGOP and PVCLAMP options affect the PV as follows:

  If PVCLAMP = NoClamp, and the PV is outside the extended range specified by PVRNGOP, the PV value is NaN (not a number).

  If PVCLAMP = Clamp, and the PV is outside the extended range specified by PVRNGOP, the PV value is clamped at the point at which it exceeded the range.

  When the PV is clamped, PVSTS = Uncertn.

- PVSTS

  PVSTS = Normal when these conditions are both true:

  PV is inside the extended range specified by PVRNGOP.

  PVSOURCE = Auto.

  PVSTS = Uncertn when **either** of these conditions is true:

  PVSOURCE contains Man or Sub.

  The PV is clamped because it is outside the extended range specified by PVRNGOP and PVCLAMP = Clamp.

PVSTS = Bad when both of these conditions are true:

PVSOURCE = Auto.

PVCLAMP = NoClamp and the PV is outside the extended range specified by PVRNGOP.

If PVSTS = Bad, the value in PV is NaN.

3.1.9 Analog Output Data Point Modes

Analog Points can be in manual (MAN) or cascade (CAS) modes only. If you need more information about modes, see 4.4.1 in *System Control Functions*.

3.1.10 Point Alarming for Analog Input Points

Alarm checking and reporting for analog inputs is as described under 4.3 in *System Control Functions.*

3.1.11 Event-Initiated Processing for Analog Input Points

Event-initiated processing is enabled when parameter EVENTPRC contains Enable. Parameter EIPEVENT defines the types of events that initiate EIP. EIP is described in detail under 4.2 in *System Control Functions*.

3.1.12 Analog I/O Point Processing

See 3.1.5.

3.1.13 Analog I/O Point Addressing

User-written programs and standard data acquisition and control functions access the analog point parameters, in the process-connected boxes and in the HG, in the same way that parameters anywhere else in the system are accessed: by specifying the data point name and the parameter; for example, `TC101.PV`. If the parameter actually resides in a box, the HG does the actual access to the database in the box.

3.1.14 Analog Input Accumulation Point for the Multifunction Controller

During configuration of an Accumulation type data point in a Multifunction Controller, a numerical value ranging from 1 through 6 must be entered for the paramater AVCONFIG (last page of the Parameter Entry Display).

To determine the value to enter, you must calculate a scaling value, “S,” using the following formula:

S = DA - D

D is selected from the following table according to the parameter PVFORMAT selection on Page 03 of the Parameter Entry Display.

PVFORMAT	D	Decimal Format
D0	0	xxxx.
D1	1	xxx.x
D2	2	xx.xx
D3	3	x.xxx

DA is selected from the table below based on the decimal format required for the maximum accumulated value. The value selected for DA must also be within the range of D-1 to D+2 (so that S will fall in the range of -1 through 2). DA is used only in the calculation; it is not found on the Parameter Entry Display.

AVFORMAT	DA	Decimal Format
	0	xxxxxx.
	1	xxxxx.x
	2	xxxx.xx
	3	xxx.xxx
	4	xx.xxxx
	5	x.xxxxx

Having calculated a value for S, use the following table to determine the entry to be made for AVCONFIG in the PED.

S	AVCONFIG	Maximum Accumulation Time	Time Base
2	1	1 hour	Hours
1	2	10 hours	
0	3	36 hours	
1	4	10 minutes	Minutes
0	5	100 minutes	
-1	6	1000 minutes	

3.2 HG DIGITAL I/O DATA POINTS

A digital input data point provides a PV that represents the state of a single digital input wired to a process-connected box. A digital output data point provides a digital output at a pair of terminals in a process-connected box. A composite digital I/O point provides one or two inputs and one or two outputs in the same data point.

3.2.1 Digital Input Points

3.2.1.1 Digital Input Point Residences

Digital input data points are HG points whose input slots are in DHPs, ECs, HLs, MCs, and PIUs.

The number of digital input data points in an MC is limited by the number of I/O slots that are configured for digital inputs, at 16 for each slot, for a maximum of 16 slots. An EC can have up to 16 digital input points.

For a DHP, the number of digital input points is limited by the number of I/O slots that are configured for digital inputs, at 16 for each slot, for a maximum of 15 slots for a Basic DHP and 30 slots for an Extended DHP.

The number in the PIU is limited by the number of I/O slots that are configured for digital inputs at 16 for each slot, for maximum of 32 slots.

3.2.1.2 Functional Structure of Digital Input Points

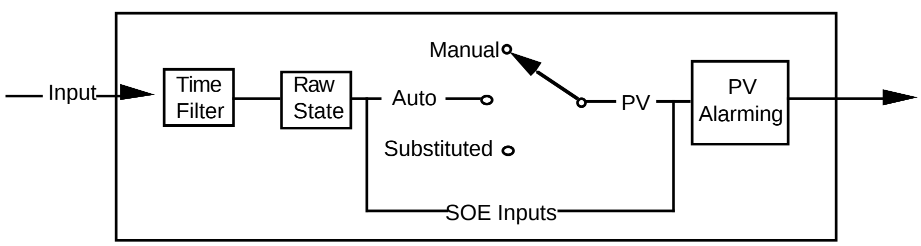


Figure 3-1 — Functional Diagram, Digital Input Data Points 1828

3.2.1.3 Types of Digital Inputs

There are two principle types of digital inputs:

- Sequence-of-events/change-detection inputs monitor events in the process that are represented by changes in the input level or by contact closures or openings.
- Notified-status inputs monitor inputs that tend to remain in one state or another for relatively longer periods of time than SOE/CDs.

A summary of the digital alarm states and the parameters that provide the state descriptors on the Alarm Summary Display are provided under 2.3.1.

3.2.1.3.1 Sequence-of-Events/Change Detection (SOE/CD) Digital Inputs

Sequence-of-events (SOE) and change detection (CD) digital inputs provide monitoring and recording of digital events. SOEs and CDs are similar. The main difference is that SOEs are recorded with the time they occurred ("time-stamped") in milliseconds, and they are stored in an SOE file in an HM for later analysis of the event and the order in which they occurred. CDs are time-stamped, but not with millisecond resolution, and they may be recorded in history files. CDs are usually treated only as events in the process, and their order at the millisecond level is not determined.

SOEs and CDs are received only from HLPIUs. HLPIUs with the SOE feature include an SOE option. Sequences-of-events and change detection inputs can be displayed or printed through the Event History Retrieval display in the Operator Personality.

CAUTION

Do not configure CRITSCAN = ON for Sequence of Events digital input points because critical alarm scanning alters the sequence-of-events time stamp, making it meaningless.

3.2.1.3.2 Notified Status Digital Inputs

Notified-status inputs record changes of state in the digital inputs. They are received from DHPs, ECs, HLPIUs, and MCs.

3.2.1.4 Functional Description

3.2.1.4.1 Input Detection

Input-Voltage Levels, Contact-Bounce Filtering—MCs and PIUs offer a selection of digital input boards to accommodate several different voltage levels and to provide differing degrees of filtering to suppress contact bounces.

The DHP itself has no input signal-conditioning boards, but the programmable controller it interfaces may have them.

Resolution in PIU Inputs for SOE/CDs—The time-stamp resolution for SOE inputs from PIUs depends on the number of input boards that are scanned in the PIU, the input filter constant, and the mix of process I/O boards. Changes in SOE and CD inputs that occur one millisecond apart, or more, can be detected with up-to-24 digital input boards in the PIU. For 32 digital input boards in the PIU, changes 1.3 milliseconds apart can be resolved (detected).

PIU Scanning Rate for Notified-Status Inputs—The PIU scans its digital inputs every 250 milliseconds.

MC Scanning Rate—MCs scan both status digital inputs and latched digital inputs. Status inputs follow the state of the process input. Latched inputs change state when a momentary input (pulse) is received from the process and stays in that state for one second. Status inputs are scanned once each second. Latched inputs can detect a pulse as short as

41.6 milliseconds, but they are processed once each second so they can detect only one pulse each two seconds.

DHP Scanning Rate—The DHP scans its digital inputs at a configurable interval from 1 to 15 seconds in increments of one second. In addition the scanner can be free-running (scanning as fast as its processor can).

3.2.1.4.2 Conversion of Raw Contact Inputs to the PV

The PV for a digital input point has two states, such as on/off or open/closed. You configure a descriptor for each of the two PV states in the STATE1 and STATE2 parameters (see 2.3.1), and when you do, you relate those states to the states of the raw contact-input wired to the process-connected box. These descriptors represent the state of each digital input when they appear on US displays.

3.2.1.4.3 PV Source Selection for Notified-Status Inputs

Parameter PVSOURCE indicates the source of the digital input PV. When PVSOURCE contains Auto, the PV is derived from the process-connected box. When it contains Man, the source is an operator at a US. When it contains Sub, a user-written program or a continuous-control data point provides the PV. See 3.1.7.

PV source selection is not available for SOE/CDs.

3.2.1.4.4 Digital Input Alarms

Digital point alarms are defined under 2.3.

3.2.1.4.5 Event-Initiated Processing

You can configure digital input points for event-initiated processing (EIP—See 4.2 in *System Control Functions*). EIP occurs for each alarm and each return-to-normal. It also occurs for all digital points in HL PIUs and DHPs, when the PV changes state.

3.2.1.4.6 Digital Input Point Functions

Sequence of Events/Change Detect (SOE/CD)

Function	Features
Input detection	Contact-bounce filtering, various input voltage-levels
PV conversion	
Alarming (off normal, change of state)	
SOE	Time-stamping
EIP	
Last reported status	

Notified Status

Function	EC	MC	DHP	PIU	Considerations
Input detection	√	√(1)	√(2)	√(3)	Contact-bounce filtering time, various input voltage levels
PV conversion	√	√	√	√	
PV source selection	√	√	√	√	
Alarming					
Off normal	√	√	√	√	
Change of state	√			√	
EIP	√	√	√	√	
Last reported status	√		√	√	

Notes:
(1) Input detection can be further specified as latched or status
(2) Inputs are scanned at selectable DHP periods or free-running
(3) Scanning period is a function of number of cards within PIU.

3.2.1.5 Initialization of Digital Inputs

Digital input data points are initialized when they are restarted. The initialization functions for inputs from MCs differ from those for inputs from DHPs and PIUs.

3.2.1.5.1 Initialization—Digital Inputs from PIU or DHP

PIUs and DHPs don't initialize in the sense that CBs, ECs, and MCs do. PIUs and DHPs "initialize" to the state of the signals currently applied to the process-input terminals when the box goes from the reset state to the processing state. When a PIU or a DHP is reset, the PV is not available to the HG.

3.2.1.5.2 Initialization—Digital Inputs from MC

Initialization occurs when the MC goes from "idle" to "processing," or when power is reapplied to the I/O file to which the input is connected.

The initial states of the data point are as follows:

- Not in alarm
- Raw input for a latched input is Off (contact assumed to be open).

3.2.1.6 Configuration Notes for Digital Inputs

Any digital input data points with an input from a PIU can be configured as CD, SOE, or notified-status points. The PIU must be configured for last reported status so that inputs are not overwritten during initialization.

3.2.1.7 Digital Input Point Parameter Descriptions

The following are digital input point parameters. Refer to the *Hiway Gateway Parameter Reference Dictionary* for the full names, value ranges, default values, value types, and access levels for these parameters.

ALENBST	NPTDIR	PV
ALMFMT	NPTPSSLT	PVAUTO
ALPRIOR	KEYWORD	PVSOURCE
BOXNUM	LBOXCLR	RAWSTATE
CCPRIPNT	NAME	SLOTNUM
CCRANK	OFFNRMPR	SPECIFI1
CHOFSTPR	OVERVAL	STATE1
CNFERRPR	PCBITI1	STATE2
DIGALARM	PIRCRDTY	UBOXCLR
DIGALFMT	PIUCRDOP	UNIT
DISPTYPE	PNTSTATE	
EIPCODE	PRIMOD	
HIGHAL	PTDESC	

3.2.2 HG Digital Output Data Points

A digital output data point produces either a single or dual output at the designated output terminals in a process-connected box, depending on the value selected for parameter NMBROUT.

3.2.2.1 Digital Output Point Residences

Digital output data points are HG points whose output slots and contacts are in DHPs, HL PIUs, and MCs.

The number of digital output data points in an MC is limited by the number of I/O slots that are configured for digital outputs. There can be up-to-8 for each slot and a maximum of 16 such slots.

For the DHP, the number of digital output data points is limited by the number of I/O slots that are configured for digital outputs. There can be up-to-8 for each slot and a maximum of 15 slots for a Basic DHP or 30 slots for an Extended DHP.

The number of digital output points in PIUs is limited by the number of I/O slots that are configured for digital outputs. There can be up-to-8 for each slot with a maximum of 32 such slots.

In any case, there may be some limitation in number of digital output points that the HG can handle, because of the number and mix of boxes on the hiway, and the types of points in the boxes.

3.2.2.2 Functional Structure

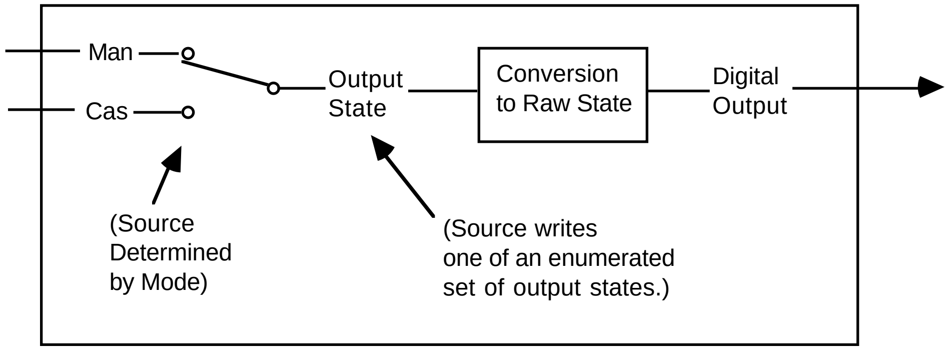


Figure 3-2 — Functional Diagram, Digital Output 1829

3.2.2.3 Digital Output Functional Description

3.2.2.3.1 Digital Output Behavior

Digital outputs have one of three types of behavior:

Momentary (doorbell)—Outputs can be sent from a Universal Station. A momentary output stays in the specified position as long as the operator or engineer continues to press the appropriate key.

