TELEDYNE HASTINGS INSTRUMENTS

SOFTWARE MANUAL

HFM-I-401 AND HFM-I-405
INDUSTRIAL
FLOW METERS

TELEDYNE
HASTINGS INSTRUMENTS
A Teledyne Technologies Company

CE

ISO 9001
CERTIFIED

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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1. Operating Algorithm

1.1. Hardware description

There is a serial communications port for digital communications, an analog (0-5 volt/0-10 volt/4-20 ma/0-20 ma) analog output proportional to the flow rate. There are two isolated open-collector alarm pins.

The flow signal is derived on a separate sensor board and supplied to the main processor digitally via an IIC bus and is also supplied as 0-0.7 volt analog signal referred to a 2 volt reference. There is also an eeprom on board the sensor that uses the IIC bus for communication. All calibration and configuration information is stored on the sensor eeprom so that the main board may be replaced without affecting calibration.

A Motorola MC9S12 with 128K bytes of flash ram is being used for the main processor.

1.2. Flow Reading

The flow reading starts with acquiring a value (AD) from the sensor A/D. This value will be in counts (16 bits signed, -32768 – 32767 corresponds to -2.048 volts – 2.047 volts). This value is converted to a voltage reading and is available via the s40 command. The zero flow sensor output value (AD0) in volts (available via s16 command and set using the "zro" command) will be subtracted from this. The result is divided by the sensor output value when flowing 5 sccm of nitrogen (SFS) in volts (see "s 45" command) the resultant value will be a floating point number between -2 and +2 typically between 0 and +1.

$$\frac{AD - AD0}{SFS} = S$$

This resultant sensor value is linearized with a normalized polynomial with a linear and a 3rd order component. The coefficients of this polynomial have been calculated such that the sum total of the coefficients is 1.00. The 3rd order value (B) is set for nitrogen with the "s 43" command, the 5th order value (C) is set for nitrogen with the "s 44" command. The linear value (A) is calculated from the fact that A + B + C = 1 and can be read with the "s 42" command. Since each gas creates a different non-linear response in the flow sensor each gas must be linearized using a different polynomial. Each gas has two factors which are used to correct the for the varying gas sensitivities of the sensor. The linear part is called the gas correction factor GCF (available via the G9 command, from GasDataTables.xls) and the coefficient that multiplies the higher order term is referred to as the gas "z" multiplier (Gz, available with the g3 command).

$$B' = B \cdot Gz, C' = C \cdot Gz$$

The resultant (SL) is also a floating point value typically (but not always) between 0 and 1.

$$\left[A(S) + B'\left(S^3\right) + C'(S^5)\right]GCF = SL$$

This resultant linear sensor value is adjusted with another gas dependent normalized polynomial to correct for the non-linearity of the laminar flow element. This polynomial has a linear and a 2nd order component. The coefficients of this polynomial have been calculated such that the sum total of the coefficients is 1.00. The 2nd order value (E) is set with the "g10" command and the 4th order value (F) is set with the "g11" command. The linear value (D) is calculated from D + E + F = 1. It cannot be set or read. The resultant (SHL) is also a floating point value typically (but not always) between 0 and 1. Changing the active gas will select a

different set of coefficients. Any gas dependent values will have a different value stored in each gas record.

$$D(SL)+E([SL]^2)+F([SL]^4)=SHL$$

This linearized shunt value is multiplied by the following factors: a shunt factor (ShF, "s46", nominal nitrogen equivalent range of the laminar flow element), a time correction factor for the flow unit (TcF, "g5"), a volume correction factor for the flow unit (VcF, "g8"), a gas dependent calibration span adjust factor (SpF, "g14") and if the flow unit is volumetric ("g15") then a reference temperature correction factor (Tc, calculated from "g19"). The end result is the flow rate in engineering units that is reported when the "f" command is received.

$$(SHL)[(ShF)(TcF)(VcF)(SpF)(Tc)]=f$$

Six different multiplication steps could be performed on each data reading or alternatively an internal factor could be maintained that is the product of the six factors. This internal factor could be updated whenever one of the other factors is changed.

The Tc value is calculated as follows:

$$\frac{T+273.15}{273.15}=Tc$$

1.3. Analog Output

The resultant flow value ("f") is divided by the full scale flow value (FSF,"g2"). This dividend is multiplied by the DAC full scale code in counts (DFS, "s 52"). The resultant counts value then has the DAC zero code (DA0, "s 51") added to it. This final result (DAC) can be sent to the analog output Digital to Analog converter.

$$\frac{f}{FSF}DFS+DA0=DAC$$

1.4. Analog Set point Input

The flow reading starts with acquiring a value (AD4) from the set point A/D. This value will be in counts (16 bits signed, -32768 – 32767 corresponds to -2.048 volts – 2.047 volts). The input voltage that corresponds to a zero flow command (4Z, available via s69 command) will be subtracted from this. The result is multiplied by the full-scale factor (FS4) (see "s24" command) to generate a full scale input range equal to the full scale analog output value.

$$(AD4-4Z)FS4=Sp$$

If the original analog input signal was a 4-20 mA or 1-5 VDC signal the zero flow command value is not numerically equal to 0.00 in these cases the value reported back for the s26 command is the Sp value plus 1.00 or 4.00 dependent on the value stored in the Product Configuration word s64.

1.5. Flow Alarms

If the flow alarm enable is set then the flow value ("f") is compared to the high flow alarm limit and the low flow alarm limit points. When the current flow reading is above the high flow alarm or below the low flow alarm limit then the flow alarm counter is incremented. If the flow alarm counter exceeds the flow alarm delay then the respective alarm bit is set for both the alarm and the alarm acknowledge.

If the flow warning enable is set then the flow value ("f") is compared to the high flow warning limit and the low flow warning limit points. When the current flow reading is above the high flow warning or below the low flow warning limit then the flow warning counter is incremented. If the flow warning counter exceeds the flow warning delay then the respective warning bit is set for both the warning and the warning acknowledge.

If the current flow value is not outside of the limits for any alarms then the alarm counter is set to zero. If the current flow value is not outside of the limits for any warnings then the warning counter is set to zero. Any alarms or warnings that are not outside of the limits will be reset. However the alarm acknowledge and warning acknowledge are not reset when the condition recovers. A message must be received by the communications channel to reset these values.

1.6. Totalizers

The current flow is divided by the product of Time correction Factor (TcF) and the number of flow readings per minute. This result is added to the current value of the totalized flow.

If the current flow reading is greater than 1% of the rated full scale flow then the flowing time total is incremented by the time required to take a flow reading. (typically $1/16^{th}$ of a second).

1.7. Setpoint selection

If the product configuration (s64) is setup to signal that the instrument is a flow controller then the instrument must send signals to the on-board PID (proportional, integral, differential) controller to tell it what the currently desired flow rate is. The PID will adjust the valve drive up or down as necessary until the current measured sensor output equals the requested flow rate.

