TELEDYNE HASTINGS INSTRUMENTS

INSTRUCTION MANUAL

DIGITAL 300 SOFTWARE GUIDE

TELEDYNE INSTRUMENTS
Hastings Instruments
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Manual Print History

The print history shown below lists the printing dates of all revisions and addenda created for this manual. The revision level letter increases alphabetically as the manual undergoes subsequent updates. Addenda, which are released between revisions, contain important change information that the user should incorporate immediately into the manual. Addenda are numbered sequentially. When a new revision is created, all addenda associated with the previous revision of the manual are incorporated into the new revision of the manual. Each new revision includes a revised copy of this print history page.

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SECTION 1

General Information

1.0 Flow Instrument States

Upon application of input power, the switching supply ramps up the supplies. 300ms after the +5V supply exceeds 4.65V the flow instrument will enter the Initialization state (1) The network command prompts contain the INIT mode string, and flow values will postfix the "*I" init mode validity string.

The sensor read interrupt routine pulses the tops of each bridge. If, after 20 - 25 seconds, both bridges are not stabilized at/above the minimum operating voltage, with top and bottom nodes within low and high limits, FAIL mode is set, where after command prompts will contain the FAIL mode string and flow rate values will show the error validity string.

After successful completion of the initialization state, the instrument drops into Idle state (2). While in the Idle state the instrument can measure flow properly but will not attempt valve control. The valve will stay in the default position. Normally the flow controllers will leave the factory configured to automatically proceed into the Operate state (4). This automatic procession can be disabled by a configuration bit in the sensor list, whereupon a network command must be received to move into the Operate state, once in operate state, the instrument will measure and control flow normally.

If a system error occurs the flow instrument will go into the fail state (6). In the fail state, all flow control and flow measurement is stopped. Once in the fail state a network command must be received to move into the Abort state (5). In the abort state, flow measurement occurs but the valve is held in the default position.

State	Description
1	Initialization
2	Idle
3	?
4	Operate
5	Abort
6	Fail
7	Cal
8	Test
9	Recover
10	Tune

A network command can move the flow instrument from the abort state to the Recover state (9). Once in the recover state the flow instrument will automatically drop into the Idle state after completion of any necessary initializations. Normally the instrument would proceed automatically on into the Operate state.

The Calibration (7), Test (8) and Tune (10) states can only be reached if the flow instrument is presently in the Idle state. The automatic transition to Operate must be disabled to reach these states.

1.1 Organization of Data

Most of data in the Digital 300 series is organized into lists/menus. Each list contains information/controls for a particular function of the instrument. Each list can be read in it's entirety or each item within the list can be read individually.

The Sensor list contains data on the instrument as a whole and the flow measurement process. The instrument serial number, firmware revision number, sensor measurements, serial port information, running hours total and the active gas number are all stored in the Sensor list. The active gas and configuration parameters such as the auto-zero process can be controlled from within this menu.

The Valve list contains data on the valve control process. This list will not be present in an instrument without a control valve. The current set point, valve drive values, loop control PID parameters, and control alarms/warning points are all accessed from this list. The controller can be set to analog or network control from this menu. The closed loop PID values in this list, can also be adjusted to optimize the flow control for the system.

Network command implemented to access "mode" items such as states, alarms and warnings are placed in the Mode list. This list contains the alarm/warning status bytes. There is an alarm summary word, alarm word, latched alarms word, flow status word, latched flow status word, warnings word, and latched warnings word present within this list. The summary word is a top-level status indicator. Active alarms or warnings in the other words will activate a bit in the alarm summary word. Some alarms/warnings may intermittently come and go before the processor samples the alarm status word. In order to notify the controlling process of intermittent occurrence the latched status words are used. The alarms/warnings that are triggered by the process are placed into the latched status words where they stay until they are acknowledged by the controlling system.

Each flow instrument contains a thermal mass flow senor and a flow divider (shunt). Each of these devices will be slightly different from other similar parts due to manufacturing differences. Therefore each flow instrument will have individual characteristics that cannot be calculated and must be measured for each instrument. This measurement occurs at the factory. During a calibration run a known gas flows through the instrument and its output is compared to a flow reference. The sensitivity to flow and the non-linearity of the instrument are measured for this gas. Information from this calibration run is placed within the instrument in a Calibration record. The calibration information can be accessed from the calibration list. Since gas density can affect the linearity of the flow divider slightly, there may be more than one of these calibration runs stored within the flow instrument. There may be up to 10 different calibration lists. Calibration list 0 is locked to prevent it from accidental corruption. Other calibration lists can be created and used for after market or field calibrations.

A gas record is used to convert the information measured during the calibration run into valid flow information or other gases and flow units. There may be up to 10 different gas records. Each record can be accessed individually by specifying the particular gas list desired or the active gas list can be read as default. Each gas list will point toward and acquire information from a particular calibration record. The number of the gas list will not normally correspond with the number of the calibration list. Each gas list could point to any of the stored calibration records. However, typically all of the gas lists will acquire information from Calibration list 0. Gas list 0 will be for air or nitrogen and is locked to prevent it from accidental corruption. Other gas lists can be created and used for after market or field calibrations.

1.2 Command Syntax

Network commands are comprised of carriage-return terminated ASCII strings containing one or more fields (arguments). In the following listings a [d] character corresponds to any decimal digit (0 – 9). [dd] will indicate that 2 decimal digits are required. An [h] corresponds to a hexadecimal digit (0 – 9, a – f, A –F). Hexadecimal values are preceded by an "x", both in commands and responses. An [a] is an alphabetic character (a – z). An [xx] indicates a value that is dependant on the particular value being adjusted. It could be an integer, a real, hexadecimal or text. Floating point values may contain (.0123456789+-eE). Curly brackets {} indicate values that may or may not be necessary depending on the situation.

The general format is:

....{*dd}...[MNEM]...{ARG1}...{ARG2}...{ARGn}..(cr)

where MNEM is the only mandatory field and is a unique mnemonic,

[*dd] is the address field used only if addressing enabled- typically used in RS485 communications) "d" stands for any decimal digit. If non-addressed (RS232) communications are being used, this field must be blank.

{ARG1} is a command-dependent first argument,

{ARG2} is a command-dependent second argument,

{ARGn} is a command-dependent no the argument,

(cr) is the mandatory terminating carriage return character,

'....' is variable length "whitespace" comprised of any characters space, comma, semicolon, colon and linefeed. Therefore users may employ these as argument field separators. The beginning of the first field can be preceded by whitespace. Note that the linefeed code is considered whitespace.

Arguments used to write a value are prefixed by '='. Only one argument per command type may be so designated.

Each network command type has a unique mnemonic, and may have one or more mandatory arguments, followed in a few cases by optional arguments.

Network commands require a specific order of appearance of arguments in order to identify the meaning of each argument. Generally, command types that perform both inquiry (read) and setting (write) are distinguished by the absence or presence of '='. Some command types are read-only, others write-only, and still others perform either action depending upon the presence of a prefixed '='. Use of prefixed '=' reduces the likelihood of erroneous or unintended changes when dual purpose (read & write commands are used)

Network commands that are expected to be used frequently have short mnemonics, one letter in some cases. An attempt has been made to name mnemonics in a reminder way, such as 'F' to read indicated flow, or ZRO to perform a user remote zeroing operation.

Examples:

"f" is an RS232 command that will request the current flow rate

"*13 zro" is an RS485 command sent to the unit at address 13 that tells the flow instrument to adjust it's current flow reading to be exactly zero.

Most of the commonly used commands are organized in lists. Each entire list can be listed with a command of this format:

[*dd] [a]L(cr)

Where the [a] denotes an alphanumeric character that indicates the list type. Characters may be upper case or lower case. Valid list types are:

List	Character
Sensor	s or S
Valve	v or V
Gas	g or G
Mode	m or M

Examples:

"SL" is an RS232 command that will generate the entire list of sensor information

"*09 VL" is an RS485 command sent to the unit at address 9. It will respond with all of the valve control data.

Each list has a number of items within it. Each item within the list can be read independently by sending the appropriate list type followed by a space and the item number.

Examples:

"S 9" reads the value of full scale DAC output voltage, whereas

"*23V 5 =10.0" RS485 command for address 23 that changes the value the flow command to 10.0% of full scale.

Some of the commands relating to different calibration records require an instance number when accessing the data. These commands have an "I" after the list type.

Examples:

"cil 0" is an RS232 command that will generate the list of information relating to calibration record "0".

"*01 gil 2" is an RS485 command sent to the unit at address 1. It will respond with all of the information about gas record "2".

When moving data from one calibration record to another, the command will require 3 parts besides the address. The first part is the command mnemonic, the second part is the source record and the third part is the destination record.

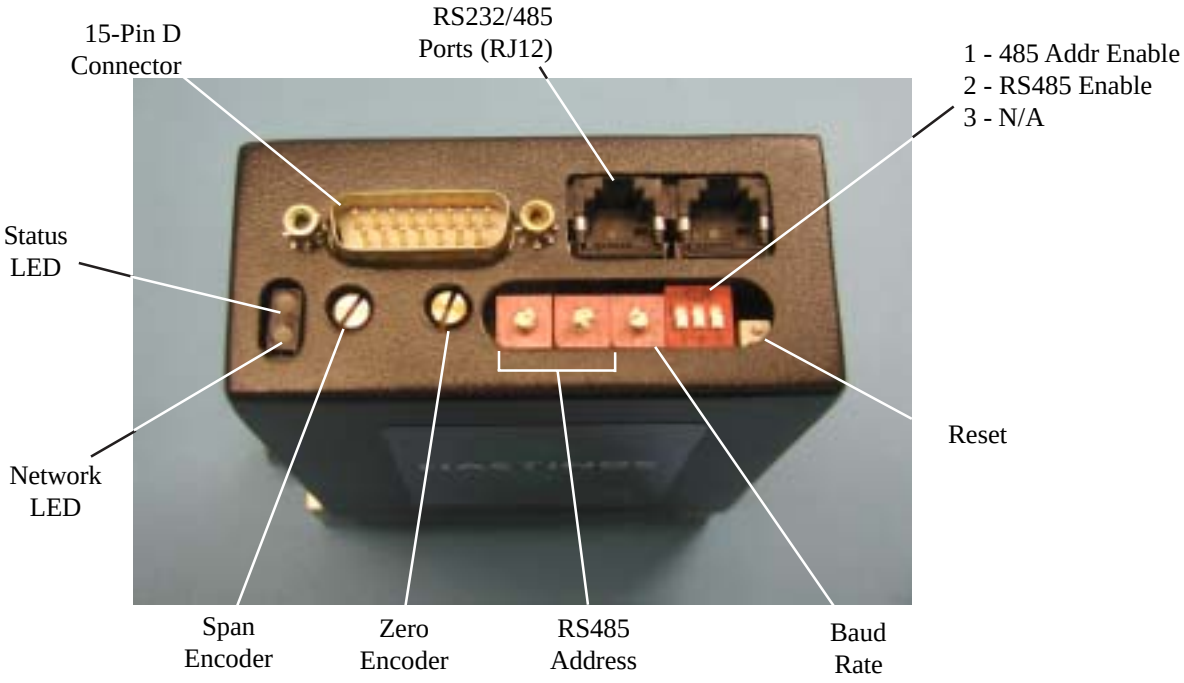
Examples:

"gic 0 3" is an RS232 command that will copy the information relating to gas record "0" to gas record 3.

"*05 cic 2 4" is an RS485 command sent to the unit at address 5 that will copy the information relating to calibration record "2" to calibration record 4.

1.3 Network Addressed and NonAddressed

If network command reception is set to require "addressed" commands, the first network command string field is always a destination address field. This field type is fixed length (three characters) and includes a leading asterisk '*' followed by two decimal digits. If the receiving instrument is operating in addressed mode, and if the command digits match the setting of the two rotary address switches, the command will be accepted for processing. (Address "99" is reserved for broadcast addressing, by which all listening instruments will process these network commands).



Network commands may be either addressed or non-addressed. The choice is mutually exclusive and made by setting dipswitch pole #1 (see fig 1)

1.4 Digital Responses

While network command entries have fixed structure, command responses may be tailored to some extent to accommodate automated network use as well as human use. Automated networks generally desire compact and cryptic responses, while a human user might benefit from verbosity.

The verbosity of responses varies according to user preferences and to command types.

The case of letters in network commands determines the style of output.