Latched—The output remains in the requested position until a new request is issued.

Pulsed—The output remains in the requested state for a configured time. This time is configured for the output board. The pulse transition is always from open contacts to closed contacts. Pulsed digital outputs are not available through the DHP.

3.2.2.3.2 Digital Output Modes and Red Tagging

The source of the output request is determined by the mode, which can be:

- CAS—Output state specified by another data point or by a user-written program
- MANual—Output state specified through a Universal Station.

When an output is defined as "red tagged," the output does not change or pulse, in spite of output requests from a Universal Station or from a user-written program (but change requests from other sources may change the output). See 3.3.13.

3.2.2.3.3 Output State Conversion to Raw Contact Output

The two states of each output are defined by two state descriptors that relate to the state of the device wired to the terminals in the process-connected box. These states could be Open/Closed or Running/Stopped, for example. When you configure a digital output point, you provide the descriptors in the STATE1 and STATE2 parameters, and assign the contact state for each of them. The state descriptors are not applied to pulsed outputs.

3.2.2.3.4 Digital Output Point Functions

The following summarizes digital output data points in each of the process-connected boxes—

Functions	MC	DHP	PIU	Notes
- Output behavior				
Latched	√	√	√	pulse width from MC 16-992 ms.
Pulse	√		√	pulse width from PIU 16-4096 ms.
- Modes/attributes	√	√	√	
- Red tagging	√	√	√	
- Output state conversion	√	√	√	Doesn't apply to pulse outputs.
- PV source	√	√	√	

3.2.2.4 Digital Output Processing

A request for a digital output change is processed at the next processing pass of the DHP, MC, or PIU. The requests are checked against the mode, attribute, and red-tag restrictions by the HG. Once an output-state change is effected by the box, the box does a read-back check to verify the actual output state.

For digital output and digital composite data points that are configured with dual outputs, the HG performs the outputs in a specific sequence that provides break-before-make operation. Following is a description of that sequence for both momentary and latched outputs.

Momentary Outputs—A variable length sequence is transmitted, depending on how long the output change key at the Universal Station keyboard is held down.

When the key is pressed, the following sequence occurs:

(1) Output 2 → Commanded State

(2) Output 1 → Commanded State

As long as the key is held down, this sequence is repeated every second.

When the key is released, the following sequence occurs:

(1) Output 2 → OFF (deactivated)

(2) Output 1 → OFF (deactivated)

Latched Outputs—A fixed sequence of four outputs is transmitted as follows:

(1) Output 2 → OFF (deactivated)

(2) Output 1 → OFF (deactivated)

(3) Output 2 → Commanded State

(4) Output 1 → Commanded State

When the outputs are connected to a PLC through a DHP, the sequences as described are not affected by the PLC addresses that are configured (parameter PCADDROX). Be aware that the output commands are queued and executed in the order received from the HG function. Accordingly, there is no guaranteed timing interval for the outputs, since the DHP is asynchronous from any HG activity. For this reason, momentary outputs are not recommended for DHP digital points.

3.2.2.5 Digital Output Initialization

A digital output point is initialized when it is restarted. During initialization, all three types of process-connected boxes read the actual state of the output and set their internal output-state to the corresponding state. In the case of the DHP, the state of the coil in the programmable controller is read. In the MC and PIU, the state of the output contacts is read. The mode in the DHP is set to the same mode as before the point was initialized.

3.2.2.6 Digital Output Configuration Note

An HL PIU digital output board must be configured for latched outputs if the output data point is to be latched or momentary and the PIU board must be configured for a pulsed output for such outputs. The terms "latched," "pulsed," and "momentary," as they relate to the output boards, are as they are used in the PIU publications.

3.2.2.7 Digital Output Parameter Descriptions

The following are digital output point parameters. Refer to the *Hiway Gateway Parameter Reference Dictionary*, for the full names, value ranges, default values, value types, and access levels for each parameter.

BADCONF	NMBROUT	PNTBOXTY
BOXNUM	NMODE	PRIMOD
RCASCENB	NMODATTR	PTDESC
KEYWORD	OP	PULSEWTH
LBOXCLR	OUTIND	SHEDMODE
MODE	OUTSLTNUM	STATE1
MODEPERM	OUTSSLT	STATE2
MODOUTIND	PCADDO1	UBOXCLR
NAME	PCADDO2	UNIT

3.2.3 HG Digital I/O Composite Data Points

A digital I/O composite data point consists of one or two digital inputs and one or two digital outputs with the same tag name. The input slot (and subslots) and the output slot

(and subslots) must be in the same process-connected box (DHP, HLPIU, or MC). Typically, the inputs show the direct or indirect result of the digital output, on the process device that the output(s) is wired to.

3.2.3.1 Point Residences

Digital I/O composite data points are HG points whose inputs and output are in slots in DHPs, MCs, or PIUs.

The number of digital I/O composite data points operating through a DHP, an MC, or a PIU, or a combination of these boxes, is the same as described under 3.2.1.1 and 3.2.2.1. The HG may impose limits on the number of these points because of the mix of boxes and point types it handles.

3.2.3.2 Functional Structure

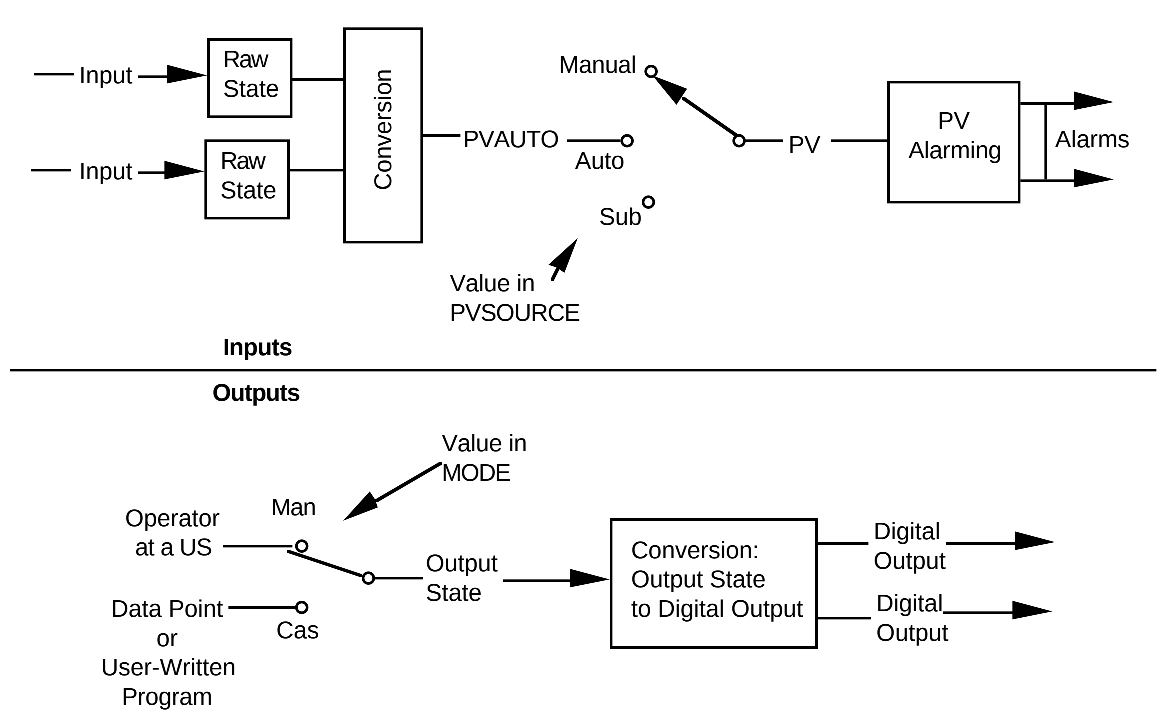


Figure 3-3 — Functional Diagram, Digital I/O Composite Data Point

3.2.3.3 Functional Description

3.2.3.3.1 Digital I/O Composite Data Point—I/O Combinations

Each digital I/O composite data point can be configured for one or two inputs (NMBRINPT) and one or two outputs (NMBROUT).

The functions for the inputs and outputs are essentially the same as for the individual inputs (3.2) and outputs (3.3).

3.2.3.3.2 Input Detection for Digital I/O Composite Points

Input detection is the same as described under 3.2.1.4.1, except that only notified-status inputs are accepted by digital I/O composite data points.

3.2.3.3.3 Conversion of Input(s) to PV(s)

The PV(s) represent the current state(s) of the input signal. A single input can generate two PVs. Dual inputs can generate four PV states. The PV for a digital input point has two states like on/off or open/closed. You configure a descriptor for each of the two PV states in the STATE1 and STATE2 parameters (see 2.3.1), and when you do, you relate those states to the states of the raw contact-input wired to the process-connected box. These descriptors represent the state of each digital input when they appear on US displays. If dual inputs are used, the descriptors for the remaining two states default to Bad and InBetween.

3.2.3.3.4 PV Source Selection for Digital Composite I/O Points

Parameter PVSOURCE indicates the source of the digital input PV. When PVSOURCE contains Auto, the PV is derived from the process-connected box. When it contains Man, the source is an operator at a US. When it contains Sub, a user-written program or a continuous-control data point provides the PV. See 3.1.7.

3.2.3.3.5 Alarming

Digital point alarms are defined under 2.3.

3.2.3.3.6 Event-Initiated Processing for Digital I/O Composite Points

You can configure digital I/O composite points for event-initiated processing. EIP occurs when an alarm is detected or on a return-to-normal. See 4.2 in *System Control Functions.*

3.2.3.3.7 Modes/Attributes/Red Tagging

The source of an output request is indicated by the value in the MODE parameter, which can be

- CAS—Output state specified by another data point or by a user-written program.
- MANual—Output state specified through a Universal Station.

When an output is defined as "red tagged," the output does not change or pulse in spite of output requests from a Universal Station or from a user-written program (but change requests from other sources may cause the output to change). See 3.3.13.

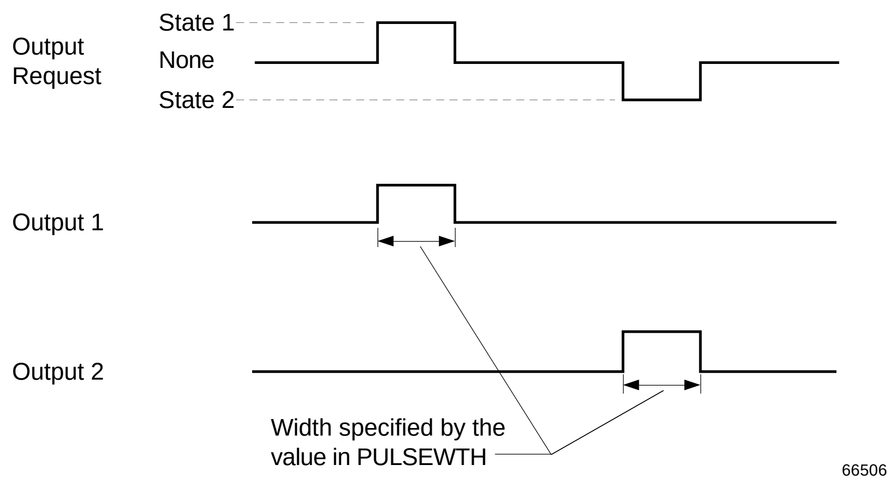
The attributes determine if an operator (Oper) or a user-written program (Prog) can change the mode and the PV when in Manual mode.

3.2.3.3.8 Output State Conversion to Raw Contact Output

The output to the process can have two states. These correspond to the state of the process device, such as Open/Closed or Running/Stopped. You configure a descriptor for each of the two states in parameters STATE1 and STATE2. The descriptors relate the state of the output to the state at the output terminals ("raw" outputs).

3.2.3.3.9 Behavior of Pulse Outputs

The behavior of single and dual outputs is as follows:



3.2.3.3.10 Digital I/O Composite Point Functions

Function	MC	DHP	PIU	Considerations
- Input detection	√(1)	√(2)	√(3)	Contact bounce filtering time, input voltage level
- PV conversion	√	√	√	
- PV source selection	√	√	√	
- Alarms(see 3.2.3.3.5)	√	√	√	
- EIP	√	√	√	
- Output behavior				
Latched	√	√	√	pulse width for MC 16-992 ms
Pulsed	√		√	pulse width for PIU 16-4096 ms
- Modes/attributes	√	√	√	
- Red tagging	√	√	√	
- Output state conversion	√	√	√	

Notes

(1) Input detection can be further specified as latched or status.
(2) Inputs are scanned at selectable DHP periods or free-running.
(3) Scanning period is a function of number of cards in PIU.

3.2.3.4 Processing of Digital I/O Composite Points

Outputs are processed as described under 3.2.2.4.

3.2.3.5 Initialization

Initialization is as described under 3.2.1.5 and 3.2.2.5.

3.2.3.6 Digital I/O Composite Configuration Note

Command-disagree alarms don't apply to single pulsed-outputs.

3.2.3.7 Digital I/O Composite Parameter Descriptions

The following are digital I/O composite point parameters. Refer to the *HG Parameter Reference Dictionary* for the full names, value ranges, default values, value types, and access levels for each parameter.

ALPRIOR	MODOUTIND	PUSLEWTH
BADCONF	NAME	PV
CASCENB	NMBROUT	PVAUTO
CCPRIPN	NMODATTR	PVSOURCE
CCRANK	NMODE	RAWSTATE
CHOFSTPR	OFFNRMPR	SHEMODE
CNFERRPR	OP	SLOTMUM
CMDDISPR	OUTIND	SOTSSLT
DIGALFMT	OUTSLTNM	SPECIFI1
DIGALM	OVERVAL	STATE1
DISPTYPE	PCADD01	STATE2
EIPCODE	PCADD02	UBOXCLR
HIGHAL	PCBITI1	UNIT
INPTDIR	PIRCRDTY	
NPTSSLT	IUCRDOP	
KEYWORD	PNTBOXTY	
LBOXCLR	PNTSTATE	
MODE	PRIMOD	
MODEPERM	PTDESC	

3.3 HG REGULATORY DATA POINTS

Regulatory data points are used to control analog process-variables by maintaining the variable at a setpoint value with as little deviation as possible. By themselves, or in combination with other points, regulatory data points act as controllers that manipulate a process device, such as a valve, to maintain the process variable at the desired value.