The user may request a flow setpoint in two ways. One is via the analog setpoint input (s26). The user may also send a digital command signal over the network. The active input is chosen by setting the following bits in the MFC Configuration word (v2).

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 setpoint A/D converter

11 = invalid assignment, choice will be forced to default (network)

The analog setpoint Sp value calculated above divided by full scale range of the analog input (Afs)[1] determined from the product configuration word s64. This value is reported via v7 in % of full scale. This value is also multiplied by the full scale flow value g2 and reported via v6 as the command value in engineering units.

$$\frac{Sp}{Afs} g2 = v6$$

[1] For 4-20 ma units the Afs = 16 and for 1-5 vdc units the Afs = 4.

The network setpoint may be set via v4 or v5. v4 generates a setpoint in units of flow and v5 generates a setpoint in % of full scale. Either value may be read or written. Writing to one will cause the embedded processor to calculate the value of the other and update it also.

$$v5 \cdot g2 = v4$$

$$v4 / g2 = v5\%$$

The active setpoint values v6 & v7 or v4 & v5 become the source for the implemented setpoint values v8 & v9.

PID input

V8 is the desired flow in engineering units. This value is equivalent to the f value calculated in the Flow Reading section. In order to determine the sensor voltage that would generate this desired flow value all of the flow calculations will need to be reversed.

$$\frac{v8}{[(ShF)(TcF)(VcF)(SpF)(Tc)]} = (SHL)$$

The next part of the inverse equation would require the inverse of the shunt linearization equation.

$$D(SL) + E[SL]^2 + F[SL]^4 = SHL$$

It is not feasible to attempt to calculate an inverse to a 4th order polynomial so an iterative process will be required to determine the value of SL. We know that SHL and SL are close so we can use SHL as the 1st guess of the value for SL.

$$SHL = G_1$$

$$D(G_1) + E[G_1]^2 + F[G_1]^4 = R_1$$

The second guess value will be SHL plus the difference between the SHL and resultant#1

$$G_1 + (SHL - R_1) = G_2$$

$$D(G_2) + E[G_2]^2 + F[G_2]^4 = R_2$$

Repeat these last two functions until the series converges in a few iterations with the resultant R value being equal to the original SHL value. At this point the guess G will be equal to the proper SL value.

A similar routine must be performed to invert the sensor linearization polynomial.

$$\left[A(S) + B'(S^3) + C'(S^5)\right] = \frac{SL}{GCF}$$

$$\frac{SL}{GCF} = G_1$$

$$\left[A(G_1) + B'\left(G_1^{\,3}\right) + C'(G_1^{\,5})\right] = R_1$$

$$G_1 + (\frac{SL}{GCF} - R_1) = G_2$$

$$\left[A(G_2) + B'\left(G_2^{\,3}\right) + C'(G_2^{\,5})\right] = R_2$$

The series will converge when the resultant R is equal to the original SL value divided by the gas conversion factor GCF. At this point the guess value G is equal to normalized sensor value S.

From this the sensor voltage can be recovered by multiplying by the sensor full scale voltage and adding the sensor offset voltage.

$$S \cdot SFS + AD0 = AD$$

This is the value that should be reported back by the sensor when the flow reaches the desired value. However the sensor voltage is offset from circuit common by 2.00 volts. Therefore the voltage that should be generated by the pulse width modulator circuit (PWM) is the sensor voltage plus 2.00 volts.

$$AD + 2.00 = PWM$$

The PWM circuit operates on counts with 0 counts being 5 volts and 64000 counts being equal to 0 volts. To convert to counts, divide the PWM by 5 volts and multiply by 64000. Subtract this number from 64000 to get the counts to actually transmit to the PWM circuit.

$$64000\left(1 - \frac{PWM}{5}\right) = PWM$$

This number should be transmitted to the PWM and then sufficient time should be allowed for the PID loop to open the valve if necessary and to come to a stable final value. Small adjustments may be made after this time if the final value is not precisely the desired value.

2. Commands

2.1. Flow reading

F read current flow rate. This command may be received in upper case or lower case. In RS485 mode the "F" command must be preceded by an asterisk* and the address(macid). The flow command reports the flow rate in the flow units chosen in the gas record (G7).

read F(cr) or *[aa]F(cr)

Sample reply: 121.32(cr)>

F1 streaming report of the flow rate. This command may be received in upper case or lower case. In RS485 mode the "F1" command must be preceded by an asterisk* and the address(macid). The flow command reports the flow rate in the flow units chosen in the gas record (G7) in a continuous manner. The flow meter will continuously report the measured flow readings until it receives an F0 command. This is useful when data logging a transitory flow change or to plot a flow oscillation.

read F1(cr) or *[aa]F1(cr)

Sample reply:

121.32(cr)

121.31(cr)

121.29(cr)

121.33(cr)

121.34(cr)

121.32(cr)…

F0 stop streaming report. This command may be received in upper case or lower case. In RS485 mode the "F0" command must be preceded by an asterisk* and the address(macid). The flow command will halt the continuous output of the flow reading. It has no effect if the streaming function has not been previously enabled.

2.2. Sensor List

S d [=n] Set/read system/sensor data items by item code d. The blank spaces are not necessary and are ignored. The commands may be received in upper case or lower case. In RS485 mode the "S" command must be preceded by an asterisk* and the address(macid).

S [d](cr) or *[aa]S [d](cr)

SL List all system/sensor data items, values and units

SL(cr) or *[aa]SL(cr)

Sensor item number list

item 1 :model

item 2 :mfm config

item 3 :port rate

item 3 :port type

item 5 :macid

item 6 :active gas inst

item 7 :flow alarm enable

item 8 :flow alarm delay

item 9 :flow warn enable

item 10:flow warn delay

item 11:FS volts

item 12:flowing hours

item 14:precision

item 16:user zero offset

item 24:A/D#0 FS factor

item 25:A/D#1 FS factor

item 26:A/D#0

item 27:A/D#1

item 28:hi alarm limit

item 29:hi alarm limit%

item 30:low alarm limit

item 31:low alarm limit%

item 32:hi warn limit

item 33:hi warn limit%

item 34:low warn limit

item 35:low warn limit%

item 36:integrated flow

item 40:Sensor Voltage

item 41:Sensor Serial Number

item 42:Sensor Linear Coefficient

item 43:Sensor 3rd Order Coefficient

item 44: Sensor 5th Order Coefficient

Item 45:sensor 5 sccm span voltage

item 46:shunt factor

item 51:DAC zero code

item 52:DAC full scale code

item 54:comment

item 64:prod cfg

item 65:nxtline

item 66:prompt

item 68:serial number

item 69:A/D#0 offset

item 70:A/D#1 offset

2.3. Sensor List by item number

item 1 :model: (read only)

S1(cr) or *[aa]S1(cr)

Sample reply: HFC-I-401 v1.38(cr)>

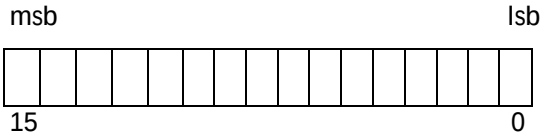
This identifies the instrument as a 400 series and gives the version of the firmware currently loaded into memory.

item 2 :mfm config:

read S2(cr) or *[aa]S2(cr)

Sample reply: xFC57(cr)>

write S2=xdddd(cr) or *[aa]S2=xdddd(cr)



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

Settings are nonvolatile.

bit 15 (msb): Set if enable high and low flow rate alarms are enabled, cleared otherwise.

bit 14: Set if enable high and low flow rate warnings enabled, cleared otherwise.