If all letters in a network command are lower case, the response will be "cryptic", intended primarily for automated receipt. Cryptic responses generally include only a numeric value with no postfixed units (but validity characters will be postfixed as necessary).

If any one or more letters in a network command are uppercase, the response will be "verbose", incorporating all of the cryptic response, as well as a units mnemonic (when appropriate).

Units mnemonics can be forced for either lower or upper case command text by setting a bit in the MFM Configuration Word (command "S 2"). See section "MFM CONFIGURATION WORD" .

A prefixed data description string will also appear if configured to do so by setting a bit in the MFM Configuration Word (command "S 2"). See section "MFM CONFIGURATION WORD"

Certain network commands elicit multiple lines of responses that are lists of data items. These commands are not intended for brevity, and therefore always include prefixed data description strings as well as units mnemonics for each data item.

All output via RS-232 or RS-485 ports occurs in response to network commands. When network commands use "addressed mode", all responses and error messages from commands sent using the broadcast address will be suppressed.

Network commands related to MFC flow control and data items will return an error message if the MFC option is not configured. See "prod cfg", user accessed as data item "S 64". A bit should be zero if the flow control feature is not installed. See PRODUCT CONFIGURATION WORD.

1.5 Responses with Validity Postfix String

Measured values are error-checked. If an error or alarm condition is detected that is associated with a reported value a character is appended that will identify the conditions.

Postfix characters are X and I. 'X' indicates errored data (when the error is detected). 'I' indicates a measurement read during initialization mode.

Because flow values are filtered with both leading and lagging filter sections, it is not feasible to relate validity indicators with the accuracy of measurement samples taken immediately after an error condition ceases.

Example:

"...2.34" reports indicated flow with no detected error condition

" ...234*I" reports a flow value taken during Initialization mode

" ..*X" reports an errored flow value (alarms and derived modes may be incorrect)

Any numeric value shown with a "*X" postfix is untrustworthy. The "X" postfix overrides "I".

1.6 Auto-Echo at User Port (CP1)

Users can configure character auto-echoing by setting/clearing bit 5 in the MFM Configuration Word . Refer to section "MFM CONFIGURATION WORD".

Use network command "S 2 =xhhhhh" to set this bit. The auto-echo function should be disabled for normal RS-485 multi-dropped network use by clearing this bit to zero so that the instrument does not transmit except after successful receipt of query network commands that cause output. Setting this bit will enable auto-echo.

Factory Port CP0 always auto-echoes.

1.7 Data Units

At the level of the user interface, numeric data is presented and entered in three types of units. "Raw" units are intended for factory or exceptional user usage.

Engineering Units (or "EU"):

EU values are generally floating point format based on a full-scale calibration at known and in user-designated units. The calibration referenced may be one or more factory-provided calibration instances.

%FS units:

EU values can also be accessed as % full scale. Most if not all such values have a magnitude (absolute value) limit of 199.99%, some are bipolar. The magnitude limit exists due to use of fixed-point storage and computation, where at least 2.0x numerical range is provided. Note that this does not imply that specification for accuracy etc. will apply above 100%FS. Full-scale is reported as '"100", rather then "1.0", and '% is postfixed whenever units are requested.

Raw units and non-dimensioned values:

This category exists for values where EU conversion is not possible or justifiable, or meaningless. It also includes string values such as Calibration Date.

A list of units may be obtained by the "LUNT" network command.

1.8 Newline and Prompt Strings

The character sequence at the end of responses to network commands may be set as desired. System data items 65 and 66 allow users to define end-of-line and prompt strings.

Strings are entered and queried as hex values. Zero to four bytes are allowed. To enter zero bytes (eg., no string), use =x00;

Example newline entries are:

For carriage-return (default), enter "s 65 =x0d".
For carriage-return linefeed, enter "s 65 =x0d0a" or "s 65 =x0a0d" as desired.
For "space space carriage-return" enter "s 65 =x20200d"

Example prompt entries are:

For a right arrow '>' use "s 66 =x3e"
For a dot (decimal point) '>' use "s 66 =x2e"
To make a "smiley face: prompt use "s 66 =x3a2d29".

Generally, the prompt string uses characters that will not appear in output strings so as to facilitate parsing of received data by the master controller.

Factory Port CP0 newline and prompt strings are fixed as "carriage return" and '>', respectively.

When establishing these, be certain that the host system is not "translating" strings unexpectedly (such as CR to CR-LF); Because the Factory Port outputs only a CR, which requires translation of CR to CR-LF for logging on dumb terminals, this might be confusing.

Values may be entered as decimal rather than hex format. Refer to table of ASCII characters translated to hexadecimal values.

SECTION 2

Serial Port Configurations

The present Digital 300 Series Instrument has two independent asynchronous serial ports, one (User Port, known as CP1 to software) user-accessible at RS-232 or RS-485 levels, the other (Factory Port known as CP0 to software) at 5V-logic levels accessible at header P1.

The User Port can be set to operate at bit rates of 1200 to 19200 bps using the rotary switch nearest the dipswitch. Position settings are as follows:

Position	Bit rate
"0"	1200bps
"1"	2400bps
"2"	4800bps
"3"	9600bps
"4"	19200bps
"5" through "9"	9600bps

The Factory Port operates at 19200bps.

2.0 RS-485 and RS-232 SELECTION FOR USER PORT (Port #1)

RS-232 operation is enabled by setting Dipswitch #2 (second from left, end nearest rotary selector switches) to the down/off/0 position. RS485 operation is selected by setting this switch to the up/on/1 position. Software checks this switch approximately every four seconds, and will change then.

The factory port (Port #0) is always set for RS-232 operation; RS-485 is not available.

The RS-485 signal naming and polarity convention used by Digital 300 is consistent with the TIA/EIA-485 standard as follows:

Signals TXA and TXB are driving outputs from the Digital 300. The "logic 0" (spacing) state is defined by TIA/EIA-485 to be the case where Signal TXA is more positive than TXB. Logic "1" (marking) exists with TXB more positive then TXA.

When the RS-485 port is used for asynchronous character transmission by Digital 300, the idle line state (no character in progress) is logic "1" (TXB (or RXB) more positive than TXA (or RXA)).

Like RS-232 mode, RS-485 mode can be used for a point-to-point connection. With a point-to-point connection, Digital 300 can be operated in the "nonaddressed" network command mode.

To establish "non-addressed" network mode using RS-485:

1. Place pole #2 of Dipswitch in on/up/1 position to enable RS-485 mode.
2. . Place pole #1 of Dipswitch in the down/off/0 position to disable "addressed network" mode. No address will be required at the beginning of network commands.
3. Set auto-echo as desired. See NETWORK COMMAND PORTS: Auto-Echo at User Port (CP1)

Software checks the dipswitches switch approximately every four seconds, and will recognize a change within that time..

To use RS-485 signaling, the jumper field on the PC-872 board must be configured for the specific RJ12 pinout desired. Be certain to provide a ground connection to all other RS-485 devices using at least one pin of J402 and J403. (RS-232/RS-485 ground is common to the instrument base/case should that be desired as a grounding point).

2.1 Rotary Switches for Network Address of User Port CP1

The pair of rotary switches nearest the encoders is used to set the network address that is active in the "network/ addressed" mode ("OFF/ONLINE" dipswitch #1 up/on). In this mode, the first three characters of a network command string must be "*nn". The switch nearest the encoders selects the most significant digit. Values from "00" to "99" are selectable.

Adopted settings may be read using the "S"' or "SL" network commands. Changes are adopted within 20 seconds. If the connected network is active, to avoid unexpected reaction to commands addressed to another instrument, the "OFF/ONLINE" dipswitch (pole #1 nearest the rotary switches) should be set to the downward/off/offline position before changing the address select switches, and for at least 20 seconds thereafter (or until verified by command read).

2.2 RS-485 Mode Network Addressed Commands

To establish "network/addressed" command mode for the User Port using RS-485:

1. Place pole #2 of dipswitch in on/up/1 position to enable RS-485 mode (while disabling RS232).

2. . Place pole #1 of dipswitch in the on/up/1 position to enable "network" mode. An address is required at the beginning of commands, eg., "*aa xxxxx" where "*aa" is the address portion, aa is the numeric address set into the network address rotary switches, and " xxxx..." is the remainder of a command.

   Software checks the dipswitches switch approximately every four seconds, and will recognize a change within that time..

3. Disable auto-echo. See NETWORK COMMAND PORTS: Auto-Echo at User Port (CP1)

Network address "99" is the broadcast address to which all online instruments will listen ("Online" in this context means that dipswitch poles #1 and #2 are in the up/on/1 position, and the instrument is otherwise operational).

Many network commands will not respond to a broadcast command. These are commands that necessarily evoke a response. If more than one instrument responded, the collisions of data would garble all responses.

Examples of addressed commands are:

" *31 f " query the indicated flow from address 31 ('3' and '1' set into rotary switches for address election)

" *99 ss =4 " place all online instruments into OPERATE state

2.3 RS-485 Tristating

User Port CP1 can be configured for RS-485 electrical levels. Command strings are identical for both RS-232 and RS-485 modes (ASCII asynchronous N-8-1) but RS-485 supports multi-drop operation when all attached instruments are properly configured. It is expected that users would set multi-dropped instruments into ONLINE mode with tri-stated transmit outputs by setting both dipswitch poles #1 and #2 to the up/on position.

Set dipswitch pole #2 up/on when RS-485 mode is to tri-state (high impedance state) its output after the last character transmitted until the next is ready to be transmitted. If bit cleared by setting dipswitch pole #2 down/off, RS485 output drive is always active (never tri-states), which should not be done if more than one instrument is connected to an RS-485 circuit.

Tri-stating works as follows. When the transmit UART for User Port (CP1) is inactive (hardware double buffers empty), RS-485 output is disabled (tri-stated). When a character exists in either UART transmitter buffer, it is either about to be or is in the process of transmission and RS-485 output is enabled (not tri-stated). Port driver software will enable User Port RS-485 output when initializing character output. The 1 millisecond interrupt routine tests buffer state and if empty, will disable User Port RS485 output drive. Therefore, drive is enabled just before the ASCII async "start" bit is sent, and will be disabled within 2 milliseconds (worst case) after the stop bit is sent.

The 2 millisecond delay in tri-stating RS-485 output can cause character errors in RS-485 half-duplex (2-wire)

setups if the master responds quickly to data output by a Digital 300 instrument and emits a character before the Digital 300 instrument tri-states its output.

Digital 300 hardware and software assume that RS-485 signaling polarity is such that the “marking” condition (which is same polarity as async stop bits) is maintained when the RS485 output drive is disabled (tri-stated). Therefore, UART receivers of all connected instruments never see a “line break” condition resulting from this tri-stating action. “Break” conditions are supposed to be caught by the UARTs error-detect mechanisms, but when caused by erratic opens and/or shorts will create false characters that are accepted by the UART receiver.

SECTION 3

OPERATION

3.0 LED INDICATORS

There are two bicolor (red, green) LEDs. They are controlled as follows:

LED associated with instrument

Instrument State	LED Mode	Condition
No or Low Power	off	No power or voltage insufficient
Initializing	alt. red & green	Warmup/Init/SelfTest/
Executing	green	
Fatal fault	red	

LED associated with network

Network Mode	LED Mode	Condition
No power/Offline	off	
Online, received command	flash dark	
Online, ready for command	green	

3.1 ALARM and WARNING LIMITS

Gas instance records keep upper and lower flow rate alarm and warning limits. Limits are checked at 8mS intervals against linearized, normalized and filtered flow measurements that have been converted to FS units.

A user-adjustable delay is imposed before reporting and clearing these alarms and warning conditions. The first violation of a limit will start a timer. If after timeout, the over-limit condition is still active, the corresponding alarm (or warning) flag will be set in the alarm (or warning) flags word. This process acts similarly with delay for clearing of these alarm conditions.

Settling delays are intended to minimize alarms due to transient flow changes. Alarms and warnings may be enabled and inhibited by network commands. See section: ALARMS, WARNINGS.

Independent timers for high and low alarms exist in order to allow alarms to be reported in the case where flow cycles rapidly above the upper and below the lower alarm limits, which may occur if they are closely spaced. It is possible for both alarm conditions to briefly exist simultaneously due to this delay mechanism.

No hysteresis is applied. Also, it is possible for users to set the upper alarm and warning limits below the lower, and vice versa.

3.2 CHANGING UNITS

Swapping units of flow is supported for predetermined types. Unit changes affect only values that are based on a measured and/or stored full-scale value. When a change is requested, only the ratio of EU to %FS is changed; the various scalings and offsets used to compute FS are not changed.