In LCN-based **TotalPlant** Solution (TPS) Systems, regulatory data points can reside in Application Modules or in Hiway Gateways (HGs). The information in this section applies only to regulatory data points in HGs.

3.3.1 HG Regulatory Point Residences

HG regulatory points use control slots in Basic Controllers (CBs), Multifunction Controllers (MCs), and Extended Controllers (ECs).

3.3.2 Functional Structure

Each HG regulatory data point uses a slot in a CB, EC, or MC and each such slot executes an algorithm. The algorithm for each slot is configured from the set of algorithms available for the box type. Figure 3-4 is a simplified diagram of the structure of a typical controller slot.

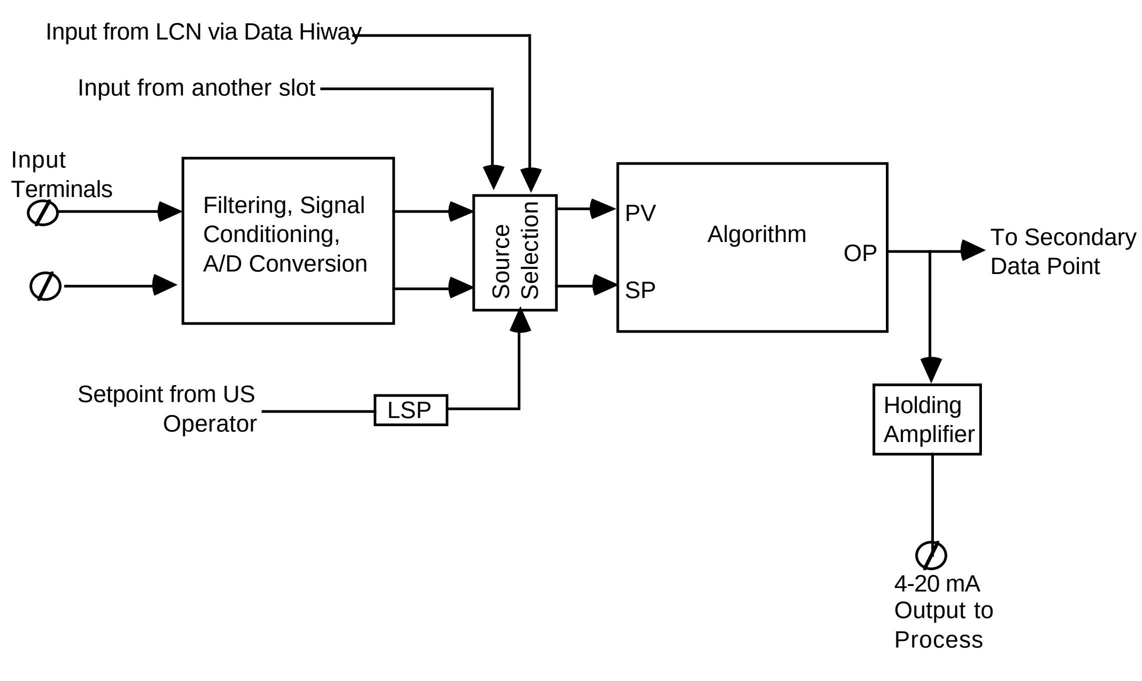


Figure 3-4 — Typical Controller Slot Structure

3.3.3 Processing Order

EC and MC control slots that are in Auto, Cas, or BCas modes are processed in descending slot-number order. If these slots are initializing in MAN mode, or are being initialized because of a request from a secondary data point (Local Manual), they are processed in ascending slot-number order. This arrangement allows points interconnected in a cascade strategy to be processed "downstream," toward the process in normal operation, and "upstream," when they are initialized.

Because of this arrangement, a primary in the same EC or MC should always be configured to be one slot above its secondary's slot number. See Figure 3-5.

CB slots are always processed in ascending slot-number order.

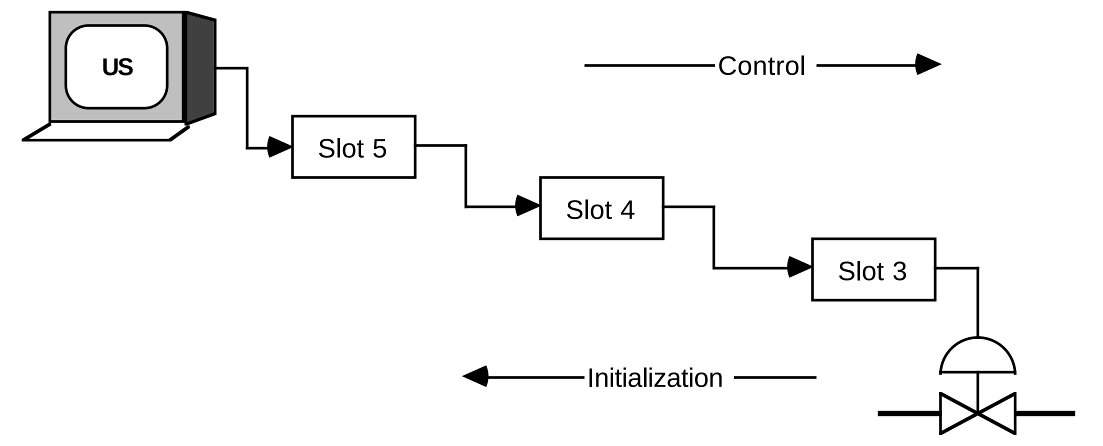


Figure 3-5 — MC and EC Processing Order in a Cascade Strategy

Control processing for each slot occurs at the following intervals:

- CB—Every 1/3-second.
- MC—Every second.
- EC—Every 1/2-second.

3.3.4 HG Regulatory Point Interconnections

Setpoints (SPs), PVs, and other inputs to controller slots can be configured by specifying the tag name of the source slot and the name of the source parameter in that slot. These inputs are not configured in the TagName.Param form used for modules on the LCN, but are configured on the forms and Parameter Entry Displays (PEDS) as a source name and a signal name. For example, a PV input to a CB slot might be configured as follows:

PVSLTSRC = FC100

and

PVSIGNAL = PV.

In this case, the source is the PV parameter in data point FC100. This data point must be in another slot in this box.

To configure the PV to come from this slot's PV terminal, PVSLTSRC would be configured with this point's tag name, and PV signal would contain PV.

The parameter names for the slot source and the signal are in the same form as for other inputs that a given slot and algorithm might have. For example, the SP input is configured in SPSLTSRC and SPSIGNAL.

Output connections, as in AM regulatory data points, are not configured for HG regulatory points. The output of a data point can be connected to the input of an HG point by specifying the tag name of the source point in the destination point's xxSLTSRC parameter, and specifying Output (OP) as the source parameter.

3.3.5 PV Processing for Regulatory Points

3.3.5.1 PV Linearization and Characterization

PVs received from nonlinear transmitters in the process can be characterized by configuring an appropriate value in parameter PVCHAR, which can have one of the following values:

- For Thermocouple Inputs

Value	Thermocouple Type	Temp. Range, CB, MC, HLPIU, Deg. C
JTherm	Type J	-73.3 to 1093.3
KTherm	Type K	-73.3 to 1371.1
TTherm	Type T	-184.4 to 389.9
STherm	Type S	-17.8 to 1760.0
ETherm	Type E (MC and EC only)	-200.0 to 1000.0
RTherm	Type R (MC and EC only)	-50.0 to 1760.0
RPTherm	Type R' (MC and EC only)	0.0 to 1770.0
BTherm	Type B (MC and EC only)	800.0 to 1700.0

- For RTD Inputs

Value	RTD Type	Temp. Range, CB, MC, HLPIU, Deg. C
CopprRTD	Copper	
NICKLRTD	Nickel	
BURNSRTD	Burns	-184.4 to 648.9
RADIAMAT	Radiamatic	593.3 to 1760.0
JISRTD	JIS RTD Curve	-200.0 to 630.0
DINRTD	DIN RTD Curve	-212.2 to 648.9

For linear PV inputs, PVCHAR is configured with Linear and INPTCOND also contains Linear. For square law inputs, such as from differential-pressure flow transmitters, INPCOND is configured to contain SqrRoot, and PVCHAR to contain Linear.

NOTE

For revision 1C Basic Controllers, if INPCOND contains SqrRoot, PVRNGOP must contain ClmpZero (see 3.3.5.2).

3.3.5.2 PV Source Selection for Regulatory Points

Parameter PVSOURCE indicates one of three sources for the PV. It can contain Auto, Man, or Sub. These values indicate which source is in effect, as follows:

- **Auto**—The PV is obtained from its configured source, as indicated by PVSLTSRC and PVSIGNAL. In this case, other points and user programs can't change the PV value.

- **Man**—The PV is a value entered by a Universal Station operator. The operator-entered value is checked against its configured limits, and if the PV exceeds one of those limits, the value is clamped at the limit. Either an operator or a user-written program can change the PV source to Man. The operator can't change the Man value while the source is Auto. No alarm checks are made on the Man value; however, alarm checking on the PV continues.

- **Sub**—The PV value is entered by a user-written program. The program-entered value is checked against the configured range limits, and if the PV exceeds one of those limits, the value is clamped at the limit. Either an operator or a user-written program can change the PV source to Sub. The Sub value can't be changed while the PV source is Auto. No alarm checks are made on the Sub value.

There are no interlocks (except for EC) to prevent switching from Auto to Man or Sub PV sources at any time. When the PV source is switched from Auto to Man, the initial Man value is made equal to the Auto value, so there is no initial bump in the value. Likewise, when the PV source is switched from Auto to Sub, the initial Sub value is made equal to Auto.

The current PV source for each data point is available in data point parameter PVSOURCE for displays or printing.

> **NOTE**
>
> For more information on the parameters mentioned in the following paragraphs, including value types, value ranges, default values, and access levels, refer to the *HG Parameter Reference Dictionary*, in the *Implementation/Hiway Gateway - 1* binder.

3.3.5.3 PV Range, PV Clamping Options, and PV Value Status

The following parameters specify PV processing options:

- PVCLAMP—PV Clamping Option. Values are NoClamp and Clamp. Access level is Engineer.

- PVRNGOP—PV Range Option. Values are None, FullRng, and ClmpZero. Access level is Engineer.

- PVSOURCE—The source of the PV. Values are Auto, Man, and Sub. Access level is Supervisor.

These parameters indicate the results of PV processing:

- PV—The Process Variable. Value range is specified in PVRNGOP.
- PVSTS—PV Value Status. Values are Normal, Uncertn, and Bad.
- PVEXHIFL—PV Extended High Range Flag. Values are True and False.
- PVEXLOFL—PV Extended Low Range Flag. Values are True and False.

The functions of these parameters are as follows:

- PVCLAMP

  If PVCLAMP = NoClamp, and the PV is outside the range indicated by PVRNGOP, PVSTS = Bad.

  If PVCLAMP = Clamp, and the PV is outside the range indicated by PVRNGOP, PVSTS = Uncertn.

  The value in PVCLAMP affects the status indicated by PVSTS.

- PVRNGOP

  If PVRNGOP = None, the extended range of the PV value is from -6.9% to 106.9%.

  If PVRNGOP = FullRng, the extended range of the PV value is from -2.9% to 102.9%.

  If PVRNGOP = ClmpZero, the extended range of the PV value is from 0 to 102.9%.

- PVSOURCE

  If PVSOURCE = Auto, the PV is obtained from its configured source, as indicated by PVSLTSRC and PVSIGNAL.

  If PVSOURCE = Man, the PV value is entered by a Universal Station operator.

  If PVSOURCE = Sub, the PV value is entered by a user-written program.

- PVEXHIFL—If the PV is above the high end of the extended range, as specified in PVRNGOP, PVEXHIFL = True. Otherwise it is False.
- PVEXLOFL—If the PV is below the low end of the extended range, as specified in PVRNGOP, PVEXLOFL = True. Otherwise it is False.
- PV—Normally the value in PV represents the magnitude of the process variable. For range checking and clamping, the PV value in percentage-of-range is used, but the PV can be represented in engineering units on the Universal Station displays.

The PVRNGOP and PVCLAMP options affect the PV as follows:

If PVCLAMP = NoClamp, and the PV is outside the extended range specified by PVRNGOP, the PV value is NaN (not a number).

If PVCLAMP = Clamp, and the PV is outside the extended range specified by PVRNGOP, the PV value is clamped at the point at which it exceeded the range.

When the PV is clamped, PVSTS = Uncertn.

- PVSTS

  PVSTS = Normal when these conditions are both true:

  PV is inside the extended range specified by PVRNGOP.

  PVSOURCE = Auto.

  PVSTS = Uncertn when either of these conditions is true:

  PVSOURCE contains Man or Sub.

  The PV is clamped because it is outside the extended range specified by PVRNGOP and PVCLAMP = Clamp.

  PVSTS = Bad when both of these conditions are true:

  PVSOURCE = Auto.

  PVCLAMP = NoClamp and the PV is outside the extended range specified by PVRNGOP.

  If PVSTS = Bad, the value in PV is NaN.

3.3.6 Setpoint Handling

Setpoint handling, as in AM regulatory points, does not apply to HG regulatory points. Some of the controller algorithms do apply ratio or bias values to the SP. These functions are defined in the following Algorithm Engineering Data publications:

- **Basic Controller**, *CB Algorithm Engineering Data*
- **Multifunction Controller**, *MC Algorithm Engineering Data*
- **Extended Controller**, *EC Algorithm Engineering Data*

These publications are in the *Product Manual* binders in the Basic System bookset.

3.3.7 HG Regulatory Point Alarms

The particular mix of alarms to be generated for an HG regulatory point is configured in parameter ALMFMT. This parameter has a range of values that offers 21 different combinations of alarm types; however, the number of permitted combinations is limited by the box type and the algorithm configured for each slot. These combinations are defined in the *Data Hiway, Box/Slot, and Data Point Form Instructions,* in the *Implementation/Hiway Gateway - 1* binder.

Parameter HIGHAL indicates the type of the highest alarm present for a data point. This parameter has a large number of enumerations as possible values. Some examples are DevLo, DevHi, PVRocN, PVRocP, PVHi, PVLl, and BadPv. The actual alarm types that can be generated by an HG regulatory point are determined by the box type, the algorithm, and ALMFMT.

For further information on alarms, see 4.3 in *System Control Functions*.