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. (flow controllers only)

bit 12: Set if Verbose replies is active. Cleared otherwise

bit 11: Set to enable tracking error alarm, clear to disable. (flow controllers only).

bit 10: Set to enable tracking error warning, clear to disable. (flow controllers only).

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

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 6-0: Reserved.

item 3 :port rate:

read S3(cr) or *[aa]S3(cr)

Sample reply: 19200 BPS(cr)>

write S3=ddddd(cr) or *[aa]S3=dddd(cr)

This reads or sets the baud rate of the serial port when the baud rate jumper is not installed. Baud rates of 1200, 2400, 4800, 9600, 19200, 38400, 57600 and 115200 bits per second are supported. If an unsupported baud rate is selected the instrument will default to 19200 baud. There is a jumper on the processor board which will force the instrument to use 9600 baud while the jumper is active (over two pins). This will allow the user to establish communications when the baud rate is unknown. A different baud rate can be selected with this S3 command and the instrument will return to this baud rate when the jumper is removed.

item 4 :port type: (read only)

read S4(cr) or *[aa]S4(cr)

Sample reply: RS232:DUPLEX(cr)>

This reports the hardware configuration of serial buss. This is set by the RS232/485 jumper and the Duplex/Simplex jumper inside the electronics enclosure. Could be RS485:Duplex or RS485:Simplex

item 5 :macid :

read S5(cr) or *[aa]S5(cr)

Sample reply: x61(cr)>

write S5=01(cr) or *[aa]S5=01(cr)

This is the RS485 address of the instrument; any 2 digit address can be selected. These digits can also contain the hexadecimal digits (A-F). AB is a valid address as is 0F. The default address when an instrument is first shipped by Hastings is 61. An instrument will always respond to a command sent to address FF.

There is a jumper on the processor board which will force the instrument to use an address of 99 while the jumper is active (over two pins). This will allow the user to establish communications when the address is unknown. A different address can be selected with this S5 command and the instrument will return to this address when the jumper is removed.

item 6 :active gas inst:

read S6(cr) or *[aa]S6(cr)

Sample reply: 0(cr)>

write S6=1(cr) or *[aa]S6=1(cr)

This number reports which of the 10 available gas calibration records is currently active. Values from 0 – 9 are acceptable. Each gas record contains the conversion factors to change the measured flow rate from the flow units used internally to the engineering units desired by the customer. These are variables such as the reference temperature, volumetric or mass unit, time units, or flowing gas. If these are not filled out in the active record, then the flow meter will not be able to respond to a flow rate command.

A flow meter will have at least one record completed by Hastings when the instrument is shipped. Multiple records may be completed if calibrations for multiple gases or for different ranges or reference temperatures were ordered. Customers may create new records if desired. See the section on the gas list for information on each of the variables. The default gas record is 0.

item 7 :flow alarm enable:

read S7(cr) or *[aa]S7(cr)

Sample reply: 1(cr)>

write S7=1(cr) or *[aa]S7=1(cr)

This is a binary value that when enabled it will allow flow values that exceed alarm limits for a time longer than specified by the flow alarm delay to set bit 15 or bit 14 of the alarm status word. Setting this bit also sets the bit 15 of the MFM config word (S2).

item 8 :flow alarm delay:

read S8(cr) or *[aa]S8(cr)

Sample reply: 0 S(cr)>

write S8=1.0(cr) or *[aa]S8=1.0(cr)

This defines the length of time in seconds between the start of an error condition until the time it is reported by the alarm status word. A setting of 0.00 will result in an immediate response.

item 9 :flow warn enable:

read S9(cr) or *[aa]S9(cr)

Sample reply: 1(cr)>

write S9=1.0(cr) or *[aa]S9=1.0(cr)

This is a binary value that when enabled it will allow flow values that exceed warning limits for a time longer than specified by the flow warn delay to set bit 15 or bit 14 of the warning status word. Setting this bit also sets the bit 14 of the MFM config word (S2).

item 10:flow warn delay:

read S10(cr) or *[aa]S10(cr)

Sample reply: 0 S(cr)>

write S10=1.0(cr) or *[aa]S10=1.0(cr)

This defines the length of time in seconds between the start of an error condition until the time it is reported by the warn status word. A setting of 0.00 will result in an immediate response.

item 11:FS volts: (read only)

read S11(cr) or *[aa]S11(cr)

Sample reply: 5.000 VDC(cr)>

This reports the full scale analog output as defined by the product configuration byte (S64).

item 12:flowing hours: (read only)

read S12(cr) or *[aa]S12(cr)

Sample reply: 1234.65 H(cr)>

This is the total time that flow (>2%FS) has been passing through the instrument. This cannot be reset to 0. Useful for determining maintenance schedules.

item 13:temperature: (read only)

read S13(cr) or *[aa]S13(cr)

Sample reply: 22.68 Deg Celsius(cr)>

This item reports the current temperature indicated by the temperature sensor mounted on the processor pc board. It will typically indicate a temperature that is slightly warmer than the ambient temperature outside of the instrument.

item 14:precision:

read S14(cr) or *[aa]S14(cr)

Sample reply: 5(cr)>

write S14=7(cr) or *[aa]S14=7(cr)

This item controls the number of places after the decimal point that the output data will have. This can be any number from 0 – 8.

item 16:user zero offset:

read S16(cr) or *[aa]S16(cr)

Sample reply: 0.03187596(cr)>

write S16=0(cr) or *[aa]S16=0(cr)

This item stores the value of the sensor offset voltage. This is the value of the sensor output when the flow is stopped. This offset is subtracted from the magnitude of the current sensor output to remove the effects of sensor internal non-symmetry. This value is typically between -0.3 and +0.3 volts.