EU values for indicated flow and total flow are never stored, but always computed on-demand from FS values.

Integrated flow (total flow) is kept internally as the integral of linearized/normalized sensor power difference in 0.1 hours, and therefore remains unaffected by both units changes, gas-type rescaling and %FS rescaling. Only changes in sensor itself or to the chosen linearization polynomial will introduce errors in gas flow totals

3.3 GAS TYPES

186 SEMI standard gas types are stored by SEMI gas code. Each gas instance may be assigned one gas type code.

A list of gas codes with mnemonics can be accessed by the "LGSY" network command.

3.4 RESCALING GAS TYPES

Gas scaling can be based on calibration data for another gas by linear (first-order) multiplication by the Span Correction Factor available for each gas instance. Adjustment will affect the %FS scaling and therefore the associated EU value. Changing the Span Correction Factor for a gas is equivalent in effect to adjusting the Span Encoder.

3.5 SPAN and OFFSET ENCODERS

These encoders adjust sensor offset and gain in steps of 1/2048 (~0.05%) of FS per click (FS is that of the gas instance, and not sensor FS). An acceleration scheme permits slow single-stepping with ability to make large adjustments in a single twist motion. These encoders may be enabled/disabled in software using the MFM Configuration Word (S 2). See MFM Configuration Word section for further information.

Encoder steps and direction are detected in hardware, accumulated (by direction) about every 8 milliseconds, with span factors and zero offset values updated every 125 milliseconds. This method will accurately accumulate individual clicks as fast as about 5 shaft rotations per second, and is free of directional aliasing in the event of faster rapid stepping.

Encoder adjustment values are stored independently of other offset and scaling factors in order that the numerical components due to encoder operation can be removed or changed by network command without knowledge of, confusing or losing other factors.

Span encoder adjustment range is limited to a range of 0.0625 to 15.999.

The zero encoder offset value is stored as associated with the sensor. Rezeroing using the user "remote zero" ZRO command or factory FZRO command will zero the encoder zero offset value.

Four zero-offset variables are maintained in NVRAM, factory offset, user offset, Autozero offset and encoder offset. The purpose of factory offset is to remove a large static offset value as may be required. The user offset component should have smaller magnitude.

The span encoder factor is stored associated with each gas instance. Therefore, changing gas instances will restore the span encoder factor in effect the last time an encoder adjustment was made using a particular gas instance. Recalibration of full-scale gas flow using the GFS command will set the span encoder factor for then current gas instance to 1.000. The span factor may be changed at any time using the G or GI network command.

3.6 FLOW AND FLOWING TIME INTEGRATION

Values for integrated flow (total flow) and flowing hours are stored internally as the integral of linearized/normalized sensor power difference in 0.1 hours, and as flowing 0.1 hours, respectively, accumulated every 10 seconds when flow rate is above 1% of present user full-scale.

Total flow is stored per gas instance.. Values are reported based on the present flow rate units (eg. if flow units are presently L/min, total flow will be reported/entered as nnn.nnn L). Since flow accumulation is kept in raw sensor units, it is not affected by changes to engineering units type nor FS scaling. (Adjusting the rotary encoders will, however, change the scaling of subsequent integration).

Total flow is queried for gas instances using network commands "g 30" or "gi [d] 30" (for watt-hours), and "g 31" or "gi [d] 31" (for EU). Data item "g 30" may be specified to be output in units of counts*hours or as watt*hours as configured per bit 6 in the MFM Configuration word.

Flowing hours are maintained for the instrument (as opposed to per-gas-instance) and is queried using network command “s 12”.

Network commands to change the totals are unrestricted so users can change to other values. “Resetting” is done by changing to 0.0 (examples: “gi 4 31 =0.0” or “s 12 =0.0”). .

Gas units, full-scale EU and full scale power difference values can be changed without destroying flow totalizer scaling. This is because flow totalizers are maintained in internal units of power difference. However, changing the fundamental scaling of the sensor will affect total flow values as they are not automatically rescaled for sensor data modifications (must be done manually).

3.7 MFC OPERATION

Flow control is activated by setting MFC mode to “1” (AUTO, use “V 1 =1”)) and instrument state to OPERATE (“ss 4”).

Flow control action is modifiable by:

- soft start
- adjustment of PID coefficients
- selection between two types of derivative action
- adjustment of drive values for valve shut, valve cracked and valve upper limit.

Note that the “valve cracked” drive value serves as the “output bias” amount that is added to the controller output.

Network commands related to MFC flow control and data items will return an error message if the MFC option is not configured. See bit 1 in variable “prod cfg”, accessed as data item “S 64”. This bit should be zero if the flow control feature is not installed. See PRODUCT CONFIGURATION WORD.

Valve control operates in accordance with the MFM “state” data item (refer to MFC MODE WORD , data item “V 1” “MFC mode:”), and also per the “MFC mode” (refer to MFC MODE WORD , data item “V 1” “MFC mode:”).

Network commands exist to directly control valve working (set to default position - purge or shut, force shut, force open (purge), set into automatic closed loop mode, set to “hold” mode (valve stays where was in auto mode), set valve drive “manually” per command).

3.8 1% SHUTOFF THRESHOLD

When the flow control setpoint (query v “item 6 :cmmd setpt”) is less than 1% of full scale flow rate for the active gas rec (query g “item 18:FS flow”) then:

1. the implemented setpoint value is forced to zero (query v “item 8 :impl setpt:”)
2. Valve is forced shut.

Bit x02 in “item 3 :valve mode:” is set to indicate this.

The action can be disable. see MFC configuration word.

Flow loop tracking error alarm & warning remain active (if user enabled) in HOLD mode as well as when setpoint is below the 1% FS threshold.

Note that tracking error is the difference between the implemented and the measured flow. Therefore the tracking alarm should not be active when 1% shutoff is active, except possibly as a transient condition.

There is a small amount of hysteresis in the 1% shutoff limit. If the command setpoint is < 1% FS, the implemented setpoint is zeroed and the valve is placed in the shut mode. If enabled, softstart operates for both network commanded setpoint as well as for analog command setpoint.

3.9 Selection of Type of Derivative Action

Bit 0 (lsb) of data item “v 2” (MFC config) select either (1) derivative is rate of change of the difference controlled variable minus setpoint (in case of bit cleared to 0), or (2)) derivative is rate of change of controlled variable (with no effect by setpoint changes (in case of bit set to 1)

Clearing this bit so that derivative action is the difference controlled variable minus setpoint will cause a pre-shoot in controller response of amplitude proportional to the coefficient of the derivative (rate) term (“item 25:PID rate coeff:”).

3.10 SOFT START

MFC action provides a user enabled soft start action. Soft start operates as a slew rate limit that acts upon increases to the implemented setpoint per the network setpoint command, or to an analog setpoint command via an analog input.. It operates all the time that flow control is active, not just during “starting”.

There is no slew rate limit for decreases in implemented setpoint.

Soft start action conflicts with the TUNE state and is disabled in TUNE state.

There is a delay of up to 1/32 second after reception of a new setpoint command before the implemented setpoint is updated. If this is undesirable when using setpoint commands via an analog input, just disable the soft start function.

Users of the analog setpoint command method should be aware that imposing a slew rate limit may destabilize “outer” control loops that embed the MFC as an “inner loop” controller.

3.11 ALARMS, WARNINGS

To read alarms	“ma”
To read latched alarms	“maa”
To read latched alarms and clear selected bits	“maa =xhhhh” where hhhh has bits set that correspond to bits to be cleared. Value read back will be before clearing.
To set flow alarm limit for active gas instance:	“g 9 =dd.dd” for high limit in EU “g 10 =dd.dd” for high in %FS “g 11 = dd.dd “ for low limit in EU “g 12 = dd.dd “ for low limit in %FS
To enable (disable) high and low flow alarm	“s 7 =1” (or =0" for disable)
To set flow alarm settling time	“s 8 =dd.d” up to 25 seconds in tenths of a second. Setting to delay by zero will delay indefinitely
To enable (disable) high and low flow warning	“s 9 =1” (or =0" for disable)
To set flow warning settling time	“s 10 =dd.d” up to 25 seconds in tenths of a second . Setting to delay by zero will delay indefinitely
To set flow warning limit for active gas instance:	“g 9 =(d.ddd)” for high limit in EU “g 10 =dd.dd” for high in %FS “g 11 =dd.dd” for low limit in EU “g 12 = dd.dd “ for low limit in %FS

To set flow alarm or warning limit for any gas instance: “gi n = dd.dd “ where “n” = instance

3.12 CALIBRATION RECORDS

To assign a calibration record referenced by a gas record, enter the “instance” number of the desired calibration record.

“ gi 2 19 =3 “ assigns cal rec #3 to gas rec #2
“ g 19 =3 “” assigns cal rec #3 to the active gas rec

To de-assign a calibration record referenced by a gas record, enter an asterisk “*” instead of a number.

“ gi 2 19 =* “ assigns no cal rec to gas rec #2
“ g 19 =* “ assigns no cal rec to the active gas rec.

The gas rec will not thereafter be associated with a cal rec. The previous scaling of gas calibration will be retained. Use the GFS command in CAL state to calibrate the full scale flow rate of a gas record as may be necessary.

An error message “INSTANCE INVALID” means the record is not deleted, but has an illogical or errored data value, and cannot be “READY”

.

To Set Cal Record Dates & Comment

>ci 0 18 =”04-11-2001" for cal date

>ci 0 18

“04-11-2001”

>ci 0 3 =”comment field” for cal comment

>ci 0 3

“comment field”

>

To change cal rec unit code =-1 to change without re-ratioing.

v 1 =4

3.13 GAS AND CAL INSTANCE RECORDS

The Digital 300 recognizes one gas instance as the “active” gas instance, that instance used for flow measurement and related functions. Network commands are used change the active instance. A subset of network commands for gas data access/control exists that operate upon the active gas instance; others require the target instance to be identified as a command argument.

There is no “active” calibration instance. Related network commands specify the target instance.

The zeroth instances are “factory default” and are “access locked” instances.

Presently, Digital 300 software has provisions for ten gas instances, ten calibration instances, and ten sets of linearization coefficients.

3.14 DELETING AND UNDELETING GAS AND CAL RECORDS

Gas and cal records may be deleted using network commands "GID i" or "CID i". Deletion sets a bit within the record that marks it as "deleted". Deletion does not increase nor decrease the number of instance records available in nonvolatile memory. Deletion is useful for hiding records that are not to be used.

Deleted status can be determined by querying any data item in the gas or cal instance. An error message "*#014:ERR: INSTANCE INVALID OR DELETED*" implies the instance is deleted.

GID and CID delete commands have an "undelete" feature. A deleted record can be undeleted by entering "GID i u" where i = instance, and single character u' specifies that undeletion is desired.

A cal rec may not be deleted if one or more gas recs reference it. Use command "gi i 19 =*" (use asterisk in place of a number) for all associated gas recs to disassociate that cal rec, then delete the cal instance.

Neither a gas nor cal rec may be deleted if marked as a factory default record or if access locked.

Certain data items can be defaulted when a record is "undeleted". All data in undeleted records should be examined to determine if any must be set or restored properly. An undeleted record may not be useable, in which case the GIC or CIC command may be used to copy an existing or create a new record for that instance.

3.15 FLOW CONTROL

Set Flow Controller mode ("MFC mode"): (to read, use "v 1"). Refer to section "CONTROL DATA: MFC (FLOW CONTROLLER) MODEWORD".

to DEFAULT	"v 1 =0" (sets default valve position).
to AUTO	"v 1 =1" (state must be set to OPERATE to enable automatic valve action, use "ss 4") (network command sets setpoint, Use "v 4 =n.nnnn for setpoint")
to HOLD	"v 1 =2" (only from AUTO in OPERATE state)
to SHUT	"v 1 =3"
to PURGE	"v 1 =4"
to VARIABLE	"v 1 =5" (network command sets valve drive, use "v 28 =nnnnn")

To set network setpoint: "v 4 =dd.d"

To enable/disable automatic OPERATE mode after INIT:

Set/clear bit x1000 in "sys config" word using command "s 2 =xhhhhh.
Example: "s 2 =x0D145" enables, whereas "s 2 =x0C145 disables.