3.3.8 Limits in HG Regulatory Data Points

In addition to the PV range and clamping options, which are described under 3.3.5.3, many HG regulatory points provide limits on values, such as setpoint limits, limits on integral control action, and output limits. These depend on the box type and algorithm and are defined in the Algorithm Engineering Data publications, which are listed under 3.3.6.

3.3.9 Initialization of HG Regulatory Points

Parameter INITCONF indicates whether or not the HG point is to participate in initialization. Its values are NoInit, or Init. This is a configurable parameter whose access level is Engineer.

The initialization functions for an HG regulatory point are dependent on the box type and algorithm, and are defined in the Algorithm Engineering Data publications, which are listed under 3.3.6.

For general information about initialization, see 3.3.1.3 in *System Control Functions*.

3.3.10 Wind-Up Protection in HG Regulatory Points

HG regulatory points that use PID algorithms are protected from windup caused by reset action. The specific functions depend on the box type and the specific PID algorithm. These are defined in the discussions on integral limits in the Algorithm Engineering Data publications, which are listed in Section 1. Current wind-up status for each point is indicated in parameters ARWNET and ARWOP.

The integral-limit values are specified in parameters ITLOLM and ITHILM. These are configurable parameters with Supervisor access level.

For general information about windup protection, see 3.3.1.5 in *System Control Functions*.

3.3.11 Override Control in HG Regulatory Points

Several of the controller algorithms, including PIDs and selectors, can participate in override control strategies. Those which do participate, and their specific functions, are determined by the box types and algorithms. These are defined in the discussions on override limiting in the Algorithm Engineering Data publications, which are listed under 3.3.6.

Parameter PTORST indicates whether a data point is connected to an override selector point, and if so, whether or not this point is selected. Its values are Sel, and NotSel. This is a read-only parameter and is not configurable.

There are several configurable parameters that relate to override control in the Override Selector algorithms. These parameters and their values are described in the *Hiway Gateway Parameter Reference Dictionary*.

There is an extensive discussion on override control under 3.1.11 in *Application Module Control Functions*. While this discussion doesn't directly apply to HG points, the guidelines for using and configuring override strategies, particularly those under 3.1.11.3, are generally applicable.

3.3.12 Modes and Attributes

Modes and attributes are defined under 4.13. The following are the parameters related to these functions in HG regulatory points:

- MODE – The current mode—Values are Man, Auto, Cas, and Bcas. A configurable parameter whose access level is Operator.
- MODEATTR – The current attribute—Values are Operator and Program. A configurable parameter whose access level is Operator.
- NMODE – The normal mode for this point—Values are Man, Auto, Cas, Bcas, and None. A configurable parameter whose access level is Engineer.
- NMODATTR – Normal attribute—Values are Operator, Program, and None. A configurable parameter whose access level is Engineer.

3.3.13 Red Tagging

Parameter REDTAG specifies if a "red tag" is in effect on this HG regulatory point. REDTAG has values of Off or On. Off allows the output of this data point to move because of changes made through Universal Stations or control functions that reside in modules or gateways on the LCN. On prevents such changes.

WARNING

The red tag function prevents changes to the output only from LCN sources (US, AM, CM60, CG). It is still possible that the output could be changed by control functions that reside in the process-connected boxes or from Operator Stations on the Data Hiway.

3.3.14 HG Regulatory Point Parameters

The following parameters are common to all HG regulatory data point parameters. Refer to the *Hiway Gateway Parameter Reference Dictionary* for more information on the values, default values, and access levels of these parameters.

ALGIDDAC	MODEATTR	PVHIPR
ALMFMT	NAME	PVLLLPR
BADPVPR	NOOATTR	PVLLPR
BOXNUM	OFFST1PR	PVLOPR
CALIBOFF	OFFST2PR	PVP
CCPRINPT	OFFST3PR	PVRAW
CCRANK	OP	PVRNGOP
CMPSHDPR	OUTIND	PVROCNPR
CTLEQN	OVERVAL	PVROCPPR
DEVHHHPR	PNTBOXTY	PVROCPR
DEVHHPR	PSTMODE	PVSIGNAL
DEVHIPR	PTDESC	PVSLTSRC
DEVLLLPR	PTDISCL	PVSOURCE
DEVLLPR	PTORST	PVSTS
DEVLOPR	PV	PVTEMP
EUDESC	PVCLAMP	REDTAG
HIGHAL	PVEUHI	S4LOGCPR
HWY	PVEULO	SLOTNUM
INITMAN	PVEXHIFL	SUPPIO
INPCOND	PVEXLOFL	TD
KEYWORD	PVFORMAT	UNIT
LOADDEST	PVP	
LSP	PVHHHPR	
MODE	PVHHPR	

In addition, HG regulatory points have several parameters that are related to the configured algorithm. These are listed for each box type and algorithm in the *Hiway Gateway Parameter Reference Dictionary*.

3.4 HG COUNTER DATA POINTS

Counter data points acquire or accumulate real numbers in a digital counter. Each counter counts pulses at its input. The inputs are typically from instruments like pulse-type flow meters, speedometers, or event counters.

3.4.1 HG Counter Point Residences

HG counter data points use counter slots in DHPs, HLPIUs, or MCs.

The number of counter data points for each slot (card) is limited as follows:

HLPIUs—Eight counters for each 16-bit counter card.

MCs—Limited by the number of pulse input cards in a point card file. Eight counters on each card.

DHPs—Limited by the number of configured timer/counter slots. There can be eight counters for each timer/counter slot.

It is possible that fewer counters than these limits will be practical because of the mix of boxes on the hiway and the HG's load.

AM counter data points use a control-counter point in an HG. The control-counter point gets its input counts from a standard HLPIU-counter subslot. The operation of the control-counter point is described under 3.3 in *Application Module Control Functions*.

3.4.2 Functional Structure, HG Counter Point

The structure of an HG counter that uses an MC counter subslot is shown on Figure 3-6.

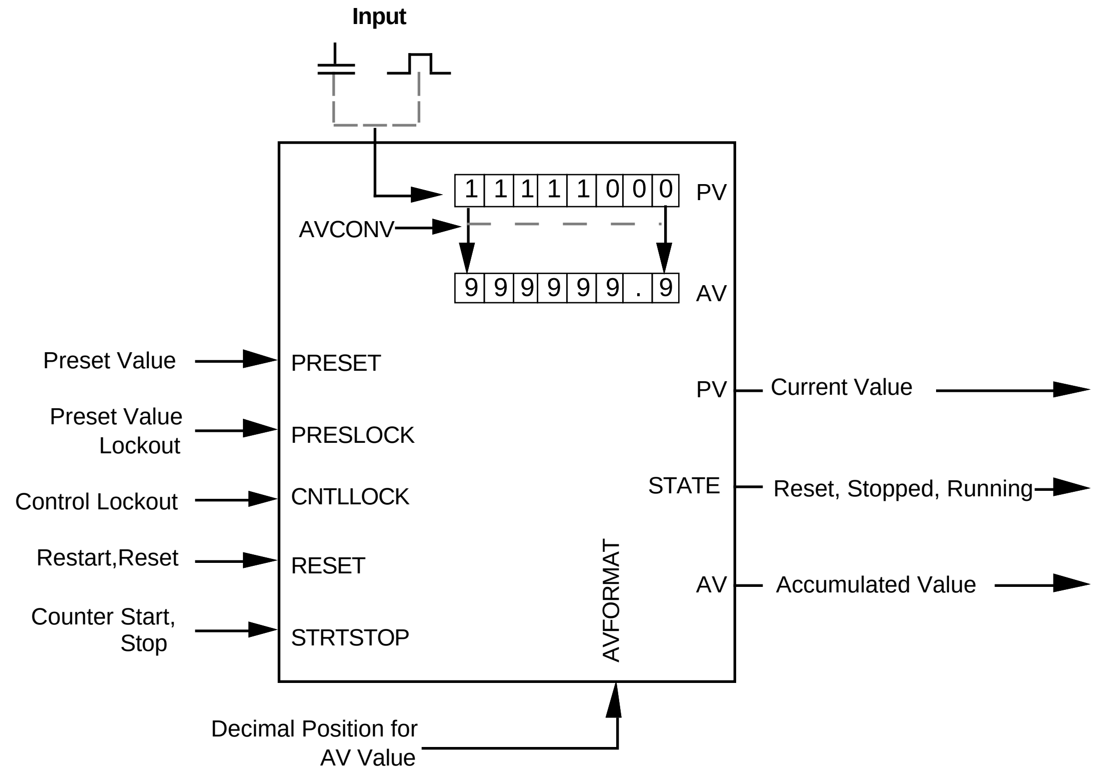


Figure 3-6 — Functional Diagram, MC Counter

3.4.3 MC Counter Functions

The MC counter provides the current pulses per second value in parameter PV and an accumulated counts value in engineering units in parameter AV. The accumulated value (AV) is incremented as defined by the scale factor in AVCONV. The initial AVCONV value is configured and its value can be changed at a Universal Station by someone with an engineer's key.

If parameter CNTLLOCK contains Permit, an operator at a Universal Station can start and stop the counter through parameter STRTSTOP. If PRESLOCK contains permit, an operator can preset the accumulation value by placing a value in PRESET.

When the counter is started, the AV value accumulates toward the value in PRESET. A prealarm value can be placed in PDEVTP to warn the operator that AV is near the value in PRESET. When the value in PRESET is reached, another alarm is generated to indicate that AV is at or above the preset value. AV overflows at 999,999.0 units.

The current state of the counter is available in STATE, which can contain Reset, Stopped, or Running.

3.4.3.1 MC Counter Parameters

The following are the MC counter parameters. Refer to the *Hiway Gateway Parameter Reference Dictionary*, for the full names, value ranges, default values, value types, and access levels for each parameter.

ALPRIOR	EIPENB	PRESLOCK
AV	EIPPCODE	PRIMMOD
AVCONV	EUDESC	PRPRSTPR
AVFORMAT	HIGHAL	PTDESC
AVP	HWYNUM	PV
AVREC	INPTSSLT	PVSTS
BOXNUM	KEYWORD	RESETCMD
CCPRIPNT	NAME	SLOTNUM
CCRANK	OVERVAL	STATE
CNFERRPR	PDEVTP	STRTSTOP
CNTLLOCK	PRESET	UNIT
DIGALFMT	PRESETPR	

3.4.4 PIU Counter Functions

The PIU counter differs from the MC counter in that it cannot be stopped. The PIU counter also has no prealarm trip point. The count value is converted to EUs by the scale factor AVCONV. A Universal Station operator can use SP to adjust the PRESET value, and OP to reset the counter or preload a count value.

3.4.4.1 PIU Counter Parameters

ALPRIOR	EIPENB	OVERVAL
AV	EIPPCODE	PRESET
AVCONV	EUDESC	PRESLOCK
AVFORMAT	HIGHAL	PRIMMOD
BOXNUM	HWYNUM	PTDESC
CNFERRPR	INPTSSLT	RESETCMD
COUNTRPR	KEYWORD	SLOTNUM
DIGALFMT	NAME	UNIT

3.4.5 DHP Counter Functions

The DHP counter has some features similar to an MC counter, but does not actually provide counter or accumulation functions. A DHP scan puts the contents of a PLC register into the Accumulated Value (AV) and output (OP) parameters, after scaling by the AVCONV parameter. A Universal Station operator can write to the PLC register using the output (OP) parameter.

Setpoint (SP) and PRESET parameters can be changed, but are forced to the same value. The SP parameter sets the 100% value for the point detail display. An alarm is generated when AV equals or exceeds the PRESET value.

There are no lock parameters, there is no STATE or PV parameter, there are no RESET or STRTSTOP functions, and no prealarm trip point is provided.

Counter Parameters

ALPRIOR	INPTSSLT	PTDESC
AV	KEYWORD	PTDISCL
AVCONV	LOADDEST	SLOTNUM
AVFORMAT	NAME	SP
BOXNUM	OP	SPECIFI1
CNFERRPR	PCADDRI1	UNIT
COUNTRPR	PNTBOXIN	
EIPCODE	PNTBOXTY	
EIPENB	PNTPCTY	
EUDESC	PRESET	
HWYNUM	PRIMMOD	

3.4.6 HG Counter Processing

MC counters are processed once each second. DHP counters are updated at a configurable scan interval of from one to 15 seconds, or they can be free-running. PIU counters are updated every 1/4 second.

3.5 HG TIMER DATA POINTS

Timer data points act like a stop watch. They measure elapsed time from when they are started until they are stopped or until they time out. Operators at a Universal Station and user-written programs can start and stop the timers. They can also read the elapsed time and the time remaining until timeout.

3.5.1 HG Timer Point Residences

HG timer data points use timer variables in MCs. Some of the parameters reside in the HG. Maximum numbers of timer data points is determined by number of timer variables in the MC, which is 32.

3.5.2 Functional Structure of HG Timer Points

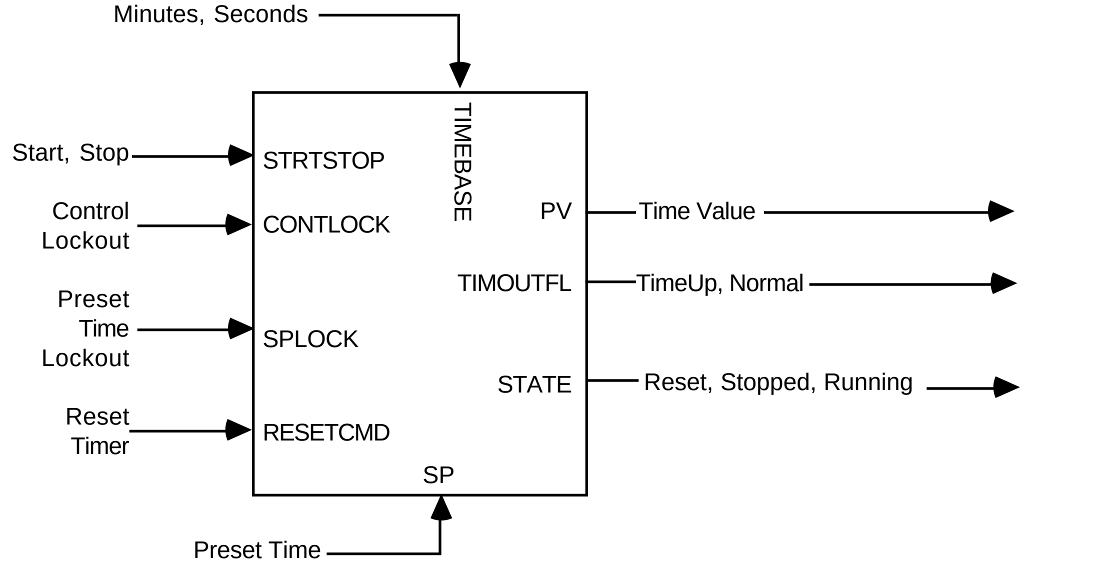


Figure 3-7 — Functional Diagram, MC Timer

3.5.3 Functional Description, Timer Point

HG timer points can be started and stopped by an operator at a Universal Station, provided parameter CNTLLOCK contains Permit. If CNTLLOCK contains NotPerm, the operator can't start or stop the timer.