This value can be written but it is normally controlled by the internal routines that handle the re-zero requests. When the processor receives a re-zero request via the "zro" command, from the internal switch or from the external remote zero lines the processor will read the current sensor value and store it in item 16.

item 24:A/D#0 FS factor:

read S24(cr) or *[aa]S24(cr)

Sample reply: 5.0000(cr)>

write S24=5(cr) or *[aa]S24=5(cr)

This item stores the gain value that is used to calibrate the analog input to the desired full scale range. This value is adjusted to make set-point analog/digital converter read correctly when a full scale input signal is being applied.

item 25:A/D#1 FS factor:

Reserved for future use

item 26:A/D#0: (read only)

read S26(cr) or *[aa]S26(cr)

Sample reply: 5.0000(cr)>

This item reports value of the analog signal that is being received on the set-point analog input lines. This analog input value is capability is also present in the flow meters but it is not interpreted as a set-point input for a control valve. This could be used to read the output signal from another remote sensor. This value will have the same range and units as the analog output signal from the flow meter.

item 27:A/D#1: (read only)

Reserved for future use

item 28:hi alarm limit: (eng units)

read S28(cr) or *[aa]S28(cr)

Sample reply: 5.0000 SLM(cr)>

write S28=5.000(cr) or *[aa]S28=5.000(cr)

If the flow alarm enable is set (S7) and the flow remains above this limit for longer than the time specified by the flow alarm delay (S8) the high flow alarm bit will be set in the alarm status word. This can enable one of the hardware alarms if it is configured. This item configures or reports the limit in the flow units chosen in the active gas record (G7). Writing to this item will affect the value reported back by S29 below.

item 29:hi alarm limit: (% of full scale)

read S29(cr) or *[aa]S29(cr)

Sample reply: 90.00 %(cr)>

write S29=90.0(cr) or *[aa]S29=90.0(cr)

If the flow alarm enable is set (S7) and the flow remains above this limit for longer than the time specified by the flow alarm delay (S8) the high flow alarm bit will be set in the alarm status word. This can enable one of the hardware alarms if it is configured. This item configures or reports the limit as a % of the full scale flow value

listed in the active gas record (G2). Writing to this item will affect the value reported back by S28 above.

item 30:Low alarm limit: (eng units)

read S30(cr) or *[aa]S30(cr)

Sample reply: 5.0000 SLM(cr)>

write S30=5.000(cr) or *[aa]S30=5.000(cr)

If the flow alarm enable is set (S7) and the flow remains below this limit for longer than the time specified by the flow alarm delay (S8) the low flow alarm bit will be set in the alarm status word. This can enable one of the hardware alarms if it is configured. This item configures or reports the limit in the flow units chosen in the active gas record (G7). Writing to this item will affect the value reported back by S31 below.

item 31:Low alarm limit: (% of full scale)

read S31(cr) or *[aa]S31(cr)

Sample reply: 10.00 %(cr)>

write S31=10.0(cr) or *[aa]S31=10.0(cr)

If the flow alarm enable is set (S7) and the flow remains above this limit for longer than the time specified by the flow alarm delay (S8) the low flow alarm bit will be set in the alarm status word. This can enable one of the hardware alarms if it is configured. This item configures or reports the limit as a % of the full scale flow value listed in the active gas record (G2). Writing to this item will affect the value reported back by S28 above.

item 32:hi warn limit: (eng units)

read S32(cr) or *[aa]S32(cr)

Sample reply: 5.0000 SLM(cr)>

write S32=5.000(cr) or *[aa]S32=5.000(cr)

If the flow warning enable is set (S9) and the flow remains above this limit for longer than the time specified by the flow warning delay (S10) the high flow warning bit will be set in the warning status word. This item configures or reports the limit in the flow units chosen in the gas record (G7). Writing to this item will affect the value reported back by S33 below.

item 33:hi warn limit: (% of full scale)

read S33(cr) or *[aa]S33(cr)

Sample reply: 80.00 %(cr)>

write S33=80.0(cr) or *[aa]S33=80.0(cr)

If the flow warning enable is set (S9) and the flow remains above this limit for longer than the time specified by the flow warning delay (S10) the high flow warning bit will be set in the warning status word. This item configures or reports the limit as a % of the full scale flow value listed in the active gas record (G2). Writing to this item will affect the value reported back by S32 above.

item 34:Low warn limit: (eng units)

read S34(cr) or *[aa]S34(cr)

Sample reply: 5.0000 SLM(cr)>

write S34=5.000(cr) or *[aa]S34=5.000(cr)

If the flow warning enable is set (S9) and the flow remains below this limit for longer than the time specified by the flow warning delay (S10) the low flow warning bit will

be set in the warning status word. This item configures or reports the limit in the flow units chosen in the gas record (G7). Writing to this item will affect the value reported back by S35 below.

item 35:Low warn limit: (% of full scale)

read S35(cr) or *[aa]S35(cr)

Sample reply: 10.00 %(cr)>

write S35=10.0(cr) or *[aa]S35=10.0(cr)

If the flow warning enable is set (S9) and the flow remains below this limit for longer than the time specified by the flow warning delay (S10) the low flow warning bit will be set in the warning status word. This item configures or reports the limit as a % of the full scale flow value listed in the active gas record (G2). Writing to this item will affect the value reported back by S34 above.

item 36:integrated flow:

read S36(cr) or *[aa]S36(cr)

Sample reply: 12456 SL(cr)>

write S36=0.0(cr) or *[aa]S36=0.0(cr)

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 "S36=0" command. This value is useful for measuring the total flow that used during a process or to fill a container with a specified amount of gas.

item 40:Sensor Voltage: (read only)

read S40(cr) or *[aa]S40(cr)

Sample reply: 0.4356 V(cr)>

This is the current flow sensor output voltage.

This value will typically be between -0.3 to +1.0 volts. Values outside of this range denote a failed flow sensor or excessive flow through the sensor.

item 41:Sensor Serial Number:

read S41(cr) or *[aa]S41(cr)

Sample reply: 1024500001(cr)>

This is the serial number given to the flow sensor after it was manufactured and tested. **Do not change this.**

item 42:Sensor Linear Coefficient: (read only)

read S42(cr) or *[aa]S42(cr)

Sample reply: 0.921(cr)>

This is the coefficient of the 1st order term of the normalized polynomial used to generate a linear relationship between the sensor output and mass flow through the sensor. This coefficient is calculated from the other two higher order coefficients. The normalized sensor polynomial has the form of $Y = Ax + Bx^3 + Cx^5$. All of the three coefficients will sum to 1.000.

item 43:Sensor 3rd Order Coefficient:

read S43(cr) or *[aa]S43(cr)

Sample reply: 0.054(cr)>

This is the coefficient of the 3rd order term of the normalized polynomial used to generate a linear relationship between the sensor output and mass flow through the

sensor. The normalized sensor polynomial has the form of $Y = Ax + Bx^3 + Cx^5$. All of the three coefficients will sum to 1.000.

This value is generated at the factory from specialized test data – changing this value can corrupt the flow readings.

item 44:Sensor 5th Order Coefficient:

read S44(cr) or *[aa]S44(cr)

Sample reply: 0.023(cr)>

This is the coefficient of the 5th order term of the normalized polynomial used to generate a linear relationship between the sensor output and mass flow through the sensor. The normalized sensor polynomial has the form of $Y = Ax + Bx^3 + Cx^5$. All of the three coefficients will sum to 1.000.

This value is generated at the factory from specialized test data – changing this value can corrupt the flow readings.