To set tracking alarm limit: "v 16 =dd.d" for flow rate in EU
: "v 17 =dd.d" for flow rate in %FS

To enable (disable) tracking alarm "v 18 =1" (or =0" for disable)

To set tracking alarm settling time "v 19 =dd.d" up to 25 seconds in tenths of a second
Setting to delay by zero will delay indefinitely

To enable (disable) tracking warning "v 22 =1" (or =0" for disable)

To set tracking warning settling time	"v 23 =dd.d" up to 25 seconds in tenths of a second Setting to delay by zero will delay indefinitely
To set PID loop gain coefficient:	"v 24 =ddddd" a positive integer from 0 to 32767.
To set PID loop rate coefficient:	"v 25 =+/-ddddd" a signed integer from 0 to 32767
To set PID loop integrator coefficient:	"v 26 =ddddd" an positive integer from 0 to 32767

3.16 MANUAL VALVE CONTROL

To set valve to default position:	"V 1 =0"
To close valve:	"v 1 =3"
To purge valve:	"v 1 =4"

To "manually" command valve drive current "v 1 =5" (then use "v 28 =ddddd, (item 28:valve set:) where nnnnn is any value from 0 to 65535. Note not limited by upper limit on valve current that is imposed on automatic control (item 31:valve lim:).

To set valve to AUTO mode: "V 1 =1"

SECTION 4

NETWORK COMMANDS

Network commands are grouped into about a dozen categories, each of which has a unique first letter that also is the first letter of the associated mnemonics. The purpose is to loosely organize the large number of command functions and objects around the underlying types of data. There are exceptions to this pattern.

Groups are:

F: flow, read-only data for indicated flow
S: data associated with the sensor
G: gas measurement setups ("instances" in Devicenet'ese)
C: calibration instances
V: valve and flow control
Z: linearization coefficient arrays
L: lists, logs, reports. List available units, Hastings and ODVA assigned.
List gas types by SEMI code number.
M: state, modes, alarms, warnings, status

A list of network commands is given below:

CFS Rescales cal instance set in "ss 7 i" command to present flow rate as 100%FS. Sets span correction factor to 1.0. Check warnings and alarms afterwards. Cal instance 0 is locked and cannot be changed until it is unlocked.

{*dd}CFS(cr)

CI i d [=n] Set/Read data for specified cal instance i using data item code d. The lists are numbered from 0-9. Typically 0 will be air or nitrogen. Cal record 0 is locked to prevent accidental corruption.

{*dd}ci {[d] or [dd]}(cr)

{*dd}ci {[d] or [dd]}=[xx](cr)

CIC i j Copy existing cal instance record i to another j by instance number. the target j'th instance must have been previously deleted. This is used to create new calibration records for field calibration or for calibrations with other surrogate gases.

{*dd}cic [d] [d](cr)

CID i [u] Delete existing cal instance record by instance number. Optional char 'u' as second arg will undelete record. Cal record 0 is locked and cannot be deleted until it is unlocked. Any calibration record that is pointed to by a gas record cannot be deleted. Any calibration record that has the same record number as the active gas record cannot be deleted.

{*dd}cid [d] [d](cr)

CIL i List data items for cal instance i. The lists are numbered from 0-9. Typically 0 will be air or nitrogen.

{*dd}cil [d](cr)

F Read indicated flow value in engineering units

{*dd}f(cr)

Example with trailing engineering unit mnemonic enabled

Command F

Response .99996 SLM

Example without trailing engineering unit mnemonic enabled

Command f

Response .99996

FLOK Certain data items, records and network commands have an access lock. The FLOK command opens or closes access to these.

Unlock access items: "FLOK =[password]"

Lock access items: "FLOK" (or enter incorrect password, or re-initialize instrument)

{*dd}flok(cr)

FS Read raw flow value in %FS units
{*dd}fs(cr)

Example i with trailing engineering unit mnemonic enabled

Command FS

Response 1.9999%

Example i without trailing engineering unit mnemonic enabled

Command fs

Response 1.9999

FR Read the output from the sensor in raw units (watts or counts). This is normally used only for trouble-shooting or sensor analysis.

{*dd}fr(cr)

Example in watts with trailing engineering unit mnemonic enabled
Command FR

Response .030231 W

G j [=xx] Set/Read data for active gas instance using data item code d. If the active gas record is record 0 then changes will not be permitted until the gas record is unlocked.
{*dd}g {[d] or [dd]}(cr)
{*dd}g {[d] or [dd]}=[xx](cr)

GFS Rescales flow rate into the active gas instance as 100%FS. Sets span correction factor to 1.0. Check warnings and alarms afterwards. Gas instance 0 is locked and cannot be changed until it is unlocked.
{*dd}GFS(cr)

GI i d [=n] Set/Read data for gas instance i using data item code d. The lists are numbered from 0-9. Typically 0 will be air or nitrogen. Gas record 0 is locked to prevent accidental corruption.
{*dd}gi {[d] or [dd]}(cr)
{*dd}gi {[d] or [dd]}=[xx](cr)

GIC i j Copy existing gas instance record i to another j by instance number. This is used to create new gas records for other ranges or for use with other gases.
{*dd}gic [d] [d](cr)

GID i [u] Delete existing gas instance record by instance number. Optional char 'u' as second arg will undelete record. Gas record 0 is locked and cannot be deleted until it is unlocked. The active gas record cannot be deleted.

{*dd}gid [d] [d](cr)

GIL i List data items for gas instance i. The lists are numbered from 0-9. Typically 0 will be air or nitrogen.

{*dd}gil [d](cr)

GL List data items for active gas
{*dd}gl(cr)

LGSY c Read Gas Symbol Info by Gas standard code c. 'c' = desired code.
If the desired code is blank the instrument will list all of the gas numbers and names. See Appendix for printed list
{*dd}lgsy {d}(cr)

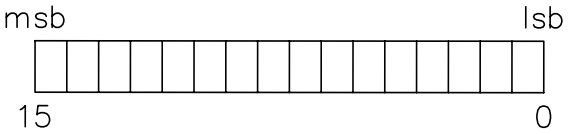
LUNT c Read Engineering Units Table by units code. 'c' = desired code.
If the desired code is blank the instrument will list all of the gas numbers and names. See Appendix for printed list.
{*dd}lunt {d}(cr)

MA Read alarms status word (alarmflags) in hex format (bit per condition)

It is read-only and cannot be changed by network command.

{*dd}ma(cr)

The response is of the following format: x[hhhh]



bit 15(msb): Set if flow above high alarm limit. Only set when MFM state = OPERATE, cleared when not OPERATE.

bit 14: Set if flow below alarm limit. Only set when MFM state = OPERATE, cleared when not OPERATE.

bit 13: Set if indicated flow reading invalid. (Examine flow status). Only set when MFM state = OPERATE, cleared when not OPERATE.

bit 12: Set if sensor failure detected. Set in any MFM state.

bit 11: Reserved

bit 10: Set if CPU powerup restart or a network command initiated the INIT state. Remains set for duration of INIT state. Cleared at end of INIT state, but corresponding bit in ALARMS ACKNOWLEDGE WORD persists set until cleared by network command (Check Acknowledged Alarm Status). This action allows users to detect re-initialization even if state or alarm status is not polled timely during the INIT state.

bit 9: Set if MFC flow control failure detected. (Only set when MFM state = OPERATE and MFC mode = AUTO. On occurrence, MFC mode automatically disabled by setting to ERROR). This flag will be cleared when MFM state is changed out of OPERATE, except if MFM state is changed to ABORT or to TEST in order that the error flag will persist for post-error detection . Subsequent setting of MFM state to RECOVER will clear all alarm flags. Unused if MFC not configured.

bit 8: Set if tracking error (indicated flow minus implemented setpoint) exceeds tracking error alarm limit. (Only set when MFM state = OPERATE and MFC mode = AUTO.).

Unused if MFC not configured.

bit 7-6: Reserved

bit 5: Set if error detected in sensor numeric data

bit 4: Set if error detected in sensor linearization coefficients

bit 3: Set if no valid ready active gas instance selected, or if an error is detected in the selected gas instance data.

bit 2: Set if errored or uninitialized digital filter value exists

bit 1: Set if internal data or hardware error detected. Not all such possible errors are detectable. Instrument should

be deemed untrustworthy if set.

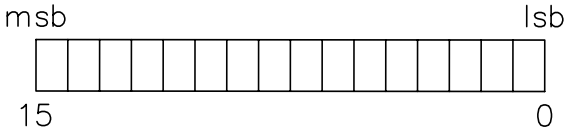
bit 0: Reserved

MAA [=n] Read/clear latched alarm status word in hex format, clear bits using optional argument n. This Alarm Acknowledge Word retains bits that are set to 1 in the Alarm Status Word until each is cleared by network command. Any bit set in the optional argument will be cleared in subsequent reads from this register. i.e. reading the register and then writing the same value back will clear the register. The meaning of each bit is the same as that listed under the MA command.
{*dd}maa(cr)
{*dd} maa =x[hhhh](cr)

MF Read flow measurement status word (flow status) in hex format (bit per condition). It is read-only and cannot be changed by network command. The Flow Status word indicates exception conditions detected that affect MFM flow readings. Not all possible conditions that affect accuracy of flow are detectable. Certain bits are summarized into alarms or warnings. Querying the Flow Status word can provide details regarding the cause of alarms and warnings.

{*dd}mf(cr)

The response is of the following format: x[hhhh]



bits 15(msb) – 8: Reserved

bit 7: Set if error detected during computation of runtime data for active gas instance. Check validity of gas instance and all related data (including linearization coefficients). Causes alarm when set.

bit 6: Set if indicated flow computation experienced detected overflow. Usually this will be caused by indicated flow exceeding +199% or -199% of the full scale value due to excess gas flow rate. Causes alarm when set.

bit 5: Set if upstream bridge sensor failure is detected. Causes alarm when set.

bit 4: Set if downstream bridge sensor failure is detected. Causes alarm when set.

bit 3: Set if full scale indicated flow range exceeds specified maximum. This applies to the calibrated range, and not to actual indicated flow. Measurements of indicated flow would continue to be made, but may be in error due to exceeding sensor range. A warning bit is also set.

bit 2: Set if full scale indicated flow range is less than specified minimum. This applies to the calibrated range, and not to actual indicated flow. Measurements of indicated flow will continue to be made, but may be in error due to operation below minimum sensor range. A warning bit is also set.

bits 1 – 0 (lsb): Reserved

The bits 7-4 of the Flow Status word will cause an ‘X” to be suffixed to indicated flow values when any bit(s) is/are set.

MFA [=n] Read latched low measurement status word (flow status) in hex format, clear bits using optional argument n. This Flow Acknowledge Word retains bits that are set to 1 in the Flow Status Word until each is cleared by network command. Any bit set in the optional argument will be cleared in

subsequent reads from this register. i.e. reading the register and then writing the same value back will clear the register. The meaning of each bit is the same as that listed under the MF command.

{*dd}mfa(cr)

{*dd} mfa =x[hhhh](cr)

ML List all values individually accessible from the MS, MSC, MA, MAA, MF, MFA, MW and MWA commands
{*dd}ml(cr)
The response will be:

state: [d]

mfm status: x[hhhh]

alarms: x[hhhh]

unacked alarms: x[hhhh]

flow status: x[hhhh]

unacked flow status: x[hhhh]

warnings: x[hhhh]

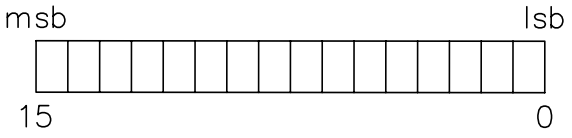
unacked warnings: x[hhhh]

MS Read instrument (MFM) state (state set by SS command)
{*dd}ms(cr)

Value	State
1	INIT.
2	IDLE.
3	reserved
4	OPERATE
5	ABORT
6	SFAIL
7	CAL
8	TEST
9	RECOVER
10	TUNE

MSC Read instrument (MFM) status in hex format (bit per condition)
{*dd}msc(cr)

The response is of the following format: x[hhhh]



bit 15(msb): Set when flow rate > 2% of fullscale.
bit 14: Set if the controller is controlling flow normally.
bit 13: Set if any failure or disablement of automatic flow controller

bit 12: Set if detected flow measurement error. Use this for summarized queries, use bits in alarmflags and flowstatus for details. This flag is not latched/retained.

bit 11: Set if a flow measurement error is detected.
bit 10: Set if a flow measurement error has not been acknowledged.
bit 9: Set if a flow alarm has been triggered
bit 8: Set if a flow alarm has not been acknowledged
bit 7: Set if a flow warning has been triggered
bit 6: Set if a flow warning has not been acknowledged
bit 5: Set during automatic zeroing (ZRO and FZRO commands in process)

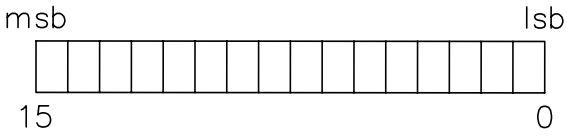
bit 4: Set or cleared when the ABORT state is asserted so as to indicate the subsequent action when the RECOVER state is asserted. If set, RECOVER state will cause a transition to the OPERATE state. If clear, RECOVER state will cause a transition to the IDLE state

bit 3: Set if unit is allowed to respond to addressed network commands (eg., "*nn" as first three characters of command string), If clear, addressed network commands are not supported, and if used will return an error.

bit 2-0: Reserved

MW Read warnings status word (warnflags) in hex format (bit per condition). It is read-only and cannot be changed by network command. {*dd}mw(cr)

The response is of the following format: x[hhhh]



bit 15(msb): Set if indicated flow above high flow warning limit. Only set when MFM state = OPERATE, cleared when not OPERATE.

bit 14: Set if indicated flow below warning limit. Only set when MFM state = OPERATE, cleared when not OPERATE.

bit 13: Set if tracking error (indicated flow minus implemented setpoint) exceeds tracking error warning limit. (Only set when MFM state = OPERATE and MFC mode = AUTO.