To use an HG timer, an operator at a Universal Station loads a preset time value into parameter SP (SPLOCK must contain Permit). Once the preset value is entered and the timer is started, the time value in PV starts at zero and increments toward the preset value, each time the timer is processed. Parameter TIMELEFT indicates the difference between PV and SP. When PV equals SP, TIMOUTFL goes from Normal to TimeUp, indicating that the time period is complete. The values in PV and SP can range from 0 to 9999.0.

NOTE: When the SP=0 (a valid value), the timer becomes a “free running” timer that never times up. The PV goes from 0 to 9999 then “rolls over” to 0 and counts up again.

Parameter STATE indicates the current state of the timer. Possible states are Stopped and Running.

The initial values of CNTLLOCK and SPLOCK are configured, and the values can be changed by someone at a Universal Station who has an engineer's key.

3.5.4 Timer Point Processing

MC Timer variables are processed once each second or once each minute, as specified in parameter TIMEBASE.

When SP = 0, the timer becomes a “free running” timer which never times up. The PV goes from 0 to 9999 and then “rolls over” to 0 and counts up again.

3.5.5 HG Timer Parameters

The following are Timer point parameters. Refer to the *Hiway Gateway Parameter Reference Dictionary* for the full names, value ranges, default values, value types, and access levels for each parameter.

BOXNUM	PRIMOD	STRTSTOP
CNTLLOCK	PTDESC	TIMELEFT
EUDESC	PV	TIMBASE
HWYNUM	RESETCMD	TIMOUTFL
INTVARNUM	SP	UNIT
KEYWORD	SPLOCK	
NAME	STATE	

3.6 HG FLAG DATA POINTS

HG Flag data points have a logical PV parameter whose state can be changed by a Universal Station operator or by a sequence program. Like numeric points, a flag point can be used to exchange values with sequence programs or as a Boolean-values' "scratch pad."

You can configure a flag data point to generate an off-normal alarm in one of its two states.

3.6.1 HG Flag Point Residences

HG Flag data points use Flag Variables in a Multifunction Controller. In the MC, Flag Variables are sometimes referred to as "internal variables."

An MC can have up-to-256 flag data points, though in some mixes of process-connected boxes and HG loads, the maximum number may be less than 256.

3.6.2 Functional Structure, Flag Point

A Flag Variable in an MC consists of a storage location for a Boolean value (true or false), principally for use in recording Boolean values calculated by sequence slots in the same MC, plus additional parameters. Some of the flag data point parameters reside in the HG.

3.6.3 Flag Point Processing

Flag data points are not scheduled and are not processed. Their parameter values change when they are accessed by a system activity, such as a Universal Station user with a appropriate access key, or by sequences in the MC.

3.6.4 Flag Point Parameters

The following are flag point parameters. Refer to the *Hiway Gateway Parameter Reference Dictionary*, for the full names, value ranges, default values, value types, and access levels for each parameter.

BOXNUM	HWYNUM	OVERVAL
CCPRIPNT	INTVARNUM	PRIMOD
CCRANK	KEYWORD	PTDESC
DIGALFMT	LBOXCLR	PV
FLAGPR	NAME	UBOXCLR

3.6.5 HG Flag Point Alarms

Only the first 64 flag points in an MC can generate alarms. The 0 state is the normal state. The 1 state is the alarm or off-normal state. When the state changes from 1 to 0 (with alarms enabled), a return-to-normal is generated.

3.7 HG NUMERIC DATA POINTS

Numeric data points have a PV that contains a real number. This number can be entered by a Universal Station operator or by a sequence program. Numeric data points can be used to exchange numbers with sequences or as numeric "scratch pads."

3.7.1 HG Numeric Point Residences

HG numeric data points use Numeric Variables in a Multifunction Controller. In the MC, Numeric Variables are sometimes referred to as "internal variables."

An MC can have up-to-88 numeric data points, though in some mixes of process-connected boxes and HG loads, the maximum number may be less than 88.

3.7.2 Functional Structure, Numeric Point

A Numeric Variable in an MC consists of a storage location for a real number, principally for use in recording real values calculated by sequence slots in the same MC, plus additional parameters. Several of the numeric data point parameters reside in the HG.

3.7.3 Numeric Point Processing

Numeric data points are not scheduled and are not processed. Their parameter values change when they are accessed by a system activity, such as a Universal Station user with a appropriate access key, or by sequences in the MC.

3.7.4 Numeric Point Parameters

The following are numeric point parameters. Refer to the *Hiway Gateway Parameter Reference Dictionary* for the full names, value ranges, default values, value types, and access levels for each parameter.

BOXNUM	KEYWORD	PV
EUDESC	NAME	PVFORMAT
HWYNUM	PRIMOD	
INTVARNM	PTDESC	

3.8 PROCESS MODULE DATA POINTS

3.8.1 General Concepts

Batch processes and discontinuous processes usually involve the transformation of raw materials as they pass through operating equipment in a specified period of time, and under specific conditions. A plant that handles such processes is usually divided into functional groups of equipment called process modules.

Examples of batch processes include pharmaceuticals, nylon resins, specialty chemicals, and urethanes.

In the TPS System, a process module data point usually represents a set of equipment (a group of data points), through which a batch control strategy, or a portion of a batch control strategy, is executed. Normally, a process module data point is the platform for execution of a sequence. There is a one-to-one relationship between these process module data points and a single Multifunction Controller sequence slot; however, "auxiliary" process modules can be defined for execution of supervisory or backup sequences, or to represent process modules through which a batch progresses although no sequence is executed in it. These auxiliary process modules do not contain the sequence- execution parameters discussed below.

A process module data point is an HG point that represents a Multifunction Controller sequence slot. It has these characteristics:

- Only one sequence program can be active at any time.
- A single set of abnormal condition handlers exists at any time.
- A single set of the following states is defined.
  - Process Module Operational State
  - Sequence Execution Mode
  - Sequence Execution State

3.8.2 Applicable Functions, Process Module Points

This section provides a high level overview of the architecture of the discontinuous/batch control subsystem. Figure 3-8 shows the relationships of the modules, gateway and boxes involved. This subsystem's functions are accomplished by sequences written in CL/MC, which is very similar to SOPL. CL/MC sequences are entered, compiled, and loaded through the Universal Station. It is also possible to write sequences in SOPL and to compile them through a hiway-based operator station or through an LBOS.

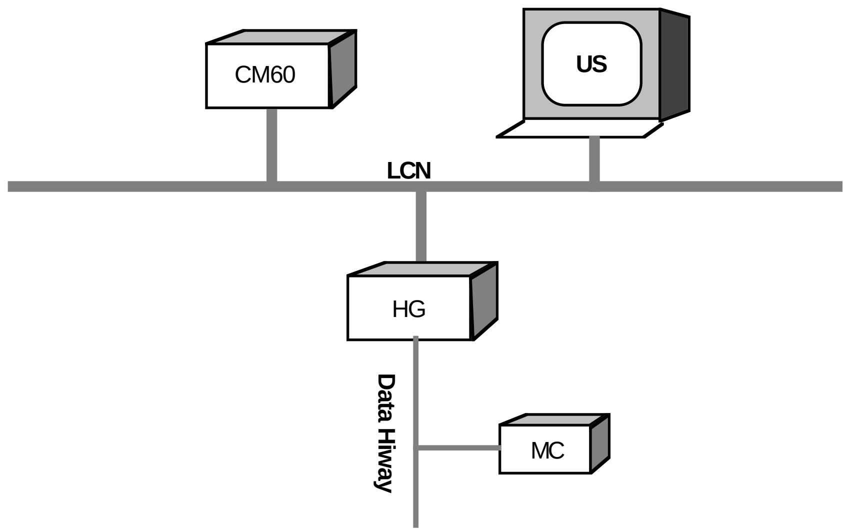


Figure 3-8 — Modules, Gateway, and Boxes Involved in Discontinuous/Batch Control

3.8.2.1 Multifunction Controller Functions

- Executes sequences written in CL/MC or SOPL to effect the discontinuous/batch control strategies.
- Is the residence of the sequence-related parameters in the process module data point. These parameters include sequence-execution state, sequence-execution mode, current phase, and current step number.

3.8.2.2 Hiway Gateway Functions

- Is the residence of the remaining parameters of the process module data point, including the process module name, description, MC number, and sequence slot number. See 3.8.
- Provides the interface between the LCN and the MC by:
  - Handling all requests for sequence status information.
  - Routing all sequence commands from Universal Stations, CM, and AMs, to the MC.
  - Interfacing with the sequence downline-load/upline-load function.
- Is the residence of the MC sequence and process libraries. See 3.8.9.

3.8.2.3 Universal Station Functions

- Off-Process
  - Provides the tools used to build process module data points (through the Data Entity Builder) and to write sequence programs (using the Text File Editor and the CL Compiler).
- On-Process
  - Provides the facilities for monitoring and controlling the process modules and sequences, through standard and custom displays, the Operator's Keyboard, and printers.

3.8.2.4 CM60 Functions

- CM60s execute higher level programs that can interface sequence programs.

3.8.3 Process Module Point Parameter Descriptions

The following are process module data point parameters. Refer to the *Hiway Gateway Parameter Reference Dictionary* for the full names, value ranges, default values, value types, and access levels for each parameter:

ABHEMSD	BH	NAME	PRIMOD	SEQSLTSZ
ABHHOLD	BOXNUM	OVERSTAT	PROCMOD	SLOTNUM
ABHRSTR	DISPTYP	OVERSTEP	PTDESC	STATMENT
ACP	EIPCODE	PHASE	SEQEXEC	STEP
ABHSHDN	HWYNUM	PHASEAL	SEQMODE	UNIT
BATCHID	MESSPEND	PHASETIM	SEQNAME	

If the process module is assigned to a sequence slot, sequence-execution parameters (included in the list above) are included (functions supporting these parameters are discussed later). These parameters contain the execution-state information for the sequence program associated with the process module. All sequence-execution parameters appear on the Process Module display and can be accessed by user-written programs. Operator messages from a sequence program appear on the Process Module display with an indication of which messages require confirmation.

3.8.4 Parameter Functions, Process Module Data Point

The following functions affect the values in certain process-module parameters.

3.8.4.1 Downline Load/Upline Load

Sequence programs execute in a Multifunction Controller slot and can be generated in one of two ways:

- Sequence programs can be written in CL/MC and compiled at a Universal Station. After compilation, the program is bound to a specific process-module data point (i.e., a specific slot) and is left in a separate file. This file can be directly downline loaded to the HG and Multifunction Controller (process module). This is probably the most common method. To prepare CL/MC programs, refer to the *Control Language/Application Module Reference Manual*. To compile a CL/MC program, bind it to a process module point, and load it in the MC, refer to 3.9 in *Control Language/Application Module Data Entry*. These publications are in the *Implementation/Application Module - 2* binder.

- Sequence programs can also be written in SOPL, compiled at an LBOS or a hiway-based Operator Station, and downloaded from the LBOS or Operator Station to the Multifunction Controller (process module). These programs can also be be upline loaded from the MC to the Universal Station.

The complement of available sequence programs for a process module can be seen on the Process Module display. The sequence programs for a process module can be saved in an HM or on a floppy diskette for future downloading. HG functions included in the downloading process include:

- Verifying that the process-module operational state is Off.

- Verifying that the program fits into the slot.

3.8.4.2 Advanced-Control Interface Data Point Name

An advanced-control program in a CM can be written to provide high-level strategy support. The advanced-control interface data point name in ACP is used by a sequence program to route commands to a program in the CM.

3.8.4.3 Sequence Commands

Valid commands to the process-module data point include the following:

- Confirm a message
- Change the process module operational state
- Change the sequence execution mode
- Start or stop the sequence
- Move the execution pointer forward or backward.

For operating details, refer to the *Process Operations Manual*.

These functions are commanded by writing in the process-module parameters, as described by the chart, below. The HG initiates execution of the commands. It also verifies that operator-only actions described below are initiated only by an operator.

Command	Conditions/ Results	Valid Initiator	Value written in Process-Module Parameter
Message Confirmation Commands—Process-Module Parameter is CONFMSG.			
Confirm msg Msg Seq Bit 0	-	Operator	0
Confirm msg sent with Msg Seq Bit 1	-	Operator Only	1
Module-State Commands—Process-Module Parameter is PROCMOD.			
Set Module State to Off	Only valid when Execution State is Fail, Error or End.	Operator Only	Off
Set Module State to Ready	Only valid when Execution State is End.	Operator Only	Ready

Command	Conditions/ Results	Valid Initiator	Value written in Process-Module Parameter
Module-State Commands—PROCMOD Parameter (Continued)			
Set Module State to Hold	Not valid if Module State is Off, Ready, Shutdown or Emergency Shutdown.	Operator, sequence prog., CM program	Hold
Set Module State to Shutdown	Not valid if Module State is Off, Ready, or Emergency Shutdown.	Operator, sequence prog., CM program	Shdn
Set Module State to Emergency Shutdown	Sequence Mode forced to Auto	Operator, sequence prog., CM program	Emsd
Sequence Operational State—Process-Module Parameter is SEQMODE			
Set Seq. Mode to Auto	-	Operator Only	Auto
Set Seq. Mode to Semi Auto	Not valid if Module State is Off or Emergency Shutdown.	Operator Only	SemiAuto
Set Seq. Mode to Single Step	Not valid if Module State is Off or Emergency Shutdown.	Operator Only	SnglStep

Command	Conditions/ Results	Valid Initiator	Value written in Process-Module Parameter
Execution-State Commands			
Start seq. execution	Seq. enters Normal Exc State. Only valid from Ready Module State.	Operator, sequence prog., CM program	START
Stop Seq. execution	Seq. enters Fail Exc State.	Operator, sequence prog., CM program	STOP
Move Execution Pointer Commands			
Advance seq. to next consecutive phase.	Not valid if no further phases.	Operator Only	Advance_Phase
Advance seq. to next consecutive step	Not valid if no further steps.	Operator Only	Advance_step
Advance seq. to next consecutive statement	Not valid if no further statements.	Operator Only	Advance_Statement
Back seq. up one phase	Not valid if first phase in sequence.	Operator Only	Backup_Phase
Back seq. up one step	Not valid if first step in phase.	Operator Only	Backup_step
Back seq. up one statement	Not valid if 1st statement in step.	Operator Only	Backup_Statement

3.8.5 Sequence Programs

A sequence program is a process engineer's tool for defining how a discontinuous or batch-control function is to take place. TPS sequence programs can accomplish the following tasks:

- **Sequencing—**Following a prescribed set of instructions.
- **Monitoring—**Reading process variables to check process conditions, such as temperatures, pressures, and flows; and the state of devices like valves and motors.
- **Regulating—**Controlling process conditions by comparing present parameter values to setpoints, and by taking appropriate corrective actions, such as calculating and setting new setpoint values.
- **Operator Interface—**Sending messages to the operator to inform him or her, and to provide instructions. Requiring confirmation of specified messages. Operator manipulation of control strategy.
- **History and Reporting—**Providing the mechanism for gathering batch history in an AM to acquire a record of the processing of the batch events.