Item 45:sensor 5 sccm span voltage

read S45(cr) or *[aa]S45(cr)

Sample reply: 0.5894 V(cr)>

This is the output voltage of the flow sensor when the 5 sccm nominal full scale sensor flow is passing through it. This value is generated at the factory from specialized test data – **changing this value can corrupt the flow readings.**

item 46:shunt factor:

read S46(cr) or *[aa]S46(cr)

Sample reply: 70(cr)>

write S46=50.0(cr) or *[aa]S46=50.0(cr)

This is the nominal full scale range of the laminar flow element (shunt) used to create a pressure drop that will force flow through the mass flow sensor. The instrument full scale value may be up to 50% above or below this value. **Do not change this unless the flow instrument is being re-ranged with a new shunt. Recalibration will be required.**

item 51:DAC zero code:

read S51(cr) or *[aa]S51(cr)

Sample reply: 8(cr)>

write S51=10(cr) or *[aa]S46=50(cr)

This is a positive integer value in the range of 0 – 4095 which is used to adjust the analog output read the correct value when the instrument's digital output is indicating a zero flow.

item 52:DAC full scale code:

read S52(cr) or *[aa]S52(cr)

Sample reply: 3903(cr)>

write S52=4003(cr) or *[aa]S52=4003(cr)

This is a positive integer value in the range of 0 – 4095 which is used to adjust the analog output read the correct full scale span value when the instrument's digital output is indicating a full scale flow rate.

item 54:comment

read S52(cr) or *[aa]S52(cr)

Sample reply: 3903(cr)>

write S52=4003(cr) or *[aa]S52=4003(cr)

This is space reserved for the customer. This could be used to provide a text message to identify instrument for users. 30 characters are available.

item 64:prod cfg: x01

read S64(cr) or *[aa]S64(cr)

Sample reply: x01(cr)>

This is hexadecimal information stored in the instrument after manufacture to tell the processor which of the various optional analog input or output configurations are installed in this particular instrument. The analog full scale value reported with the S11 command is generated from this list. **Do not change this value unless the I/O boards are being replaced.**

	S64	
Option	Meter	Controller
0-5 VDC	X00	X01
0-10 VDC	X02	X03
0-20 mA	X14	X15
4-20 mA	X1C	X1D
1-5 VDC	X08	X09

item 65:nxtline:

read S65(cr) or *[aa]S65(cr)

Sample reply: x0D(cr)>

write S65=x0A(cr) or *[aa]S65=x0A(cr) (change to linefeed)

This is the hexadecimal version of the ascii code for the character you will use to signal flow instrument that the transmission from the computer is complete instead of the normal carriage return(x0D). This could be a line feed (x0A) or other seldom used character such as >(x3E), <(x3C), #(x23) or ^(x5E). After this command is complete the flow instrument will only respond to commands that terminate with the newly specified character. I. E. to read item 65 the new command structure would appear as: write S65> or *[aa]S65> if x3E were chosen as the new terminator.

Be careful when choosing a new terminator to ensure that the software that is used to communicate with the instrument can generate the chosen character. Most terminal programs cannot generate most of the unprintable character ascii codes that are less than x20 (other than x0D and x0A) or greater than x7F. Routines written in Labview® or other programming environment can be set up to use these codes. If an instrument has been setup with a terminating character that cannot be generated locally there will be no way to communicate with the instrument to return the terminator to the original condition. The instrument would need to be returned to the factory for to reset this.

item 66:prompt: x3E000000

read S66(cr) or *[aa]S66(cr)

Sample reply: x0D3E(cr)>

write S66=x0D0A3E(cr) or *[aa]S65=x0D0A3E(cr)

(carriage return, linefeed and “>” character)

This is the hexadecimal representation of the ascii codes for the character string that the instrument will use to signal to the computer that it has ended its transmission. This string may be up to 11 characters long. The string format starts with an “x” to signal that the string is hexadecimal and it is followed by a series of pairs of

hexadecimal digits. Each hexadecimal pair is the hexadecimal ascii code for a character to transmit as part of the "end of transmission" message.

item 68:serial number: Comply-3

read S68(cr) or *[aa]S68(cr)

Sample reply: 1024500001(cr)>

This is the serial number of this particular instrument. This value must match the serial number printed on the label on the side of the instrument. Do Not Change This.

item 69:A/D#0 offset:

read S69(cr) or *[aa]S69(cr)

Sample reply: V0.1000(cr)>

write S69=5(cr) or *[aa]S69=0.005(cr)

This item stores the offset value that is used to calibrate the analog input to the desired zero flow value. This value is adjusted to make set-point analog/digital converter read correctly when a minimum scale input signal is being applied.

item 70: A/D#1 offset:

Reserved for future use

Item 112: Enable verbose replies

read S112(cr) or *[aa]S112(cr)

Sample reply: 0(cr)>

write S112=1(cr) or *[aa]S112=1(cr)

This item does not show in the sensor list. But setting S112 equal to 1 will cause all of the responses from the instrument to include some explanatory text before each data item in the various lists and when data is requested individually. This is useful when using a text terminal program to communicate with the instrument and an explanation of the various list item numbers is desired.

2.4. Gas List

There are provisions for 10 different sets of gas/calibration records in these flow instruments. At least one of them will be filled out and ready for use (record 0). Other records may be also filled out with alternative calibrations for use with other gases or flow units if multiple calibrations were requested on the original order. The sensor list command S6 (active gas inst) controls which record is accessed when the gas commands are employed.

G d [=n] Set/read gas/calibration data items by item code d. The blank spaces are not necessary and are ignored. The commands may be received in upper case or lower case. In RS485 mode the "G" command must be preceded by an asterisk* and the address (macid).

G [d](cr) or *[aa]G [d](cr)

GL List all gas record data items, values and units

GL(cr) or *[aa]GL(cr)

Gas item number list

item 1: gas instance:

item 2: FS flow:

item 3: gas z factor:

item 4: gas symbol:

item 5: time factor:

item 6: units conversion factor:

item 7: units symb:

item 8: volume factor:

item 9: gas corr factor:

item 10: 2nd order gas factor:

item 11: 4th order gas factor:

item 12: comment:

item 13: cal date:

item 14: span correction factor:

item 15: volumetric unit:

item 14: Unknown1:

item 14: unknown2:

item 19: ref temp:

2.5. Gas list by item number

item 1 :gas instance: (read only)

read G1(cr) or *[aa]G1(cr)

Sample reply: 0(cr)>

This is the gas record number and the value that has been set using the sensor "s 6" command to activate this particular record. This can be from 0 – 9.

item 2:FS flow:

read G2(cr) or *[aa]G2(cr)

Sample reply: 400.00(cr)>

write G2=500(cr) or *[aa]G2=500(cr)

This is the full scale flow rate for the instrument in the engineering units listed by the G7 command. Other gas records may be present in the same instrument with differing full scale values.

item 3: gas z factor:

read G3(cr) or *[aa]G3(cr)

Sample reply: 1.00(cr)>

write G3=1.1(cr) or *[aa]G3=1.1(cr)