Unused if MFC not configured.

bits 12 - 6: Reserved

bit 5: Set if DAC output temporarily zeroed, or forced to non-realtime value.

bit 4: Set if no valid cal instance associated with active gas instance. This is not necessarily an error or problem, and the lack of an association may be intended.

bit 3-0: Reserved

MWA [=n] Read/clear latched warnings status word in hex format, clear bits using optional argument n. This Warnings Acknowledge Word retains bits that are set to 1 in the Warnings Status Word until each is cleared by network command. Any bit set in the optional argument will be cleared in subsequent reads from this register. i.e. reading the register and then writing the same value back will clear the register. The meaning of each bit is the same as that listed under the MW command.
{*dd}mwa(cr)

{*dd} mwa =x[hhhh](cr)

The response is of the following format: x[hhhh]

S d [=n] Set/read system/sensor data items by item code d
{*dd}s {[d] or [dd]}(cr)
{*dd}s {[d] or [dd]}=[xx](cr)

SL List all system/sensor data items, values and units
{*dd}sl(cr)

SS s Set instrument state. Sets the instrument to the desired state. Cal, Test & Tune states can only be set if the present state is Idle. If the instrument is setup to automatically drop from Idle to Operate, setting the state to 2 will automatically bring up state 4.
{*dd}ss [d](cr)

Value	State
1	INIT.
2	IDLE.
3	reserved
4	OPERATE
5	ABORT
6	SFAIL
7	CAL
8	TEST
9	RECOVER
10	TUNE

SS 7 i Set instrument state to CAL. Specify target cal instance when setting CAL state using syntax “SS 7 i” . “i” = desired calibration record instance and is mandatory.
{*dd}ss 7 [d](cr)

V d [=x] Set/read MFC mode and valve control data items by item code d
{*dd}v {[d] or [dd]}(cr)
{*dd}v {[d] or [dd]}=[xx](cr)

TOFF Stop test mode. Stops all active tests. Instrument remains in the test state.
{*dd}toff(cr)

TDAO Sets the analog output to the value that it would indicate for a flow rate of zero. Used for adjusting the analog output signal zero value. Instrument must be in the Test state to use this command.
{*dd}tdao(cr)

TDAS Sets the analog output to the value that it would indicate for a flow rate of full scale. Used for adjusting the analog output signal to the full scale value. Instrument must be in the Test state to use this command.
{*dd}tdas(cr)

TDAZ Sets the analog output to the lowest possible value that it can. Used for troubleshooting the analog output circuit. Instrument must be in the Test state to use this command.
{*dd}tdaz(cr)

VL List all MFC and valve control data items

{*dd}vl(cr)

ZI i j [=v] Set/read linearization coeffs by instance i for coeff j. There are 10 instances of 5th order polynomials available for calibration error correction. The instances are numbered from 0-9. Typically 0 will be air or nitrogen. Linearization instance 0 is locked to prevent accidental corruption. Each instance has 5 values (numbered 1 – 5) that correspond to the coefficients of a 5th order normalized polynomial. Each polynomial has had the offset value removed and each value normalized by dividing by the sum of all of the coefficients.

{*dd}zi [d] [d]}(cr)

{*dd}zi [d] [d]=[xx](cr)

Example

Zi 2 1 =1	set x coefficient of second set of coefficients to 1
Zi 2 2 =0	x^2 coefficient of second set of coefficients to 0
Zi 2 3 =0	x^3 coefficient of second set of coefficients to 0
Zi 2 4 =0	x^4 coefficient of second set of coefficients to 0
Zi 2 5 =0	x^5 coefficient of second set of coefficients to 0

This is the equation of a straight line and is linearization set that must be used in an initial calibration run to collect the data to generate a new set of linearization values that would be used to correct the errors for this particular gas and flow.

ZRO Adjusts zero of flow meter to read at present flow rate. Updates user offset value. This command should executed periodically when the flow rate is known to be zero.
{*dd}zro(cr)

SECTION 5

MENU/LIST:

5.0 Sensor List

>sl
item 1 :model: DIGITAL 300 v1.30d
This gives the software version (read only)
item 2 :mfm config: x0FC57
Instrument configuration bits. See section on MFM Configuration
item 3 :port rate: 9600 BPS
Baud rate of user port
item 4 :port rate: 19200 BPS
Baud rate of factory port(read only)
item 5 :macid : 04
Address set by rotary switches on the top (read only)
item 6 :active gas inst: 0
This defines which gas record is being used at the moment. Changing this value will switch between the available gases/ranges.
item 7 :flow alarm enable: 1
When this is enabled flow alarms will show up in the status words
item 8 :flow alarm delay: 0. S
This defines the length of time in seconds between the start of an error condition until the time it is reported by the status words.
item 9 :flow warn enable: 1
When this is enabled flow alarms will show up in the status words
item 10:flow warn delay: 0. S
This defines the length of time in seconds between the start of an error condition until the time it is reported by the status words.
item 11:FS volts: 5.V
This defines the full scale analog output.
item 12:flowing hours: 107.0436 H
This defines the time that flow has been passing through the instrument. This can be reset to 0. Useful for determining maintenance schedules.
item 13:cal state inst: *
not used
item 14:precision: 7
This is the number of decimal places that the output data will have.
item 15:total zero offset: -2.164217e-03 W
Differential power value that is subtracted from the sensor value to determine the zero flow value.
item 16:user zero offset: -3.806106e-03 W
This value is updated whenever a „zro" command is received
item 17:autozero offset: 8.596337e-06 W
This value is updated everytime an autozero event occurs
item 18:encdr zero offset: 0.W
This is used to rezero the instrument from the rotary encoder
item 19:filter#1 lpf delay: .4
item 20:filter#2 hpf gain: .23
item 21:filter#2 hpf delay: 4.
item 22:filter#3 hpf gain: .4
item 23:filter#3 hpf delay: .4
These are 3 digital filters that are used to speed up and remove noise from the sensor .
item 24:A/D#0 FS factor: 18048

item 25:A/D#1 FS factor: 18190

These values are adjusted to make the analog/digital convertors read correctly at full scale.

item 26:A/D#0: -2.746582e-03 V

item 27:A/D#1: .07019043 V

These are the values read on the 2 analog input pins. Typically the set point is on A/D #1.

item 28:sensor spec full scale: .04029675 W

item 29:sensor spec full scale: 100.%

item 30:sensor sat limit: 9.191183e-04 W

item 31:sensor sat limit: 2.280875%

item 32:sensor spec low limit: 2.667006e-04 W

item 33:sensor spec low limit: .6618415%

item 34:sensor norm factor: 1.

item 35:bridge match ratio: .9904175

item 36:ub sen cnvrt factor: 1.68976e-04

item 37:ub com cnvrt factor: 5.526083e-04

item 38:db sen cnvrt factor: 1.68617e-04

item 39:db com cnvrt factor: 5.484863e-04

These are internal values pertaining to a particular sensor

item 40:ub sense: 2.092599 V

item 41:ub comm: 6.60588 V

item 42:db sense: 2.106532 V

item 43:db comm: 6.653137 V

These are the values from the upstream and downstream sensor measurements. They should always be in the 1-10 volt range. If they are excessively small or large they are indication that the sensor or the sensor drive circuitry has failed. Typically the comm values are larger than the sense values.

item 44:shunt res: 150.

item 45:watts/counts factor: 6.22517e-10

internal values

item 46:ub power: .09209604 W

item 47:db power: .09328914 W

Power used in the upstream and downstream sensor. They should be approximately the same at zero flow and between .04 - .15 watt.

item 48:A/D cal volts: 5. V

Value that the internal A/D was calibrated to. Should be 5 volts

item 49:ub corr factor: 32768.

item 50:db corr factor: 32768.

Internal values

item 51:DAC zero code: 183

This value may be adjusted to make the analog output read the correct value at zero flow.

item 52:DAC 10volt code: 3903

This value may be adjusted to make the analog output read the correct value at the full scale flow.

item 53:noise thresh: 4200

Increasing this value will decrease the noise values slightly.

item 54:comment: “hello”

Place for a text message to identify instrument for users.

item 55:cal inst gas code: 13

item 56:cal inst gas: N2

item 57:units code: 0

item 58:units name: std.cubic cm/minute

item 59:units symb: SCCM

item 60:span corr factor: 1.

item 61:linz instance: 0

item 62:cal date: 07/22/02

item 63:cal temp: 22

Information about the active calibration run.

item 64:prod cfg: x01

Product configuration. See Product Configuration word information.

item 65:nxtline: x0D000000
The ascii character that will signal the end of the communication line.
item 66:prompt: x3E000000
The ascii character that will Digital 300 will use to signal that it has ended its transmission.
item 67:fact zero offset: 1.633292e-03 W
Value set at the factory.
item 68:serial number: Comply-3
Instrument serial number
item 69:A/D#0 offset: -1
item 70:A/D#1 offset: 0
These are used to adjust the values read by the A/Ds for the minimum value.
item 71:test var: 0.
item 72:test var: 0
item 73:inst config: xFE
item 74:nvmem rec ver: 1
item 75:eerom rec ver: 1
item 76:sensor rec ver: 1
These are internal values

5.1 Gas List

The list is the same whether the Digital 300 is listing the active gas or a specific gas instance.