Sequence programs are written in CL/MC and are compiled and tested at a Universal Station with the Engineering Personality. They can also be written in SOPL and compiled at an LBOS or a hiway-based operator station, but this is expected to be done only in systems without an LCN and is not covered here.

Sequence programs are downline loaded to the specified sequence slot in the specified MC where they are executed.

3.8.5.1 Sequence Program Structure

A sequence program consists of these four parts (see Figure 3-9):

- Data declarations
- Normal sequence (main program)
- Abnormal-condition handlers
- Subroutines

NOTE

For more detail on Control Language (CL) programming, refer to the *CL/AM Reference Manual* in the *Implementation/Application Module - 2* binder.

Data Declarations—The data-declaration section consists of optional statements that relate user-defined names to MC flags and numerics, and that declare numeric, logical, and enumeration constants. The 'LOCAL' statement is used for these purposes.

Examples:

```
LOCAL a AT (NN1)
LOCAL switch1,switch2: LOGICAL AT (FL100)
LOCAL table: NUMBER ARRAY (1..20) AT (NN100)
LOCAL bits: LOGICAL ARRAY (5..35) AT (FL200)
LOCAL pi = 3.1416
LOCAL value = ON
LOCAL mode set = auto
```

Multifunction Controller data points can't be renamed using the 'LOCAL' statement.

Normal Sequence—The normal sequence section performs the mainline task of the program and can be viewed as the "main program." It is the portion of the program that executes when conditions are normal. The main program is divided into phases, steps, and statements (see Figure 3-10). A 'PHASE' statement must be the first statement in the sequence program after the data declarations. If a phase has any steps, the first statement in the phase must be a 'STEP' statement.

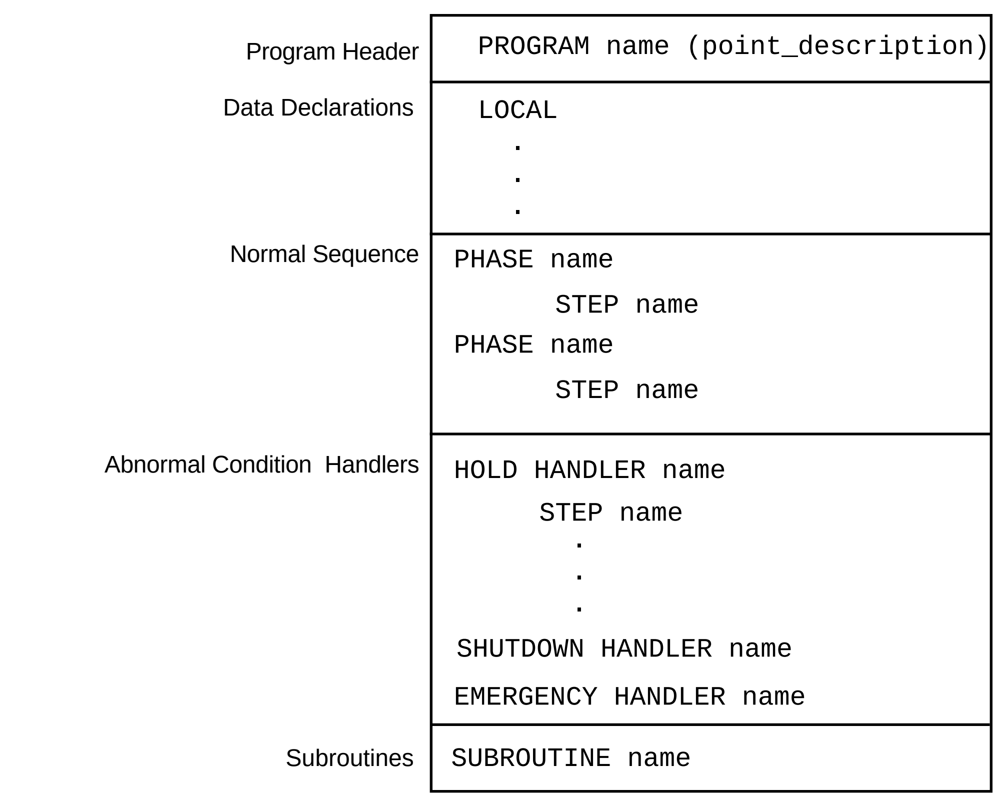


Figure 3-9 — Sequence Program Structure 1836

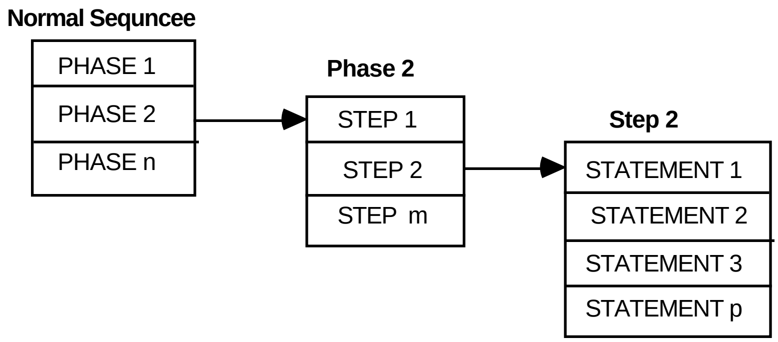


Figure 3-10 — Normal Sequence Structure 1837

These are the parts of a normal sequence:

- **Phase**—A sequence program consists of a grouping of phases. A phase executes a major process function or marks a major process milestone, such as a charging phase or heat-up phase. Phase boundaries are key points of synchronization in the control program. A phase is identified in the sequence program by the 'PHASE' statement, and consists of steps.

- **Step**—A step executes a minor process function such as opening a valve with associated checks and verification, or checking a temperature. At least one step is executed each time the sequence is executed. A step is visible at a Universal Station as a process milestone. It is identified in the sequence program by a 'STEP' statement, and consists of an ordered set of CL/MC statements.

- **Statement**—One CL/MC instruction. A statement performs an elementary action, such as:

```
open VALVE101
```

Abnormal-Condition Handlers—Abnormal-condition handlers are alternatives to the normal sequence. They provide corrective action when abnormal conditions are encountered. When such a condition is detected, the normal sequence is suspended and the appropriate abnormal-condition handler begins to execute. These are the three types of abnormal-condition handlers:

- **Hold—**For a condition that requires a partial shutdown.

- **Shutdown**—For a condition that requires a systematic shutdown.

- **Emergency Shutdown**—For a condition that requires a complete, sudden shutdown.

Abnormal-condition handlers are identified in the sequence program by the 'HANDLER' statement, preceded by the name for the type of handler, and followed by the user-given handler name. Example:

```
HOLD HANDLER cooldown
```

Abnormal-condition handlers consist of steps. Hold and shutdown abnormal-condition handlers can be terminated either by a restart section that is identified by the 'RESTART' statement, or by an 'END' statement. Emergency shutdown handlers can be terminated only by an 'END' statement. Abnormal-condition handlers have priority over each other and over normal sequences. The priorities are as follows:

Emergency Shutdown	Highest Priority
Shutdown	|
Hold	|
Normal Sequence	Lowest Priority

Note that the priority of a Restart Section is the same as the abnormal-condition handler that contains the Restart Section. Handlers are enabled at phase boundaries, using the 'PHASE' Statement. A 'WHEN' clause in the abnormal-condition handler specifies a condition for execution. Conditions listed in enabled handlers are automatically monitored at each sequence execution. Any true condition causes suspension of the normal sequence and execution of the abnormal-condition handler that specified the abnormal condition that was found to be true.

Subroutines—These are used to simplify program structure, readability of program listings, and to create a modular-program effect. Subroutines can be started by only the normal sequence. Nesting of subroutines is not supported. Subroutines are specific to one sequence program, i.e., subroutines defined outside of the program and maintained in subroutine libraries are not supported in the Multifunction Controller.

3.8.6 Sequence Execution

3.8.6.1 Normal Execution

Execution of the normal sequence can be initiated by one of these events:

- By a Universal Station operator.
- By another sequence, executing on another process module. Generally, this other sequence is a supervisory sequence, that is, a sequence program that initiates, monitors, and controls other sequences.
- By a CL Block in an AM.
- By a user-written program in a CM.

Execution of a sequence is interleaved with that of other sequences in the same MC. Suspension of a sequence to allow another sequence to run is called preemption. A sequence program continuously executes until one of the following preemption conditions occurs:

Condition	Action
Beginning a new step or phase, except the first step in a subroutine	Suspends one second, then continues, or in single-step mode, suspends until operator's request.
Execution of a loop, back to a phase, a step, or a labeled statement in a step.	Suspends one second, then continues.
Execution of a statement with a wait function as follows: - `ON, OPEN, OFF, CLOSE` with an error clause - `WAIT` statement - `SEND` statement with confirmation	Suspends until the condition is satisfied or optional timeout occurs, then continues.
Execution of a `SEND` statement without confirmation if MC buffer is full.	Suspends until the message can be put in buffer or 10 seconds have elapsed, then continues.
Execution of a statement that communicates between MCs, such as `START` a sequence in another MC.	Suspends until the communication between MCs is completed, or a communication error occurs, then continues.
Execution of a `PAUSE` statement when in semi-auto mode.	Suspends until operator demand to resume execution.
Execution of `READ` or `WRITE` statement.	Suspends for 1 second while operation occurs, then continues.

3.8.6.2 Execution of Abnormal-Condition Handlers

Enabled abnormal-condition handlers can be initiated by:

- A request from a Universal Station operator.
- By a true condition in the abnormal-condition handler heading. The condition is checked by the MC point processor before sequence execution.
- Activation by a statement in the sequence (e.g., `INITIATE HOLD`).
- An `INITIATE` statement from another sequence.
- A CL block in an AM.
- A user-written program in a CM.

Abnormal-condition handlers execute with step processing and preemption processing the same way normal sequences do. When an abnormal-condition handler is started, execution of any lower-priority sequence or abnormal-condition handler is aborted. See Figure 3-11.

Hold and shutdown abnormal-condition handlers can be terminated by a restart section. This section begins when a RESTART statement is executed. A RESUME statement can appear anywhere inside a Restart Section. The RESUME statement causes the normal sequence to be reentered at the phase named in the statement. No operator intervention is required to confirm execution of a RESTART or a RESUME statement. Restart sections can't be in emergency-shutdown abnormal-condition handlers. See Figure 3-12.