This is a value that is used to correct for the differing specific gravity dependent sensor sensitivities for different gases. This will be 1.00 for Air or Nitrogen but it will vary when the flow instrument is calibrated for gases with densities that are significantly different than air. This value will be listed for each gas in the gas conversion factor table for this instrument.

item 4: gas symbol:

read G4(cr) or *[aa]G4(cr)

Sample reply: N2(cr)>

write G4=C3H8(cr) or *[aa]G3= C3H8(cr)

This used to identify the gas for which this record is calibrated. This is only a text identifier and does not affect the calibration. Any identifier that is 9 characters or less may be used for gas identification.

item 5: time factor:

read G5(cr) or *[aa]G5(cr)

Sample reply: 1.00(cr)>

write G5=60.0(cr) or *[aa]G3= 60.0(cr)

This is the number of minutes in the time unit of the desired flow unit. When the flow unit is given as an amount per hour this will be 60 (scfh), if the flow unit is given as an amount per second this unit will be 1/60 = 0.01667 (gm/sec). Changing this value will affect the calibration.

item 6: units conversion factor:

Reserved for future use

item 7: units symb:

read G7(cr) or *[aa]G7(cr)

Sample reply: SLM(cr)>

write G7=SCFH(cr) or *[aa]G6= SCFH(cr)

This used to identify the flow unit for which this record is calibrated. This is only a text identifier and does not affect the calibration. Any identifier that is 9 characters or less may be used for engineering unit identification.

item 8: volume factor:

read G8(cr) or *[aa]G8(cr)

Sample reply: 1.00(cr)>

write G8=1000.0(cr) or *[aa]G8= 1000(cr)

This is the ratio between the amount of gas that is contained in a standard liter vs the amount of gas that is contained in the current amount unit. As an example, this would be 1000 if the current flow unit was a standard cm^3 since there are 1000 standard cm^3 in a standard liter. If a direct mass unit is being employed, this will be the gas density.

Changing this value will affect the calibration.

item 9: gas corr factor:

read G9(cr) or *[aa]G9(cr)

Sample reply: 1.00(cr)>

write G9=1.43.0(cr) or *[aa]G9= 1.43(cr)

This is a value that is used to correct for the differing specific heat dependent sensor sensitivities for different gases. This will be 1.00 for Nitrogen but it will vary when the flow instrument is calibrated for gases that are complex molecules or the noble gases. This value will be listed for each gas in the gas conversion factor table for this instrument.

item 10: 2nd order shunt factor:

read G10(cr) or *[aa]G10(cr)

Sample reply: 0.04(cr)>

write G10=0.005(cr) or *[aa]G10= 0.005(cr)

This is the coefficient of the 2nd order term of the normalized polynomial used to generate a linear relationship between the volumetric flow through the sensor and volumetric flow through the laminar flow element (shunt). The normalized sensor polynomial has the form of $Y = Ax + Bx^2 + Cx^4$. All of the three coefficients will sum to 1.000.

This value is generated at the factory from test data – changing this value will affect the calibration of the instrument. Do not change this unless a normalized linearity calculation was performed beforehand.

item 11: 4th order shunt factor:

read G11(cr) or *[aa]G11(cr)

Sample reply: 0.01(cr)>

write G10=0.0005(cr) or *[aa]G10= 0.0005(cr)

This is the coefficient of the 4th order term of the normalized polynomial used to generate a linear relationship between the volumetric flow through the sensor and volumetric flow through the laminar flow element (shunt). The normalized sensor polynomial has the form of $Y = Ax + Bx^2 + Cx^4$. All of the three coefficients will sum to 1.000.

This value is generated at the factory from test data – changing this value will affect the calibration of the instrument. Do not change this unless a normalized linearity calculation was performed beforehand.

item 12: comment:

read G12(cr) or *[aa]G12(cr)

Sample reply: Gas0(cr)>

write G12=Fuel(cr) or *[aa]G12= Fuel(cr)

This is space reserved for the customer. This could be used to provide a text message to identify this particular gas calibration for users. This is only a text identifier and does not affect the calibration. Any identifier that is 9 characters or less may be used.

item 13: cal date:

read G13(cr) or *[aa]G13(cr)

Sample reply: 01/01/0000(cr)>

write G12= 01/01/2006(cr) or *[aa]G12= 01/01/2006(cr)

This is the date that this gas record was last calibrated for this particular instrument. The format is day-month-year.

item 14: span correction factor:

read G14(cr) or *[aa]G14(cr)

Sample reply: 1.000(cr)>

write G14= 1.001(cr) or *[aa]G14= 1.001(cr)

This is the value that is adjusted at calibration time to correct for differences in the indicated full scale flow value and the flow values reported by the flow reference. Changing this value will affect the calibration of the instrument; do not change unless a flow reference is available to verify the calibration.

item 15: volumetric unit:

read G15(cr) or *[aa]G15(cr)

Sample reply: 1(cr)>

write G14= 0(cr) or *[aa]G14= 0(cr)

This is a binary value that alerts the processor when the mass flow unit is a standard volumetric unit (1) that requires a reference temperature for definition or if the flow unit is a direct mass or molar unit (0) which does not require a reference temperature.

Thermal mass flow meters report a flow that is proportional to the number of molecules passing through the units. Normally a mass unit is defined as the number of molecules that are required to fill a specific volume to atmospheric pressure at a given reference temperature. If a unit of this type is being used as the flow unit then the reference temperature must be used in the flow measurement and this item must be enabled. See G19 below.

item 16: Unknown1:

Reserved for future use

item 17: unknown2:

Reserved for future use

item 19: ref temp:

read G19(cr) or *[aa]G19(cr)

Sample reply: 0.00(cr)>

write G19= 21.1(cr) or *[aa]G14= 21.1(cr)

This is applicable only if G15 is enabled. This is temperature that is used when a volumetric unit is being defined as a mass unit. The temperature must be in °C. This is N/A if the current flow unit is a direct mass such as grams or molar unit. This temperature is not the temperature that existed in the laboratory during calibration. Changing this will affect the calibration.

2.6. Valve list (Controller versions only)

V d [=n] Set/read flow control data items by item code d. The blank spaces are not necessary and are ignored. The commands may be received in upper case or lower case. In RS485 mode the "S" command must be preceded by an asterisk* and the address(macid).