>gl
item 1 :gas instance: 0
This is the gas record number and the value that must be set in “s 6” to activate this particular record.
item 2 :instance mode: READY
Ready means that this gas record may be used for normal operation
item 3 :gas code: 13
item 4 :gas symbol: N2
This is the gas type that this gas record will measure. See the appendix for the lists of the gases and their respective gas codes.
item 5 :units code: 1
item 6 :units name: std.liter/minute
item 7 :units symb: SLM
item 8 :units ratio: 1.
The engineering units that is used to report the flow values and the ratio between the particular unit and a standard liter. These engineering units and their codes can be found in the appendix.
item 9 :hi alarm limit: .2731323 SLM
item 10:hi alarm limit: 27.31323%
This value may be set in engineering units or %FS. Any flow above this value will set the high flow alarm bit in the status words.
item 11:low alarm limit: .09997559 SLM
item 12:low alarm limit: 9.997559%
This value may be set in engineering units or %FS. Any flow less than this value will set the low flow alarm bit in the status words.
item 13:hi warn limit: .300415 SLM
item 14:hi warn limit: 30.0415%
This value may be set in engineering units or %FS. Any flow above this value will set the high flow warning bit in the status words.
item 15:low warn limit: .1091309 SLM
item 16:low warn limit: 10.91309%
This value may be set in engineering units or %FS. Any flow less than this value will set the low flow warning bit in the status words.
item 17:span corr factor: 1.
This value is used to correct the indicated flow rate to the value on a reference flow meter. This value typically

incorporates the differences between the gases, flow units and reference temperatures between the gas record and the Calibration record.
item 18:FS flow: 1. SLM
This unit is the full scale flow rate for the instrument in engineering units. Other gas records may be present in the same instrument with differing full scale values.
item 19:cal inst: 0
The calibration record that this gas record is using.
item 20:cal inst gas code: 13
item 21:cal inst gas: N2
This is the surrogate gas that was used during the linearization run.
item 22:cal inst FS flow: 1.434599 SLM
The maximum flow for which the calibration data is valid.
item 23:linz instance: 1
item 24:linz coef 1: 1.004007
item 25:linz coef 2: .02106538
item 26:linz coef 3: -.0614481
item 27:linz coef 4: .0363762
item 28:linz coef 5: 0.
The normalized linearizing polynomial values. See the zi command for more information.
item 29:FS flow pwr diff: .02808922 W
This is the output of the sensor when the instrument is at the desired full scale flow.
item 30:integrated flow: 8.902582 WH
item 31:integrated flow: 19016.37 SL
This is the amount of gas that has passed through the flow instrument since the last time that this value was reset. Reset this value by sending a “g 31 =0” command. This value is useful for measuring the total flow that used during a process or to fill a container.
item 32:ready status: x1F
item 33:inst config: x18
internal value
item 34:span encdr factor: 1.
This value is adjusted for simultaneously for all gas records when the span encoder on the top of the instrument is adjusted. Normally this should be 1 or very close to it. Certain spurious conditions have been known to set this value to ~ 0.06. Resetting this value back to 1 will return the instrument into operation.
item 35:gas rec ver: 1

5.2 Calibration List

>cil 0
item 1 :cal inst: 0
This is the calibration instance that gas records should use in “g 19”.
item 2 :instance mode: READY
Ready indicates that record is available for use
item 3 :comment: “hello”
Text position for users.
item 4 :gas code: 13
item 5 :gas symbol: N2
Surrogate gas that was used during the calibration. See appendix for gas codes
item 6 :units code: 1
item 7 :units name: std.liter/minute
item 8 :units symb: SLM
The engineering units that were used during the calibration. See appendix for units codes.
item 9 :units ratio: 1.
The ratio between the calibration units and standard liters.
item 10:span corr factor: 1.
This should always be 1.
item 11:FS flow: 1.434599 SLM

The maximum flow for which the calibration data is valid.

item 12:linz instance: 1
item 13:linz coef 1: 1.004007
item 14:linz coef 2: .02106538
item 15:linz coef 3: -.0614481
item 16:linz coef 4: .0363762
item 17:linz coef 5: 0.

The normalized linearizing polynomial values. See the zi command for more information.

item 18:cal date: 2-21-03

The date the calibration run was performed.

item 19:cal temp: 0

This is the reference temperature for the standard volumetric flow unit used during the calibration.

item 20:FS flow pwr diff: .04029675 W

The sensor output signal for the maximum flow. This should be 0.040 watts

item 21:ready status: x1F
item 22:inst config: x01
item 23:cal rec ver: 1

Internal values

>

5.3 Valve list

>vl
item 1 :MFC mode: 1
This controls the operating mode of the valve control. See MFC Mode word in control and status words section.

0: DEFAULT mode.
1: AUTO
2: HOLD
3: SHUT
4: PURGE
5: VARIABLE (or “manual”)

item 2 :MFC config: x0041

This controls the source of the command signal. See MFC Configuration word in control and status words section.
X0041 = Digital control
X0081 = Analog Control

item 3 :valve posn: x58
Read only indicator of valve control status. See Valve Position word in control and status words section.

x10 SHUT.
x20 PURGE
x30 HOLD
x40 MANUAL
x50 AUTO

item 4 :netwk setpt: 7.995605e-03 SLM
item 5 :netwk setpt: .7995606%

The last Digital command that was received in either engineering units or % of Full scale. A change to these values will change the flow controller set point when the MFC Configuration word is set for digital control. “v 5 =100” will change the flow to 100%.

item 6 :cmmd setpt: 7.995605e-03 SLM
item 7 :cmmd setpt: .7995606%

These values are read only and correspond to the current set point plus any modification to allow soft-start control changes.

item 8 :impl setpt: 7.995605e-03 SLM
item 9 :impl setpt: .7995606%

These values are the set point that is being used to control the flow. They will correspond to the Digital or Analog set point depending on the condition of the MFC Configuration word.

item 10:cntrlld var: -.2929688%

item 11:cntrlld var: -2.868652e-03 SLM

This is the current value of the system parameter that is being controlled by the valve. Typically this is the current flow reading but it could be an analog value on A/D#0 or A/D#1 if an external system parameter such as pressure is being controlled.

item 12:softstart type: x03

This is the type of soft start that is active.

item 13:softstart value: 500

Decreasing this value will speed up the response of the system to changes in the command signal. Increasing it will slow down the command ramp to minimize overshoot.

item 14:trckg error: -.01092529 SLM

item 15:trckg error: -1.086426%

This is the error between the command signal and the process variable. Read only. A large error that persists a significant amount of time after changes in the command signal are indications of failures in the system. Typically, this is cause by insufficient pressure for the requested flow or a failed valve.

item 16:trckg alarm limit: 2.685547e-03 SLM

item 17:trckg alarm limit: .2685547%

When enabled, tracking errors above this settable value that persist longer than the tracking alarm delay will set the tracking alarm bit in the Alarm Word.

item 18:trckg alm enable: 1

Clearing this bit will disable tracking errors from setting bits in the Alarm word.

item 19:trckg alarm delay: .2 S

This is the amount of time that must occur after a tracking error exceeds the alarm setpoint before an alarm is activated. This will allow the valve to stabilize after changes in command without triggering the alarm.

item 20:trckg warn limit: .01361084 SLM

item 21:trckg warn limit: 1.361084%

When enabled, tracking errors above this settable value that persist longer than the tracking warning delay will set the tracking alarm bit in the Warning Word.

item 22:trckg warn enable: 1

Clearing this bit will disable tracking errors from setting bits in the Warning word.

item 23:trckg warn delay: 2. S

This is the amount of time that must occur after a tracking error exceeds the warning setpoint before an alarm is activated. This will allow the valve to stabilize after changes in command without triggering the warning.

item 24:PID propor coeff: 500

This is the PID gain/proportional value. Increasing this value will increase the instantaneous response of the loop to changes in the command signal. Increasing this too much will create valve instabilities. Decreasing this will tend to stabilize unstable control loops.

item 25:PID rate coeff: 300

This is the PID differential/rate term. It changes the valve drive when there are large changes in the setpoint or the process variable. Typically this does not have a primary effect, however if this value gets too large the valve will drop into a high frequency oscillation.

item 26:PID intg coeff: 300

This is the PID integration/reset term. This value integrates the error between the desired process variable and the indicated variable and increases or decreases the valve drive to attempt to bring this integrated error value to zero. A larger value shortens the integration time and speeds up system response. If the value gets too large the system will oscillate. Lower values will slow down system response. A properly functioning controller in a system with adequate flow channels should not require a value lower than 50 for stability.

item 27:valve drive: 40000

This is a read only value between 8 and 40000 that correspond to valve drive voltages between 0 – 24 volts.

item 28:valve set: 14000

This is the value that may be set between 8 and 40000 to set the valve drive voltage whenever the controller has been set variable/manual control by the MFC Mode word.

item 29:valve crackg: 8500

This is the value that will just start to open the control valve.

item 30:valve shut: 0
item 31:valve lim: 40000
These are the minimum and maximum values for the loop control.
item 32:MFC intgratr: -6811363
Internal variable.

5.4 Mode list

See the information on the ML command and the alarms and status section for more information on these.

>ml
state: 2
mfm status: x0080
alarms: x0000
unacked alarms: x0000
flow status: x0001
unacked flow status: x0001
warnings: x0004
unacked warnings: x0004

SECTION 6

Control & Status Words:

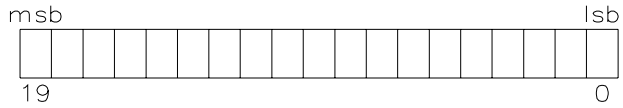
6.0 PRODUCT CONFIGURATION WORD

Read using network command **"**S 64". Data item is factory access locked for writing.

Option	Meter	Controller
0–5 VDC	X00	X01
0–10 VDC	X02	X03
0–20 VDC	X14	X15
4–20 VDC	X1C	X1D
1–5 VDC	X08	X09

6.1 MFM CONFIGURATION WORD

Read using network command **"**S 2"



The MFM Configuration Word selects or enables various instrument features as described below. Settings are nonvolatile.

bit 19 (msb)-18: Unused

bit 17: Set to enable the Zero encoder

bit 16: Set to enable the Span encoder

bit 15 (msb): Set to enable high and low flow rate alarms, clear to disable.

bit 14: Set to enable high and low flow rate warnings, clear to disable.

bit 13: Set to enable AutoZero capability. Clear to disable. If set Autozero action will rezero the instrument approximately 3 minutes after receiving a command to shut the valve.

bit 12: Set if instrument is to automatically enter OPERATE state after successfully entering IDLE state.

bit 11: Set to enable tracking error alarm, clear to disable. (Unused if MFC not configured).

bit 10: Set to enable tracking error warning, clear to disable. (Unused if MFC not configured).

bit 9: Set to enable prefixing of state mnemonic to network command prompt character

Mnemonics representing instrument state may be prefixed to command prompt character ">". These are as follows:

"SFAIL"; // Sensor of flow related failure
"INIT"; // INIT state

"CAL"; // CAL state
"TEST"; // Test state
"IDLE"; // IDLE state (eg., not OPERATEing)
"OPER"; // OPERATE state (SEMI "executing").
"ABORT"; // ABORT state.
"RCVR"; // RECOVERING state.

bit 8: Set to append value units to command response strings irrespective of case of letters in command line

bit 7: Set to prepend data item descriptions to command response strings

bit 6: Set to select output of bridge power difference values in watts, else clear to output in counts>>8.

bit 5: Set if user port CP1 is to echo received characters in non-addressed RS-232 and in RS-485 modes. (Port #0 always echoes). Echoing is disabled when in RS232 and RS485 network addressed modes (refer to section NETWORK COMMAND PORTS: Auto-Echo at User Port).

bit 4: Set if user port CP1 when in RS-485 mode will tristate transmit drive after last character transmitted until next. Used for electrical half-duplex and multidrop schemes. If cleared, RS485 transmit drive is always active.

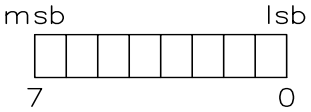
bit 3: Reserved.

bits 2 through 0: Field specifies number of digits precision in floating point number output strings. (Minimum is 3, maximum is 7)

6.2 MFM STATE WORD

The MFM State Word is queried by network command "MS". It is read-only and cannot be changed directly by network command; rather, the "SS n" command is used to request (if permissible) a desired state.

Refer to sections "SS" Set State Command" and "Automatic OPERATE Mode" for further information.



This byte-wide value is set to one of ten values indicating the instrument major state as follows:

Value	State	State Attributes

1 INIT. Initialization in progress, disables auto flow control, disables MFM alarms. Clears all alarms when beginning INIT state.

2 IDLE. MFM alarms are cleared and disabled (certain alarms such as instrument failures are not cleared and remain enabled). Indicated flow values are available. Flow totalizing is disabled. MFC flow control stopped, valve goes to user-defined default position. Many configuration commands are only allowed in the IDLE state

3 reserved

4 OPERATE Executing, MFM and MFC alarms and flow totalizing are enabled. Automatic flow control enabled if otherwise permitted.

5 ABORT Network command sets ABORT state to permit diagnosis and recovery commands to be entered if/as necessary before restoring instrument to IDLE, OPERATE or INIT state. MFC flow control stopped, valve set to user-defined default position.

6 SFAIL Recoverable error detected such as critical data not set, missing, or out of range. Reset using

power down, the reset button, or setting state to INIT (=1) are the only escapes.

7 CAL Calibration state. disables auto flow control, clears and disables MFM and MFC alarms. Network commands to perform flow calibration are permitted.

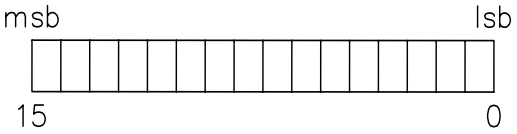
8 TEST Network commands to perform certain tests are permitted. May disable alarms, may disable auto flow control, depending upon specific test invoked. Tests in TEST state are generally factory-only.

9 RECOVER Setting RECOVER state while in ABORT state initiates return to IDLE state.

10 TUNE Network command to perform certain flow and flow control tests are permitted. May disable alarms, may disable auto flow control, depending upon specific test invoked.