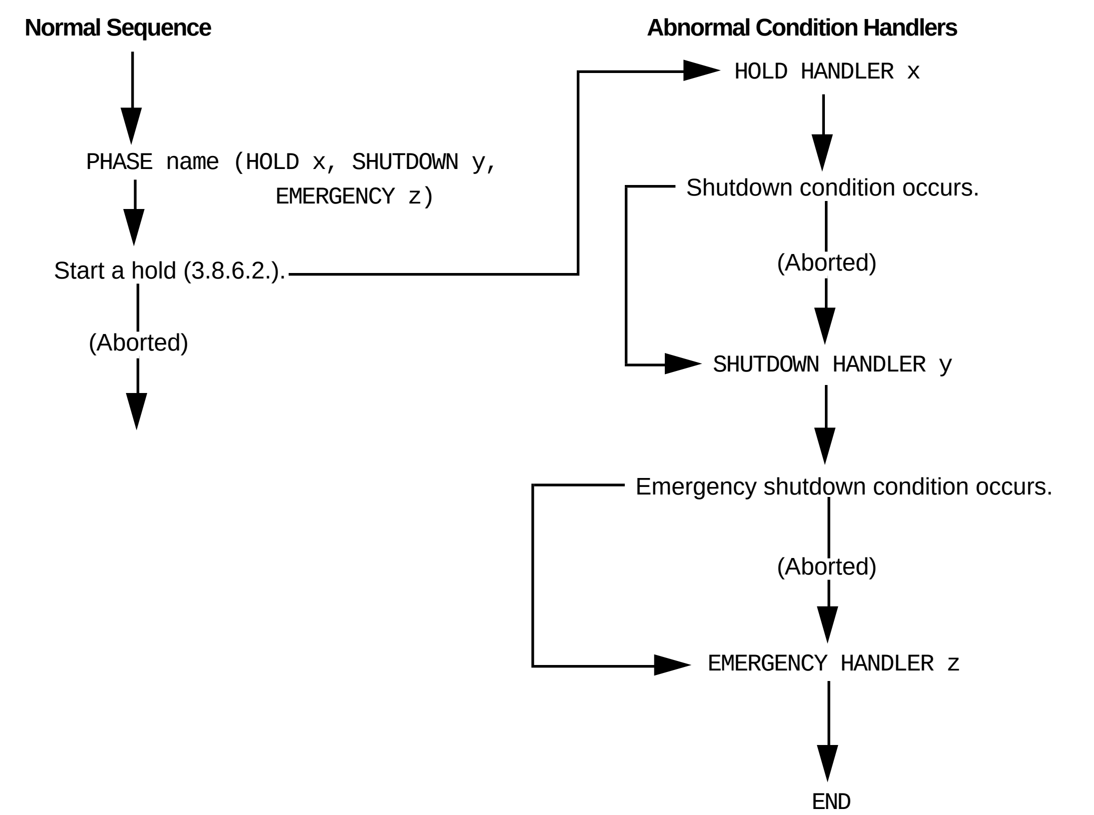


Figure 3-11 — Execution of Abnormal-Condition Handlers 1838

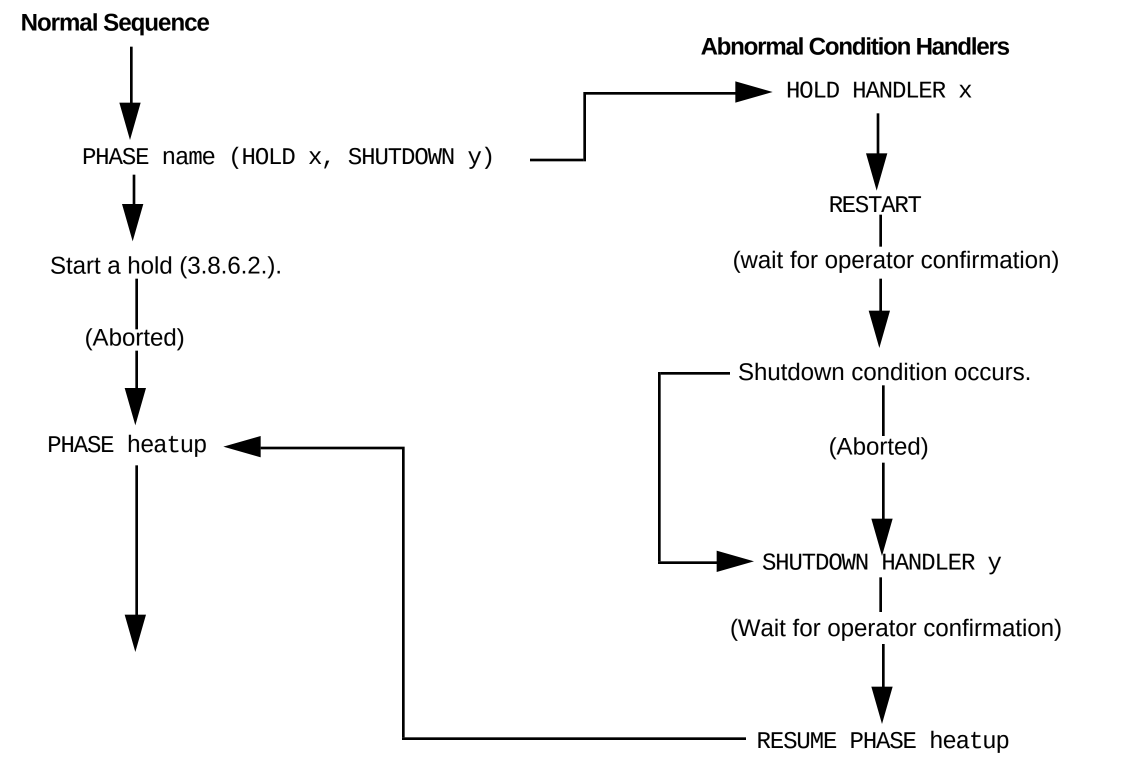


Figure 3-12 — Execution of Abnormal-Condition Handlers RESTART Sections

3.8.6.3 Additional Sequence-Execution Control

To provide additional sequence-execution control and flexibility, the following functions are available through the Process Module display:

- **Phase Override**—Allows the user at a Universal Station to move forward or backward through the phases by pressing the up or down arrows on the operator keyboard. Phase override works only in the same sequence. (Phase override is available at the Sequence Unit display and is the value in parameter OVERPHAS that moves the phase forward or backward.)

- **Step Override—**Allows the user at a Universal Station to move forward or backward through the steps by pressing the up or down arrows on the operator keyboard. Step override works only in the same phase and it is parameter OVERSTEP that moves the step forward or backward.

- **Statement Override—**Allows the user at a Universal Station to move forward or backward through sequence-program statements by pressing the up or down arrows on the operator keyboard. Statement override works only in the same step and it is parameter OVERSTAT that moves the step forward or backward.

The override functions are available only when the sequence is in one of the following execution states: fail, error, pause, and loaded.

3.8.6.4 Alarms and Messages

Sequence alarms are generated when:

- The process-module operational state (parameter: PROCMOD) changes to a hold, shutdown, or emergency shutdown.

- The sequence execution state (parameter: SEQEXEC) changes to: fail, error, pause, or end.

- The phase timer (parameter: PHASETIM) has elapsed.

Sequence-status messages are generated when

- The process-module operational state (parameter: PROCMOD) changes.

- The sequence-execution mode (parameter: SEQMODE) changes.

- The sequence-execution state (parameter: SEQEXEC) changes.

- The sequence progresses to a new phase.

- A sequence message is issued.

Data point alarms are generated when the state of one of the first 64 flags in the MC goes to on. (Note: Flags are internal variables in an MC. A total of 256 flags is provided for each MC; the first 64 flags are alarm flags.) Two types of operator messages can be explicitly generated by the sequence:

- **Message with feedback—**A `SEND` statement with the confirmation option (`WAIT`) causes the sequence to be suspended until the message has been confirmed.

- **Message without feedback—**This message is a one way communication from the sequence to the destination.

3.8.7 Sequence/Module States

3.8.7.1 Process-Module Operational States

The process-module operational state (the module state) represents the operational condition of a process module, as controlled by a sequence. The module-state parameter is PROCMOD, which contains one of the following values:

- **Off**—A sequence can be assigned to the process module but cannot execute. Sequence-execution mode doesn't apply.
- **Ready—**The sequence has been assigned to a process module and can be initiated by appropriate action. The sequence-execution mode is forced to auto.
- **Norm—**The process module is operating in the normal sequence.
- **Hold—**The process module is executing the hold abnormal-condition handler.
- **ShDn—**The process module is being operated by the shutdown abnormal-condition handler.
- **EmSd—**The process module is executing the emergency-shutdown abnormal-condition handler. The sequence execution mode is forced to Auto.

Valid module state transitions are shown in Figure 3-13.

3.8.7.2 Sequence Execution Modes

The sequence execution mode (the sequence mode) defines the execution mode of the sequence program. The sequence mode parameter is SEQMODE, which contains one of the following values:

- **Auto—**The normal mode of operation. The sequence operates under normal execution rules without operator intervention.
- **SemiAuto—**The sequence operates under normal execution rules, except that the PAUSE statement causes suspension of program execution. PAUSE requires operator action to resume execution.
- **SnglStep—**Normally used for debugging. The sequence is executed only one step at a time and operator action is required to resume execution at the next step.

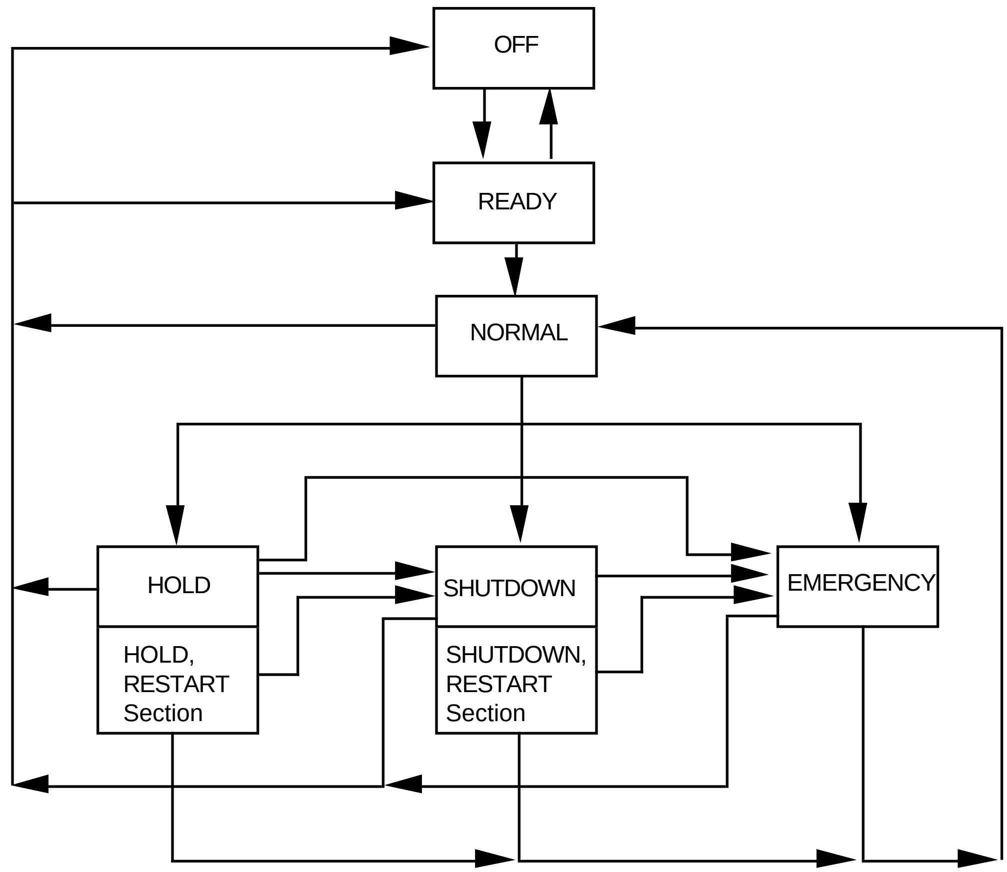


Figure 3-13 — Process Module State Transitions

1840

3.8.7.3 Sequence Execution States

The sequence execution state (the execution state) represents the state of the sequence (see Figure 3-14). The following are the valid states for the execution state parameter, SEQEXEC:

- **Nl**—In this state, a sequence is not assigned to a process module. This state is automatically entered if loading to the MC is aborted.
- **Dll**—This is a transient state that occurs during loading of the sequence program. This state is entered from the not loaded or loaded state when downline loading is initiated.
- **Loaded**—The sequence has been assigned to the process module. This state is automatically entered from the loading state, when the module state changes to off or ready.

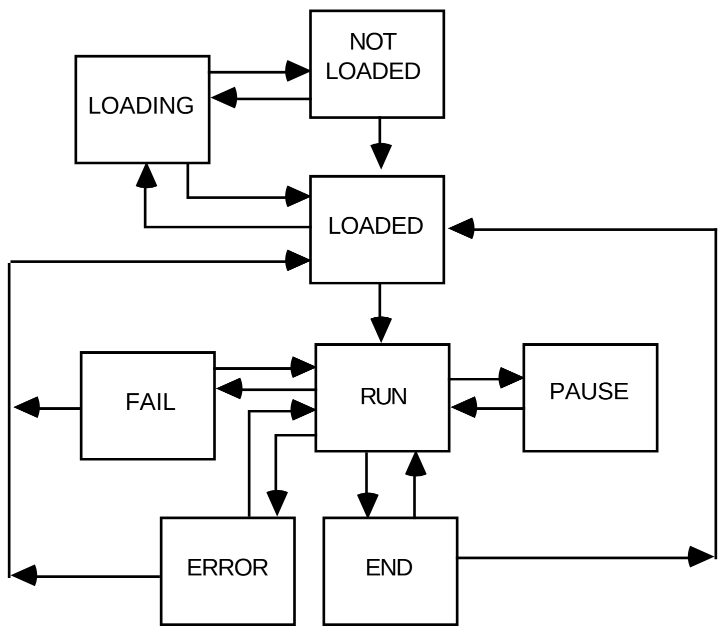


Figure 3-14 — Sequence Execution State Transitions

- **Run**—The sequence is executing.
- **Pause**—Sequence execution is suspended by one of these pause conditions:
  - Completion of a step when in the single-step sequence mode.
  - Execution of a `PAUSE` statement when the sequence mode is semi-auto mode. Sequence execution is restarted by an operator.
- **Error**—Sequence execution is suspended because of one of the error conditions in the list below. A system message is generated that indicates the cause of the error. Operator action is required to resume execution.
- **Fail**—Sequence execution is suspended because of one of the failure conditions in the list below. A system message is generated that indicates the source of the failure. Operator action is required to resume execution.
- **End**—Sequence execution has been finished by the execution of an `END` statement at the end of the normal sequence or at the end of an abnormal-condition handler without a restart section.

Error Conditions

1. Arithmetic overflow: divided by zero or result is a number greater than the largest that can be handled.
2. Illegal intermediate code or use of the same box number as this MC in a statement communicating between boxes.
3. Attempted write to a read-only variable.
4. I/O-board type not compatible with requested operation.
5. Analog input point not configured.
6. Parameter not applicable to analog input point.
7. Parameter not applicable to modulating slot.
8. Parameter not applicable to digital output point.

Failure Conditions

9. `STOP` request from a Universal Station, or a `FAIL` statement was executed by a sequence program.
10. `START` of an abnormal-condition handler that is not enabled, or no lower priority abnormal-condition handler is enabled.
11. Communication failure within the MC.

12. Failure in communication to other MCs.

13. Feedback timeout in ON/OFF/OPEN/CLOSE statements.

14. Condition timeout in WAIT statement with no error destination.

15. Access variable has partially failed.

16. Attempted digital output when attribute not Prog and mode not MAN.

17. Attempted analog output when attribute not Prog and mode not MAN.

18. Attempted to write SP when attribute not Prog and mode not MAN.

19. Attempted to write OP when attribute not Prog and mode not MAN.

20. Attempted to write bias in modulating slot not in CAS mode.

21. Attempted to write ratio in modulating slot not in CAS mode.

22. Illegal mode change on a digital output, analog output, or regulatory (modulating) slot.

23. Attempt to START a sequence that is in the OFF module state.

Note that the attribute can be either Prog or Oper when writing to the RATIO or the BIAS parameter of a modulating slot.

3.8.8 Sequence Binding

Sequences are assigned to the process module when they are compiled.

3.8.9 Multifunction Controller Libraries

The HG is the residence of sequence libraries. There is one of each of these libraries for each C-Link cluster on the hiway.