V [d](cr) or *[aa]V [d](cr)

VL List all valve control data items, values and units

VL(cr) or *[aa]VL(cr)

Valve item number list

item 1: MFC mode:

item 2: MFC config:

item 3: valve posn:

item 4: netwk setpt:

item 5: netwk setpt:

item 6: analog setpt:

item 7: analog setpt:

item 8: impl setpt:

item 9: impl setpt:

item 10: cntrlld var:

item 11: cntrlld var:

item 12: softstart type:

item 13: softstart value:

item 14: trckg error:

item 15: trckg error:

item 16: trckg alarm limit:

item 17: trckg alarm limit:

item 18: trckg alarm enable:

item 19: trckg alarm delay:

item 20: trckg warn limit:

item 21: trckg warn limit:

item 22: trckg warn enable:

item 23: trckg warn delay:

item 27: valve drive:

item 28: valve set:

item 29: valve crackg:

item 30: valve shut:

item 31: valve lim:

2.7. Valve List by item number

item 1 :MFC mode:

read V1(cr) or *[aa]V1(cr)

Sample reply: 1(cr)>

write V1= 0(cr) or *[aa]V1= 0(cr)

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:

read V2(cr) or *[aa]V2(cr)

Sample reply: x0041(cr)>

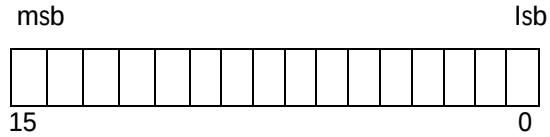
write V1= 0(cr) or *[aa]V1= 0(cr)

This controls the source of the command signal. See MFC Configuration word in control and status words section.

X0041 = Digital control

X0081 = Analog Control

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.

item 3 :valve posn: (read only)

read V3(cr) or *[aa]V3(cr)

Sample reply: x00(cr)>

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: (Flow units)

read V4(cr) or *[aa]V4(cr)

Sample reply: 100 SLM(cr)>

write V4= 200(cr) or *[aa]V4= 200(cr)

This is the value of the setpoint that was received digitally. This item configures or reports the setpoint in the flow units chosen in the active gas record (G7). Writing to this item will affect the value reported back by V5 below. The flow controller will increase or decrease the valve opening until the flow reading equals this desired flow value. The value received here is ignored if V2 is set for analog control.

item 5 :netwk setpt: (% of full scale)

read V5(cr) or *[aa]V5(cr)

Sample reply: 50.00 %(cr)>

write V5= 50(cr) or *[aa]V5= 50(cr)

This is the value of the setpoint that was received digitally. This item configures or reports the setpoint as a % of the full scale flow value listed in the active gas record (G2). Writing to this item will affect the value reported back by V4 above. The flow controller will increase or decrease the valve opening until the flow reading equals this desired flow value. The value received here is ignored if V2 is set for analog control.

item 6 :analog setpt: flow units (read only)

read V6(cr) or *[aa]V6(cr)

Sample reply: 101.23 SLM(cr)>

This is the value of the setpoint that was received on the analog input pins as read by A/D#0. This item configures or reports the setpoint in the flow units chosen in the active gas record (G7). The flow controller will interpret the A/D reading such that a minimum input reading is a request for no flow and a maximum input reading is a request for the full scale flow indicated by G2. Any input between these minimum and maximum values will be interpreted as a request for a flow rate that is a corresponding ratio of the full scale flow. The flow controller will increase or decrease the valve opening until the flow reading equals this desired flow value. The value received here is ignored if V2 is set for digital control.

item 7 :analog setpt: % of full scale (read only)

read V7(cr) or *[aa]V7(cr)

Sample reply: 56.23 %(cr)>

This is the value of the setpoint that was received on the analog input pins as read by A/D#0. This item configures or reports the setpoint as a % of the full scale flow value listed in the active gas record (G2). The flow controller will interpret the A/D reading such that a minimum input reading is a request for no flow and a maximum input reading is a request for the full scale flow indicated by G2. Any input between these minimum and maximum values will be interpreted as a request for a flow rate that is a corresponding ratio of the full scale flow. The flow controller will increase or decrease the valve opening until the flow reading equals this desired flow value. The value received here is ignored if V2 is set for digital control.

item 8 :impl setpt: flow units (read only)

read V8(cr) or *[aa]V8(cr)

Sample reply: 101.23 SLM(cr)>

This is the flow setpoint value that the controller is trying to implement. This may be the analog setpoint, the digital setpoint or some other value such as 0.00 if the valve is in shutdown mode. The command source is controlled by the values stored in V1 and V2. This item configures or reports the setpoint in the flow units chosen in the active gas record (G7).

item 9 :impl setpt: % of full scale (read only)

read V9(cr) or *[aa]V9(cr)

Sample reply: 56.23 %(cr)>

This is the flow setpoint value that the controller is trying to implement. This may be the analog setpoint, the digital setpoint or some other value such as 0.00 if the valve is in shutdown mode. The command source is controlled by the values stored in V1 and V2. This item configures or reports the setpoint as a % of the full scale flow value listed in the active gas record (G2).

item 10:cntrlld var: % of full scale (read only)

read V10(cr) or *[aa]V10(cr)

Sample reply: 56.23 %(cr)>

This is the current value of the system parameter that is being controlled by the valve. In a flow controller this is the current flow reading. This item reports the flow as a % of the full scale flow value listed in the active gas record (G2).

item 11:cntrlld var: flow units (read only)

read V11(cr) or *[aa]V11(cr)

Sample reply: 101.23 SLM(cr)>

This is the current value of the system parameter that is being controlled by the valve. In a flow controller this is the current flow reading. This item reports the flow in the flow units chosen in the active gas record (G7).

item 12:softstart type:

Reserved for future use

item 13:softstart value:

Reserved for future use

item 14:trckg error: flow units (read only)

read V14(cr) or *[aa]V14(cr)

Sample reply: 5.01 SLM(cr)>

This is the error between the desired flow (setpoint command) and the actual indicated flow reported in the flow units chosen in the active gas record (G7). It is normal for significant errors to occur for a short time immediately after a change in the setpoint due to the time it takes to move the valve to a new stable position. This error should decrease over time and approach a very small value. A large error that persists for a significant amount of time after a change in the command signal is an indication of a failure in the system. Typically, this is caused by insufficient pressure for the requested flow or a failed valve.

item 15:trckg error: % of full scale (read only)

read V15(cr) or *[aa]V15(cr)

Sample reply: 0.31 %(cr)>

This is the error between the desired flow (setpoint command) and the actual indicated flow reported as a % of the full scale flow value listed in the active gas record (G2). It is normal for significant errors to occur for a short time immediately after a change in

the setpoint due to the time it takes to move the valve to a new stable position. This error should decrease over time and approach a very small value. A large error that persists for a significant amount of time after a change in the command signal is an indication of a failure in the system. Typically, this is caused by insufficient pressure for the requested flow or a failed valve.

item 16:trckg alarm limit: flow units

read V16(cr) or *[aa]V16(cr)

Sample reply: 5.0 SLM(cr)>

write V16= 2.00(cr) or *[aa]V16= 2.00(cr)

If the flow alarm enable is set (V18) and the tracking error remains above this limit for longer than the time specified by the tracking alarm delay (V19) the tracking alarm bit will be set in the alarm status word. This can enable one of the hardware alarms if it is configured. This item configures or reports the limit in the flow units chosen in the active gas record (G7). Writing to this item will affect the value reported back by V17 below.

item 17:trckg alarm limit: % of full scale

read V17(cr) or *[aa]V17(cr)

Sample reply: 1.0 %(cr)>

write V17= 2.00(cr) or *[aa]V17= 2.00(cr)