6.3 MFM STATUS WORD

The MFM Status Word is queried by network command "MSC". It is read-only and cannot be changed by network command.



bit 15(msb): Set when flow rate > 1% of full scale.

bit 14 – 13: Reserved.

bit 12: Set if detected flow measurement error. Use this for summarized queries, use bits in alarm flags and flow status for details. (inclusive OR of bits in flow status word) This flag is not latched/retained.

bit 11: Set if a flow measurement error is detected. Inclusive-OR summary of bits in flow status

bit 10: Set if a flow measurement error has not been acknowledged. Inclusive-OR summary of bits in flowstatus

bit 9: Set if a flow alarm has been triggered. Inclusive-OR summary of bits in alarm flags

bit 8: Set if a flow alarm has not been acknowledged. Inclusive-OR summary of acknowledge bits in alarm flags

bit 7: Set if a flow warning has been triggered. Inclusive-OR summary of warning flags bits

bit 6: Set if a flow warning has not been acknowledged. Inclusive-OR summary of acknowledge bits in warning flags.

bit 5: Set if periodic autorezeroing is presently active.

bit 4: Set or cleared when the ABORT state is asserted so as to indicate the subsequent action when the RECOVER state is asserted. If set, RECOVER state will cause a transition to the OPERATE state. If clear, RECOVER state will cause a transition to the IDLE state

bit 3: Set if unit is allowed to respond to addressed network commands (eg., "*nn" as first three characters of command string), If clear, addressed network commands are not supported, and if used will return an error.

bit 2: Set while ZRO and FZRO commands are in process, or when automatic periodic zeroing is active measuring and computing a new offset (latter condition lasts about 35 milliseconds). See bit 2 for flag that indicates when periodic autorezeroing is enabled

bit 1 - 0(lsb): Reserved

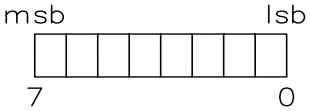
6.4 MFC MODE WORD

(Data item "V 1" MFC mode:)

(available only if instrument has flow control option)

The MFC Mode Word stores the network commanded MFC mode, and is set by command “V 1”. It is user-writeable and nonvolatile (if instrument resets from ERROR or HOLD modes, MFC MODE will be forced to DEFAULT).

Do not confuse the MFC Mode Word with the Valve Status Word



value = 0: DEFAULT mode.

Valve is set into the user default position as specified in MFCMODE_VALVEDEF . Automatic closed-loop action is disabled.

value =1: AUTO

Automatic closed-loop operation is enabled. Valve position is controlled to maintain flow at the implemented setpoint.

value =2: HOLD

Automatic closed-loop operation is suspended. Valve drive is maintained constant. Can be set only from AUTO mode while in OPERATE state. If instrument is reset or repowered while in HOLD mode, valve position will revert to the user defined default position.

value =3: SHUT

Valve is set to the shut position. Automatic closed-loop operation is disabled.

value = 4: PURGE

Valve is set to the full-open position. Automatic closed-loop operation is disabled.

value = 5:VARIABLE (or “manual”)

Valve drive is controlled by network command (“V 28”), or by analog voltage input as chosen in the MFC (Flow Controller) Configuration Word (Data item “V 2”). Automatic closed-loop operation is disabled.

value = 6: ERROR

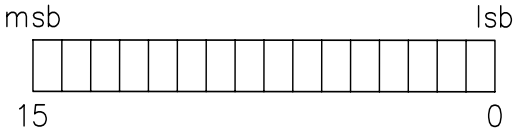
Valve is set into the user default position as specified in MFCMODE_VALVEDEF . Automatic closed-loop action is disabled. If instrument is reset or repowered while in ERROR mode, MFC mode will become DEFAULT and valve position will revert to the user defined default position. The ERROR mode may be set by internal detection of an error condition, or by network command. Once set, the ERROR mode is maintained until changed by user. These operations are not intended as a safety feature.

6.5 MFC CONFIGURATION WORD

(Data item “V 2” “MFC config:”)

(available only if instrument has flow control option)

The MFC Configuration word stores user settings that establish the features and behavior of the flow controller, and is set by network command “V 2”. It is user-writeable and nonvolatile.



bits 15(msb) to 9; reserved, unused

bit 8: One bit field controls automatic valve shutoff threshold. Setting bit to 1 disables the 1% threshold for automatic valve shutoff when the implemented setpoint is 1% or less.

When this bit is clear (0) the instrument will interpret any command of less than 1% of full scale to be a command to close the valve.

If this bit is set (1) the instrument will control flows down to 0% Full scale. Command signals that are identically = 0% or less will activate the close valve control..

Flow totalizer threshold action is not affected.

bits 7(msb), 6: Field of two bits selects source of command setpoint:

00 = invalid assignment, choice will be forced to default (network)
01 = command setpoint taken from network command
10 = command setpoint taken from A/D converter #1
11 = invalid assignment, choice will be forced to default (network)

bits 5,4: Field of two bits selects source of controlled variable:

00 = Controlled variable taken MFM sensor flow value
01 = Controlled variable taken from A/D converter #0
10 = Controlled variable taken from A/D converter #1
11 = undefined

bits 3,2: Field of two bits selects source of valve override command:

00 = no valve override except powerup default, on error
and by network command
01 = valve override from A/D converter #0
10 = valve override from A/D converter #1
11 = undefined

bit 1: Set if valve powerup and error default is PURGE.

Clear if valve powerup and error default is SHUT.

bit 0 (lsb): Set if derivative (rate) term in feedback control loop is taken as the derivative of tracking error (controlled variable minus implemented setpoint.

Clear if derivative (rate) term in feedback control loop is taken as the derivative of controlled variable.

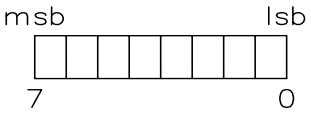
A change in this selection will not be bump less.

6.6 VALVE POSITION WORD

(Data item “V 3” “valve posn:”)

(available only if instrument has flow control option)

This data item is controlled indirectly by the MFC (Flow Controller) Mode Word (data item “V 1”)



Bits 7 - 4: (upper 4 bit field)

value = 0x10

SHUT. Valve forced closed (no current).). Automatic re-zeroing can be enabled in this circumstance.

value = 0x20

PURGE. Valve forced 100% open (max current per data item “V 31” valve lim:)

value = 0x30

HOLD. Valve current held at last auto mode value. This condition can only be entered by transition from a prior automatic control mode.). Automatic rezeroing can be enabled in this circumstance.

value = 0x40

MANUAL. Valve current is non-zero, and may be in the range from closed to max open (max current per data item “V 31”) as commanded by analog input from A/D or by network command “V 28 =nnnn” to program valve current per data item 28:valve set:. Automatic closed loop control is disabled. Automatic rezeroing will not be enabled.

value = 0x50

AUTO. Valve operating under automatic closed loop control.

bit 3: Bit set only when soft-start behavior is permitted (but not necessarily in effect). Valve Position Word must be = CONTROL. Soft start may be disabled when implemented setpoint less than 1%, but this bit will remain set in that circumstance.

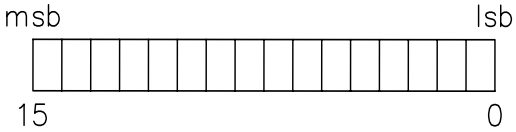
bit 2: Bit set when A/D# 0 input above 5 volts and valve override enabled per bits 2 and 3 of the MFC Configuration word (Data item “V 2” “MFC config:”). Valve will be overridden into SHUT position when operating under automatic closed loop control (when bits field 4-7 above = AUTO) . Automatic rezeroing can be enabled in this circumstance

bit 1: Bit set when implemented setpoint is at or below the Valve Shutdown Threshold (1.00% or 0.00%, or similar if A/D is setpoint source). Valve will be overridden into SHUT position when operating under automatic closed loop control (when bits field 4-7 above = AUTO). Automatic rezeroing can be enabled in this circumstance.

bit 0(lsb): Bit set when A/D# 0 input below 1 volt and valve override enabled per bits 2 and 3 of the MFC Configuration word (Data item “V 2” “MFC config:”). Valve will be overridden into SHUT position when operating under automatic closed loop control (when bits field 4-7 above = AUTO). Automatic rezeroing can be enabled in this circumstance.

6.7 ALARMS STATUS WORD

Read using MA network command. It is read-only and cannot be changed by network command.



bit 15(msb): Set if flow above high alarm limit. Only set when MFM state = OPERATE, cleared when not OPERATE.

bit 14: Set if flow below alarm limit. Only set when MFM state = OPERATE, cleared when not OPERATE.

bit 13: Set if indicated flow reading invalid. (Examine flow status). Only set when MFM state = OPERATE, cleared when not OPERATE.

bit 12: Set if sensor failure detected. Set in any MFM state.

bit 11: Reserved

bit 10: Set if CPU powerup restart or a network command initiated the INIT state. Remains set for duration of INIT state. Cleared at end of INIT state, but corresponding bit in ALARMS ACKNOWLEDGE WORD persists set until cleared by network command (Check Acknowledged Alarm Status). This action allows users to detect re-initialization even if state or alarm status is not polled timely during the INIT state.

bit 9: Set if MFC flow control failure detected. (Only set when MFM state = OPERATE and MFC mode = AUTO. On occurrence, MFC mode automatically disabled by setting to ERROR). This flag will be cleared when MFM state is changed out of OPERATE, except if MFM state is changed to ABORT or to TEST in order that the error flag will persist for post-error detection . Subsequent setting of MFM state to RECOVER will clear all alarm flags. Unused if MFC not configured.

bit 8: Set if tracking error (indicated flow minus implemented setpoint) exceeds tracking error alarm limit. (Only set when MFM state = OPERATE and MFC mode = AUTO.).

Unused if MFC not configured.

bit 7: Reserved

bit 6: Reserved

bit 5: Set if error detected in sensor numeric data

bit 4: Set if error detected in sensor linearization coefficients

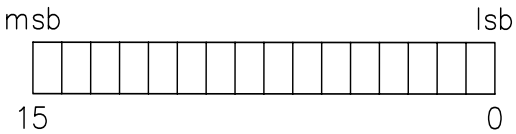
bit 3: Set if no valid ready active gas instance selected, or if an error is detected in the selected gas instance data.

bit 2: Set if errored or uninitialized digital filter value exists

bit 1: Set if internal data or hardware error detected. Not all such possible errors are detectable. Instrument should be deemed untrustworthy if set.

bit 0: Reserved

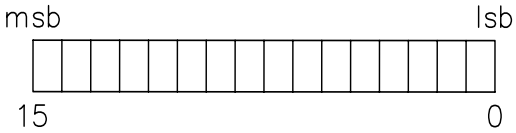
6.8 ALARMS ACKNOWLEDGE WORD



Read or read then clear using MAA network command. Read once more to see result of clearing.

The format of this word is identical to the Alarms Status Word (eg., bits have same meaning). This Alarms Acknowledge Word retains bits that are set to 1 in the Alarms Status Word until each is cleared by network command.

6.9 WARNINGS STATUS WORD



Read using MW network command. It is read-only and cannot be changed by network command.

bit 15(msb): Set if indicated flow above high flow warning limit. Only set when MFM state = OPERATE, cleared when not OPERATE.

bit 14: Set if indicated flow below warning limit. Only set when MFM state = OPERATE, cleared when not OPERATE.

bit 13: Set if tracking error (indicated flow minus implemented setpoint) exceeds tracking error warning limit. (Only set when MFM state = OPERATE and MFC mode = AUTO.

Unused if MFC not configured.

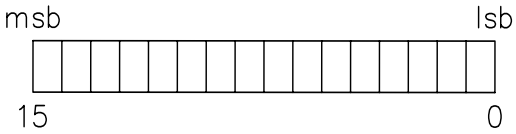
bits 12 through 6: Reserved

bit 5: Set if DAC output temporarily zeroed, or forced to non-realtime value.

bit 4: Set if no valid cal instance associated with active gas instance. This is not necessarily an error or problem, and the lack of an association may be intended.

bit 3 – 0: Reserved

6.10 WARNINGS ACKNOWLEDGE WORD



Read or read then clear using MWA network command. Read once more to see result of clearing.

The format of this word is identical to the Warnings Status Word (eg., bits have same meaning). This Warnings Acknowledge Word retains bits that are set to 1 in the Warnings Status Word until each is cleared by network command.