Identifiers in these libraries are used for sequence program names, phase names, step names, and sequence messages. Normally, the identifiers are automatically entered into a library by the CL compiler when it is compiling a sequence program for an MC slot; however, you can see, enter, modify, and delete these identifiers through the Data Entity Builder. To use the DEB to configure or reconfigure HG libraries, select the BUILD HG LIBRARY pick on the Engineering Main Menu and enter appropriate values in the HG LIBRARY CONFIGURATION display (you can also enter these values on Form *PC88-445*). Refer to the *Hiway Gateway Parameter Reference Dictionary* for more information about the parameters that appear on the display (and on the form), and refer to the *Data Entity Builder Manual* in the *Implementation/Engineering Operations - 1* binder for DEB instructions.

Each active HG can have one to four libraries, and each library can have up to 576 entries.

Entries from existing LBOS libraries must be reconfigured with the Data Entity Builder.

3.9 HG Logic Block Data Points

3.9.1 Functional Summary

Logic block data points are HG points that use Logic Blocks in an MC. A logic block data point makes a logical calculation, as defined by its logic algorithm and the state of its inputs. It can produce outputs to parameters in the MC database. An MC has up-to-128 logic blocks.

Each logic block data point is configured to make one of the following logical calculations:

- AND
- OR
- XOR
- AND w/Output
- OR w/Output
- XOR w/Output
- Flip-Flop
- LINK
- On-Delay
- Off-Delay
- Pulse

Inputs to the logic blocks are configured from the following types of MC slots:

- Digital I/O
- Counter
- Analog I/O
- Flag
- Timer
- Regulatory
- Logic Block

The status of the MC timeout gate, soft-failure status, and partial-failure status may also be used as inputs.

The AND w/Output, OR w/Output, XOR w/Output, Flip-Flop, and Link algorithms can output to a limited group of parameters of the following types of MC data points:

- Digital I/O
- Counter
- Analog input
- Flag
- Timer
- Regulatory

Configured outputs can be specified to occur only during logic block state changes or continuously.

3.9.2 Logic Block Processing

Each logic block is scanned once each second in an ascending order from logic block data-point number one to logic block 128.

3.9.3 Logic Block Initialization

The initial state of the all logic block data points is Off (0). All timers for delay or pulse algorithms are reset.

3.9.4 Logic Block Configuration

Two Engineering Personality activities are required to configure logic blocks (in the following order):

1. Data Entity Builder, using the Hiway Gateway pick.
2. Logic Block Builder, using the Logic Block pick.

You must first configure logic blocks (LBs) with the Data Entity Builder, otherwise the HG and LCN won't understand how to process or display them. You can then define for the MC which inputs are connected to the LBs and what operations to perform on those inputs.

When you select HIGHWAY GATEWAY and then select LOGIC BLOCK, the Point Assignment display appears. On that display, you configure the following parameters for each logic block point:

- NAME
- UNIT
- PTDESC
- KEYWORD
- PRIMMOD
- HWYNUM
- PNTBOXTY
- BOXNUM

The remainder of logic block definition is through the LOGIC BLOCK pick on the Engineering Main Menu. This invokes the logic block builder function of the Universal Station's Engineering Personality. The logic block builder also downline loads the logic block database in the MC.

After the logic functions are defined, block functions are defined by specifying the following:

- Logic algorithm
- Input parameters
- Output parameters
- Constant parameters

References—For additional information on logic blocks, refer to the *Logic Block Form Instructions*, and *Logic Block Data Entry* in the *Implementation/Hiway Gateway - 2* binder.

3.10 HG BOX/SLOT DATA POINTS

Box/slot data points contain parameters that relate to the functions of each box on a Data Hiway. One such point is configured for each box on each hiway. The set of parameters for each type of box differs somewhat. Box/slot data points are built in the BOX/SLOT CONFIGURATION activity of the Engineering Main Menu, which is a part of Network Configuration. Typically, box/slot data points are built after the Data Hiway is configured. Both the Hiway Configuration and Box/Slot configuration activities use the Data Entity Builder.

3.10.1 Box/Slot Data Point Processing

Box/slot data points are not scheduled for processing nor processed at regular intervals like other data points are. Their parameters are updated when necessary by the HG and the boxes.

3.10.2 Box/Slot Data Point Parameters

The following are the box/slot data point parameters. For information on the functions, value types, ranges, and access levels, refer to the *Hiway Gateway Parameter Reference Dictionary*, and to the *Network Form Instructions.*

Box /Slot Point Parameters Common to All Box Types

BOXASSN	BOXTOG1	CHPINOPR
BOXFSTAT	BOXTOG2	HIWAYWRD
BOXINT	BOXTYPE	HWYNUM
BOXNUM	CHPINDAC	TOGINSTL

Basic Controller (CB) Box/Slot Point Parameters

BOXCRDST	BOXSTAT	CBREV
BOXRCDAD	BOXTHRSH	

Data Hiway Port (DHP) Box/Slot Point Parameters

BOXCRDST	BOXTHRSH	PCnPORTA
BOXINIT	NUMBBASE	PCnTYPE
BOXPROT	PCnALIVE	PIUCRDTY
BOXSIZE	PCnALVBT	SCANTIME
BOXSTART	PCnALVSP	
BOXSTAT	PCnPORT	

Extended Controller (CB) Box/Slot Point Parameters

BOXSTAT	BOXRCDAD	BOXCRDST

Multifunction Controller (MC) Box/Slot Point Parameters

BOXCLINK	FL	SOPLMEN
BOXCRDST	LB	TMPV
BOXINIT	LIBRYNUM	TMRS
BOXRCDAD	MCREV	TMRV
BOXSTAT	NMRBRBCFL	TMSP
BOXTHRSH	NN	TMST
BOXTREND	PIUCRDTY	TMTB
BOXUAC	PIUCRDOP	
CLINKNUM		

Process Interface Unit (PIU) Box/Slot Point Parameters

BOXCRDST	BOXSTAT	CHPINOPR
BOXINIT	BOXTHRSH	PIUCRDOP
BOXSIZE	CHPINDAC	PIUCRDTY

3.10.3 Box/Slot Point Names

Box/slot points have reserved-entity names, which are automatically established by the Data Entity Builder as you build the points. Users and user programs can refer to box/slot point parameters through the reserved-entity names. For example

```
$HY02B05.BOXSTAT
|  |  |   |
|  |  |   └── The box status parameter
|  |  └────── Box number 05
|  └───────── Data Hiway 02
└──────────── Identifies this as a reserved entity
```

3.10.3.1 MC Box/Slot Point Access by Sequence Programs

Access to MC box/slot data point parameters by sequence programs is different when the program is in the same MC from that when the program is in another MC. The name forms described below are available to only sequence programs. They are known to only the CL compiler and the MC interpreter, and are not generally available outside of the MC.

Local Access

Access to MC box/slot data point parameters in the same MC is as follows. In this case the box name is omitted.

NN(xx)
FL(xx)
LB(xx)
TG
SF

where xx is the variable number.

For timers, the format is:

TM(xx).STATE
TM(xx).STRTSTOP
TM(xx).TIMOUTFL
TM(xx).SP (set time)
TM(xx).PV (elapsed time)
TM(xx).TIMELEFT (remaining time)
TM(xx).RESETCMD

where xx is timer number

Access by a Sequence Program in Another MC on the Same C-Link

Access to MC box/slot data point parameters of another Multifunction Controller must identify the box/slot data point. Numerics, flags, timer state, and logic block output state can only be read. Sequence programs can write in numeric and flags across C-Links.

Here are some examples of the name forms:

$HY01B06.NN(xx)
$HY02B03.FL(xx)
$HY10B17.LB(xx)
$HY04B05.TM(xx).STATE

3.10.3.2 MC Box/Slot Point Access by Other Functions

Access to Data Points not Associated with MC Internal Variables

While direct access to internal variables in an MC is possible, such access to regulatory (modulating-control) data points, analog data points, digital data points, and counter data points is not possible. These are not box/slot data points, but are normal HG data points, and are described elsewhere in this manual.

Access to MC Timer Parameters

MC timers have box/slot point parameters that can be accessed by the modules and gateways through the reserved-entity name. These parameters are arrays of 32 values, one for each of the timers in an MC.

These are examples of the Reserved_Entity.Parameter_Name form:

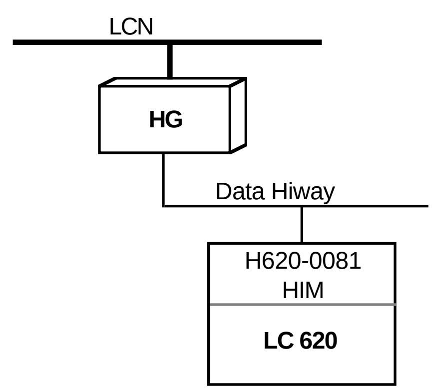
$HY02BO7.TMPV(nn)
$HY02BO7.TMRS(nn)
$HY02BO7.TMRV(nn)
$HY02BO7.TMSP(nn)
$HY02BO7.TMST(nn)
$HY02BO7.TMTB(nn)

Where nn is an integer from 0 to 32.

3.11 POINTS IN 620 LOGIC CONTROLLERS

HG points in 620 Logic Controllers with the H620-0081 Hiway Interface Module (HIM) use the same protocol and have the same functions as, or similar functions to, the DHP points described elsewhere in this publication. The principal exception is that the HIM-equipped 620 Logic Controller appears to have the functions and database capacity of four extended DHPs.

The 620 Logic Controller with the HIM connects to the Data Hiway, and through an HG, to the LCN as shown in this sketch.



5518

3.11.1 HIM/620 Features and Constraints

The box address (5 to 31) and the number of consecutive DHPs (1 to 4) emulated by the HIM/620 are determined by the HIM hardware.

In Box/Slot Configuration for a HIM/620, the following parameter values must be entered:

Parameter	Value	Parameter	Value
BOXTYPE	DHP	PC5TYPE	Notconfg
BOXSIZE	Extended	PC6TYPE	Notconfg
BOXPROT	Honywell	PC7TYPE	Notconfg
PC1TYPE	I620	PC8TYPE	Notconfg
PC2TYPE	Notconfg	PC1PORT	1
PC3TYPE	Notconfg	PC1PORTA	1
PC4TYPE	Notconfg		

When you build data points for the HIM/620 (any type that can be built for a DHP), enter the following values for these parameters for each such point:

Parameter	Value
PNTBOXTY	DHP
PNTPCTY	Honywell
PNTBOXIN	1
PNTBOXOT	1

For I/O composite points, both the input box number in BOXNUM and the output box number in OUTBOXNM must be the same.

The **Hiway Status Display** shows the HIM/620 as up-to-four DHPs on the Hiway. When the "cold start" option is selected, a Start command issued to one of the four emulated DHPs disables processing in all four emulated boxes. Processing must be enabled individually in each box. All other box commands issued to the emulated DHPs work independently.

Because the HIM/620 emulates up-to-four DHPs (four boxes), the HG's **Hiway Swap Algorithm** (see 8.4 in the *Engineer's Reference Manual* in the *Implementation/Startup and Reconfiguration - 2* binder) can force a hiway-cable swap if only one HIM fails to respond, and if that HIM and its four boxes represent 25% or more, 50% or more, or 100% of the boxes on the hiway.

When a HIM/620 is backed up by a redundant HIM/620, status information for the redundant HIM/620 does not appear on the Hiway Status, nor Box Status displays, but is available through data points that access the appropriate timer/counter/status inputs.

3.12 SPECIAL POINT RELATED FUNCTIONS

3.12.1 Associated Display

With Release 510 and later software, an Associated Display can be configured for each HG point at build time by entering the name of a custom-built schematic in the ASSOCDSP parameter. At operating time, the operator can call up that associated custom schematic from a point Detail Display or Group Display.

The ASSOCDSP parameter can be changed from the configuration page of the Detail Display (for points that have a configuration page).

3.12.2 Auxiliary Units

Alarmable HG points in Release 520 and later software have an Auxiliary Unit ($AUXUNIT) parameter. If this 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.

$AUXUNIT can be configured at build time or, with the proper keylevel, it can be initially assigned or changed by schematics, CL programs, the DEB alter parameters function, or from the configuration page of the Point Detail display. The keylevel necessary to change $AUXUNIT is configurable in the System Wide Values section of the Network Configuration File.

Alarms from a point where $AUXUNIT has been configured are accepted only by Universal Stations having an Area Database in which both the Primary Unit and the Auxiliary Unit are configured.

If an $AUXUNIT assignment is changed and there are outstanding alarms on the old unit, alarms are deleted from the old unit and added to the new unit.

Index

Topic	Section Heading
Access, Raw PV	2.7.3.1
Accumulation Point, Multifunction Controller	3.1.14
Alarms	
Analog Points	3.1.10
Critical	2.6.3
Critical Status	2.6.3
Digital	2.3
Flag Point	3.6.5
Regulatory Point	3.3.7
Alias Points	3.2
Analog Input Points	2.6.5
Analog-I/O Data Points, HG	3.1
Analog-Output Data-Point Modes	3.1.9
Associated Display	3.12.1
Attributes and Modes	3.3.12
Attribute Handling by Hiway Gateways	2.4
Auxiliary Units	3.12.2
Backup, HG	2.5
Basic Controllers, RV Inputs to	2.7.2
Binding, Sequence	3.8.8
Box Control States	2.2.10
Box Data Point	3.10
Names	3.10.3
Parameters	3.10.2
Processing	3.10.1
Box Startups	2.7.1.1
Box-State Transitions	2.2.11
Boxes	
Functions Related to Process-Connected	2.7.1
Process-Connected, Functions Related to	2.7.1
Process-Connected, Status of	2.2
C-Link Support	2.7.1.10
Calibration-Offset Points	2.6.6
Capacity, Data Point, HG	2.6
Cascade Requests, Handling of by HGs	2.4.1
Change Detection	3.2.1.3.1
Characterization and Linearization, PV, Analog Points	3.1.6
Clamping	2.7.1.6
Options, PV, Analog Points	3.1.8
Composite Data Points	
Composite Points in One Box	2.6.2
HG Digital I/O	3.2.3
Configuration, Logic-Block	3.9.4
Contact-Cutout Secondary Points	2.6.9
Control Counter Points	2.6.10
Control Time-out Function	2.7.1.2
Control, Override	3.3.11
Controllers, Basic, RV Inputs to	2.7.2

Index

Index

Index

Index

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Honeywell

Industrial Automation and Control
Honeywell Inc.
16404 North Black Canyon Highway
Phoenix, Arizona 85023-3033

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