If the tracking alarm enable is set (V18) and the tracking error remains above this limit for longer than the time specified by the tracking alarm delay (V19) the tracking alarm bit will be set in the alarm status word. This can enable one of the hardware alarms if it is configured. This item configures or reports the limit as a % of the full scale flow value listed in the active gas record (G2). Writing to this item will affect the value reported back by V16 above.

item 18:trckg alm enable:

read V18(cr) or *[aa]V18(cr)

Sample reply: 1(cr)>

write V18= 0(cr) or *[aa]V17= 0(cr)

This is a binary value that when enabled it will allow tracking error values that exceed alarm limits for a time longer than specified by the tracking alarm delay to set bit 8 of the alarm status word. Setting this bit also sets the bit 11 of the MFM config word (S2).

item 19:trckg alarm delay:

read V19(cr) or *[aa]V19(cr)

Sample reply: 0.00 S(cr)>

write V19= 2.0(cr) or *[aa]V19= 2.0(cr)

This defines the length of time in seconds between the start of an error condition until the time it is reported by the alarm status word. This will allow the valve time to stabilize to a new setpoint without setting off the alarm. A setting of 0.00 will result in an immediate response.

item 20:trckg warn limit: flow units

read V20(cr) or *[aa]V20(cr)

Sample reply: 5.0 SLM(cr)>

write V20= 2.00(cr) or *[aa]V20= 2.00(cr)

If the tracking warning enable is set (V22) and the tracking error remains above this limit for longer than the time specified by the tracking warning delay (V23) the

tracking warning bit will be set in the warning status word. This item configures or reports the limit in the flow units chosen in the active gas record (G7). Writing to this item will affect the value reported back by V21 below.

item 21:trckg warn limit: % of full scale

read V21(cr) or *[aa]V21(cr)

Sample reply: 5.0 SLM(cr)>

write V21= 2.00(cr) or *[aa]V21= 2.00(cr)

If the tracking warning enable is set (V22) and the tracking error remains above this limit for longer than the time specified by the tracking warning delay (V23) the tracking warning bit will be set in the warning status word. This item configures or reports the limit as a % of the full scale flow value listed in the active gas record (G2). Writing to this item will affect the value reported back by V20 above.

item 22:trckg warn enable:

read V22(cr) or *[aa]V22(cr)

Sample reply: 1(cr)>

write V22= 0(cr) or *[aa]V22= 0(cr)

This is a binary value that when enabled it will allow tracking error values that exceed warning limits for a time longer than specified by the tracking warning delay to set bit 8 of the warning status word. Setting this bit also sets the bit 10 of the MFM config word (S2).

item 23:trckg warn delay:

read V23(cr) or *[aa]V23(cr)

Sample reply: 0.00 S(cr)>

write V23= 2.0(cr) or *[aa]V23= 2.0(cr)

This defines the length of time in seconds between the start of an error condition until the time it is reported by the warning status word. This will allow the valve time to stabilize to a new setpoint without setting off the warning. A setting of 0.00 will result in an immediate response.

item 27:valve drive: (read only)

read V27(cr) or *[aa]V27(cr)

Sample reply: 0.31 %(cr)>

This is a positive integer value in the range of 0 – 64000 that correspond to the internal pulse width modulator output voltages between 0 – 5 volts.

item 28:valve set:

read V28(cr) or *[aa]V28(cr)

Sample reply: 41354(cr)>

write V28= 32000(cr) or *[aa]V28= 32000(cr)

This is the value that may be set between 0 - 64000 to set the pulse width modulator voltage whenever the controller has been set variable/manual control by the MFC Mode word.

item 29:valve crackg: (read only)

read V29(cr) or *[aa]V29(cr)

Sample reply: 32198(cr)>

This is the integer value between 0 – 64000 (typically around 30000) required to set the pulse width modulator voltage equal to the 2 volt reference signal that corresponds to zero flow.

item 30:valve shut:

Reserved for future use.

item 31:valve lim: (read only)

read V31(cr) or *[aa]V31(cr)

Sample reply: 32198(cr)>

This is the integer value between 0 – 64000 (typically around 43000) required to set the pulse width modulator voltage equal to the full scale flow value listed in the active gas record (G2).

2.8. Mode list

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

ML List all values individually accessible from the MS, MSC, MA, MAA, MF, MFA, MW and MWA commands

{*dd}ml(cr)

>ml

state: 2

mfm status: x0080

alarms: x0000

unacked alarms: x0000

flow status: x0001

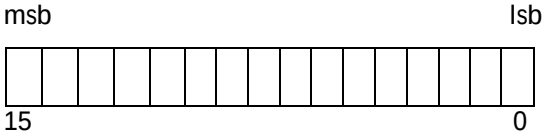
unacked flow status: x0001

warnings: x0004

unacked warnings: x0004

2.9. 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.

bit 14: Set if flow below alarm limit.

bit 13: Set if indicated flow reading invalid. (Examine flow status).

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

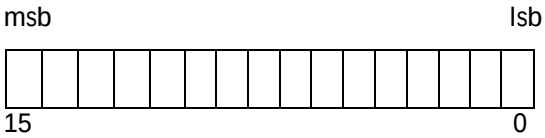
bit 11-10: Reserved

bit 9: Set if MFC flow control failure detected. (On occurrence, MFC mode automatically disabled by setting to ERROR).

bit 8: Set if tracking error (indicated flow minus implemented setpoint) exceeds tracking error alarm limit. Unused if MFC not configured.

bit 7-0: Reserved

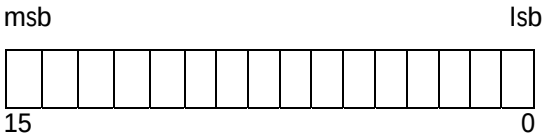
2.10. ALARMS ACKNOWLEDGE WOR



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.

2.11. WARNINGS STATUS WORD



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

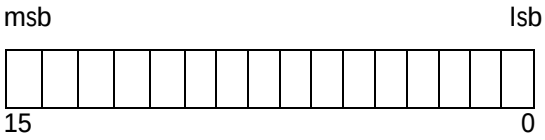
bit 15(msb): Set if indicated flow above high flow warning limit.

bit 14: Set if indicated flow below warning limit.

bit 13: Set if tracking error (indicated flow minus implemented setpoint) exceeds tracking error warning limit.

bits 12- 0: Reserved

2.12. WARNINGS ACKNOWLEDGE WORD

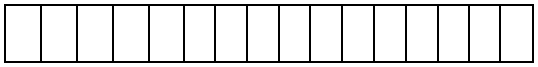


Read or read then clear using MWA network command. Read once more to see result of clearing.

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.

2.13. MFM FLOW STATUS WORD

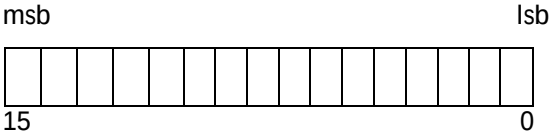
msb lsb



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) - 0(lsb): Reserved

2.14. 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

3. 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