6.11 MFM FLOW STATUS WORD

Query by network command "MF". The Flow Status word indicates exception conditions detected that affect MFM flow readings. Not all possible conditions that affect accuracy of flow are detectable. Certain bits are summarized into alarms or warnings. Querying the Flow Status word can provide details regarding the cause of alarms and warnings.

bits 15(msb) through 8: Reserved

bit 7: Set if error detected during computation of runtime data for active gas instance. Check validity of gas instance and all related data (including linearization coefficients). Causes alarm when set.

bit 6: Set if indicated flow computation experienced detected overflow. Usually this will be caused by indicated flow exceeding +199% or -199% of the full scale value due to excess gas flow rate. Causes alarm when set.

bit 5: Set if upstream bridge sensor failure is detected. Causes alarm when set.

bit 4: Set if downstream bridge sensor failure is detected. Causes alarm when set.

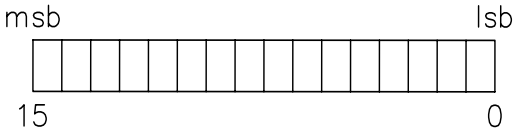
bit 3: Set if full scale indicated flow range exceeds specified maximum. This applies to the calibrated range, and not to actual indicated flow. Measurements of indicated flow would continue to be made, but may be in error due to exceeding sensor range. A warning bit is also set.

bit 2: Set if full scale indicated flow range is less than specified minimum. This applies to the calibrated range, and not to actual indicated flow. Measurements of indicated flow will continue to be made, but may be in error due to operation below minimum sensor range. A warning bit is also set.

bits 1, 0(lsb): Reserved

The bits 7-4 of the Flow Status word will cause an 'X" to be suffixed to indicated flow values when any bit(s) is/are set.

6.12 MFM FLOW STATUS ACKNOWLEDGE WORD



Read or read then clear using MFA network command. Read again to see result of clearing.

The format of this word is identical to the Flow Status Word (eg., bit positions have same meaning). This Flow Status Acknowledge Word retains bits that are set to 1 in the Flow Status Word until each is cleared by network command.

Bits in this Flow Status Acknowledge Word are not summarized into either the alarms or warnings words, so clearing them will not affect bits in the Alarms Status Word, Alarms Acknowledge Word, Warnings Status Word or the Warnings Acknowledge Word

SECTION 7

APPENDIX

ERROR MESSAGES

Error messages exist as follows:

#001:ERR: COMMAND NOT IMPLEMENTED
#002:ERR: VALUE OUT OF RANGE
#003:ERR: BAD CMMD
#004:ERR: BAD CHARACTER
#005:ERR: OVERRUN, CMD LOST
#006:ERR: MISSING OR BAD ARGUMENT
#007:ERR: TOO MANY ARGUMENTS
#008:ERR: ACCESS DENIED
#009:ERR: FLOW SETPOINT > FULLSCALE OR NEGATIVE
#010:ERR: INSTANCE INVALID OR NOT SET
#011:ERR: NO ACTIVE INSTANCE ASSIGNED
#012:ERR: INSTANCE NOT READY //Essential values not yet set
#013:ERR: INSTANCE READ ONLY
#014:ERR: INSTANCE INVALID OR DELETED
#015:ERR: INSTANCE IN USE
#016:ERR: USE IN TEST MODE
#017:ERR: COMMAND READ ONLY
#018:ERR: NEGATIVE VALUE
#019:ERR: BAD DATA ITEM CODE
#020 ERR: CHANGE DENIED
#021:ERR: WRONG STATE
#022:ERR: SET ZERO FIRST
#023:ERR: INVALID UNIT
#024:ERR: USE OTHER CMD
#025:ERR: USE '='
#026:ERR: INTERNAL DATA ERROR
#027:ERR: INSTANCE DELETED
#028:ERR: ACTIVE GAS INSTANCE INVALID
#029:ERR: CANT ASSIGN UNITS
#030:ERR: CANNOT DELETE INSTANCE
#031:ERR: INSTANCE NOT DELETED
#032:ERR: FULL SCALE POWER OUT OF RANGE
#033:ERR: ONE OR MORE LIN COEFFICIENTS TOO LARGE
#034:ERR: ACCESS LOCK
#035:ERR: CAL INSTANCE ASSIGNED

Certain error messages may be emitted when making seemingly innocuous changes. Most of these happen because the reasonableness checks against sensor limits are using uninitialized values for the sensor range.

Appearance of error message #032:ERR: FULL SCALE POWER OUT OF RANGE probably means the power difference value is too small, causing internal numeric overflow. In that case the gas or cal rec will be set NOT READY. There is not an explicit check for power difference value is too small (although there could be, perhaps based on sensor range values), this error message appears if computational overflow is detected when the conversion factor from raw counts to "corrected" power difference is computed.

Units Data

Example "LUNT" network command output, lists unit codes by ODVA code scheme (with Hastings proprietary units as well)

IDLE>LUNT

code 0: std.cubic cm/minute: SCCM: 1000.
code 1: std.liter/minute: SLM: 1.
code 2: percent: %:
code 3: volt: V:
code 4: millivolt: MV:
code 5: counts: CNT:
code 64: normal liter/minute: NLM: 1.
code 65: std.liter/second: SLS: 60.
code 66: normal liter/second: NLS: 60.
code 67: std.liter/hour: SLH: .016667
code 68: normal liter/hour: NLH: .016667
code 69: std.milliliter/minute: SMLM: 1000.
code 70: normal milliliter/minute: NMLM: 1000.
code 71: std.milliliter/second: SMLS: 60000.
code 72: normal milliliter/second: NMLS: 60000.
code 73: std.milliliter/hour: SMLH: 16.667
code 74: normal milliliter/hour: NMLH: 16.667
code 75: normal cubic cm/minute: NCCM: 1000.
code 76: std.cubic cm/second: SCCS: 60000.
code 77: normal cubic cm/second: NCCS: 60000.
code 78: std.cubic cm/hour: SCCH: 16.667
code 79: normal cubic cm/hour: NCCH: 16.667
code 80: std.cubic foot/minute: SCFM: .035335
code 81: normal cubic foot/minute: NCFM: .035335
code 82: std.cubic foot/second: SCFS: 2.1201
code 83: normal cubic foot/second: NCFS: 2.1201
code 84: std.cubic foot/hour: SCFH: 5.8894e-04
code 85: normal cubic foot/hour: NCFH: 5.8894e-04
code 86: std.cubic meter/minute: SM^3M: 1.e-03
code 87: normal cubic meter/minute: NM^3M: 1.e-03
code 88: std.cubic meter/second: SM^3S: .06
code 89: normal cubic meter/second: NM^3S: .06
code 90: std.cubic meter/hour: SM^3H: 1.6667e-05
code 91: normal cubic meter/hour: NM^3H: 1.6667e-05
code 92: std.cubic inch/minute: SCIM: 16.388
code 93: normal cubic inch/minute: NCIM: 16.388
code 94: std.cubic inch/second: SCIS: 983.28
code 95: normal cubic inch/second: NCIS: 983.28
code 96: std.cubic inch/hour: SCIH: .27314
code 97: normal cubic inch/hour: NCIH: .27314
code 98: pound/minute: LBM: 2.2026e-03
code 99: pound/second: LBS: .13215
code 100: pound/hour: LBH: 3.6711e-05
code 101: kilogram/minute: KgM: 1.e-03
code 102: kilogram/second: KgS: .06
code 103: kilogram/hour: KgH: 1.6667e-05
code 104: gram/minute: GRM: 1.
code 105: gram/second: GRS: 60.
code 106: gram/hour: GRH: .016667
code 107: mole/minute: MolM: .044614
code 108: mole/second: MolS: 2.6768
code 109: mole/hour: MolH: 7.4359e-04
code 110: KgMole/minute: KMolM: 4.4614e-05
code 111: KgMole/second: KMolS: 2.6768e-03
code 112: KgMole/hour: KMolH: 7.4359e-07
code 113: counts: CNT:
code 114: watt: W:
code 115: bits/s: BPS:
code 116: second: S:
code 117: minute: M:
code 118: hour: H:
code 119: watt-hours: WH:

SECTION 8

GAS DATA

IDLE>LGSY

code 1: He
code 2: Ne
code 3: Rn
code 4: Ar
code 5: Kr
code 6: Xe
code 7: H2
code 8: Air
code 9: CO
code 10: HBr
code 11: HCl
code 12: HF
code 13: N2
code 14: D2
code 15: O2
code 16: NO
code 17: HI
code 18: F2
code 19: Cl2
code 20: H2O
code 21: Br2
code 22: H2S
code 23: H2Se
code 24: HCN
code 25: CO2
code 26: NO2
code 27: N2O
code 28: CH4
code 29: NH3
code 30: O3
code 31: PH3
code 32: SO
code 33: CH3F
code 34: COS
code 35: AsH3
code 36: CH3Cl
code 37: ClCN
code 38: C2H4
code 39: SiH4
code 40: CS2
code 41: OF2
code 42: C2H2
code 43: GeH4
code 44: CH3Br
code 45: C2H4O
code 46: CF2O
code 47: CH4S
code 48: BF3
code 49: CHF3
code 50: N2H4
code 51: C2H3F
code 52: CH5N
code 53: NF3
code 54: C2H6
code 55: C2H3Cl
code 56: C2H3Br
code 57: CHClF2
code 58: B2H6
code 59: C2N2
code 60: CCl2O
code 61: C3H6
code 62: PF3
code 63: CF4
code 64: C2H2F2
code 65: CHCl2F
code 66: C3H4
code 67: SiH2Cl2
code 68: C3H4
code 69: C3H6
code 70: BCl3
code 71: CHCl3
code 72: ClO3F
code 73: C2H6O
code 74: CClF3
code 75: C2H5Cl
code 76: BrF3
code 77: ClF3
code 78: N2O3
code 79: BBr3
code 80: CBrF3
code 81: C3H6O
code 82: C2H4F2
code 83: CHBr3
code 84: CCl2F2
code 85: C2H7N
code 86: SF4
code 87: SO2F2
code 88: SiF4
code 89: C3H8
code 90: ****
code 91: CCl3F
code 92: ****
code 93: C4H6
code 94: C2F4
code 95: N2O4
code 96: AsF5
code 97: Si2H6
code 98: C4H8
code 99: GeF4
code 100: C4H6
code 101: CCl4
code 102: POCl3
code 103: C2H3ClF2
code 104: C4H8
code 105: C2BrF3
code 106: C4H8
code 107: C4H8
code 108: SiCl4
code 109: C3H9N
code 110: SF6
code 111: C4H10
code 112: C2H3Cl3
code 113: GeCl4
code 114: TiCl4
code 115: IF5
code 116: BrF5
code 117: C4H10
code 118: C2F6
code 119: C2ClF5
code 120: C5H10
code 121: WF6
code 122: C5H12
code 123: UF6
code 124: MoF6
code 125: C2Cl2F4
code 126: C2Cl3F3
code 127: C6H14
code 128: C3F8
code 129: C4F8
code 130: C2Br2F4
code 131: C3H9BO3
code 132: C3H9P
code 133: C3H9PO3
code 134: SiH2F2
code 135: C2H6Zn
code 136: C2H6O
code 137: C2HBrClF3
code 138: C3F6
code 139: C6H18Si2

code 140: NiC4O4
code 141: NOCl
code 142: B5H9
code 143: PF5
code 144: C8H20O4Si
code 145: SnCl4
code 146: Cl2H27Al
code 147: SiHCl3
code 148: C6H15Ga
code 149: C3H9Al
code 150: C3H9Sb
code 151: C3H9As
code 152: C3H9Ga
code 153: C3H9In
code 154: C4H12Si
code 155: C2HF5
code 156: C2H2F4
code 157: N2F4
code 158: C4Hl6Si4O4
code 159: T2
code 160: CH2F2
code 161: C4H11As
code 162: C4H11P
code 163: C6H15O3B
code 164: C2H7Al
code 165: C3H12AlN
code 166: C4H14NAl
code 167: HNO3
code 168: C2Cl4
code 169: C2H6O2
code 170: C6H14O2
code 171: H2SO4
code 172: C6H5Cl
code 173: C2H3N
code 174: C8H10
code 175: CHN
code 176: CH4O
code 177: C7H14
code 178: C6H12
code 179: C8H10
code 180: C6H6O
code 181: C7H8
code 182: C4H8O
code 183: CH3Cl3Si
code 184: C3H6O
code 185: CH6Si
code 186: C2HCl2F3