



Serial Communication Protocol

Models 991R & 991R-MFC—Models 990X & 990X-MFC



Florite International, Inc.
Models 991R & 991R-MFC—Models 990X & 990X-MFC
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SERIAL COMMUNICATION PROTOCOL 991R & 991R-MFC – 990X & 990X-MFC

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6.0

Serial Value Programming

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1.0 Revision History

<u>Effective Date</u>	<u>Revision Enhancement</u>
25Dec2007	1. Initial edit conversion of source Protocol Document
28Jul2008	1. Initial release complete - sent to J. Dewaldt via email
26Feb2009	1. Edited content with respect to Brooks-oriented applicability based on the premise that "if you don't sell it - then delete it"
06Mar2009	1. Edit Dewalt observations highlighted red
12Mar2009	1. Edit sections 6.3, 6.4 describing affect-result of interrogating Port Type
16Sep2009	1. Instruct meaning of "Half-Duplex"; edit unit address to be aaaaa , port sub-address to be .p or .pp - incorporated in twenty-two different numbered sub-sections of master sections: 4.0, 5.0, and 6.0.
19Oct2012	1. Edits to from Section 2.0 to 6.0 to improve customer understanding such as for example shown by bolded items in the text immediately above for 16Sep2009
02Nov2012	1. Updated Sections: 2.0 Serial Port Parameters, 5.2.1 Measure String 96ms Send Latency
03Feb2014	1. Added Section: 5.2.1.2 Measure Rate Value(s)

2.0 Purpose

The purpose of this document is to describe in detail the various aspects of providing 0254 instrument commands and responses that result in operating value programming - fundamental to employing the system for acquiring and communicating measured information - and providing for process control output.

The serial port rate is fixed at 9600 bits per second (bps) rate, no parity, and one stop bit minimum.

3.0 System Overview

3.1 Structure - this instrument is a general platform into which are installed certain standard and special operating modules. This document focuses on standard universal input-output module offerings. The platform supports input signal measures; and control output signals. The platform supports various communication facilities.

3.2 Channels and Ports - the instrument is comprised of pairs of ports comprised of an input and output to form a channel. The basic instrument is comprised of four channels.

4.0 Serial Command Organization

4.1 Command Structures

This protocol was selected to service the need for serial error control while operating in local or wide area networks to transfer information between a unit and host computer.

4.1.1 Elements

The command format is a free form variable entry implementation, enabling expeditious economic means of achieving required programming results. Commands are comprised of the following structural elements:

4.1.1.1 Block Pre-limiter - sentinel indicating start of multiple packets message

4.1.1.2 Packet Pre-limiter - sentinel indicating start of a packet message

4.1.1.3 Information Frame - contains comma pre-limited fields which start with the first character immediately following the message pre-limiter and includes all successive characters up to and including a comma which immediately precedes the first ASCII hexadecimal checksum character.

4.1.1.4 Checksum - is two ASCII hexadecimal characters created for a mod256 negated sum of all message characters used to check message packet validity, incorporated within the more widely used transfer protocol known as "Intel Hex".

4.1.1.5 Packet delimiter - sentinel indicating end of a packet message which must be received by the host prior to sending a subsequent command.

4.1.1.6 Block Delimiter - sentinel indicating end of multiple packets message

4.1.2 Transfer - all messages are serial half duplex send-response types; besides numerous

operational attributes; the most important being that both parties insure that only one party is authorized to talk to the other party at any one time.

4.1.3 Mastering - the protocol initiator or originator is the master. The master is responsible for managing the communication link connection.

4.2 Command Addressing

4.2.1 The 0254 unit is assigned a unique aaaa address from 0 to 65535 which must be pre-programmed in the instrument prior to deployment in a network environment. An instruments ports used to comprise channels are designated as ".p" or ".pp" port sub-address.

4.2.2 The five digit address may be omitted when operating a single un-network unit - but must be used in multiple unit networks to differentiate the units from each other.

4.2.3 Command arguments are single ASCII alpha non-case sensitive characters, FOR EXAMPLE:

HOST SEND

```
AZ   aaaaa   .pp   K   <cr>
|     |           |     |     |
|     |           |     |     + -- message delimiter
|     |           |     +-- command argument
|     |           +-- port sub-address
|     +-- unit address
+-- message prelimiter
```

AZ .pp <argument> <cr> Non-networked sub-addressed port

AZ aaaaa.p <argument> <cr> Networked sub-addressed port

RESPONSE - <argument> dependent

5.0 Command Operation

5.1 General Commands

These commands are general basic utility types not described in any particular order.

5.1.1 Command Synchronize

This command string terminates commands that may be presently in process and resets the command state machine operation to the initial ready state. It can be sent to instruments in a network to provide command state machine synchronization.

HOST SEND

```
<esc>AZ<cr>
```

RESPONSE – none

5.1.2 Menu Command

This command is provided for terminal oriented use and causes display of a menu listing the basic available command arguments, make, model, code version and object code start vector. The menu does not include special factory diagnostic and production test commands.

HOST SEND

AZM <cr>	Non-network
AZ aaaaa M <cr>	Network

RESPONSE

```
<cr><lf><lf><lf><lf><lf><lf><lf><lf><lf><lf><lf><lf><lf><lf><lf><lf><lf><lf>
Brooks Instruments
COMMANDS - Model 0254 V01.03.21 FE00
<cr><lf><lf>
[M] Command Select Menu<cr><lf>
[V] Display Port Values<cr><lf>
[K] Send Measured <cr><lf>
[ I ] Product Identify<cr><lf>
[P] Program New Values<cr><lf>
[Z] Clear Measured Values<cr><lf>
[F] Batch Control Service<cr><lf>
[B] Blend Control Service<cr><lf>
[G] Log Record Service<cr><lf>
```

5.1.3 View Programmed Channel Port Values

This command enables the operator to review all present programmed channel port values.

HOST SEND

AZ .pp V <cr>	Non-network xx=port number (1-8)
AZ aaaaa.p V <cr>	Network

RESPONSE

Response is dependent upon whether the port is off, input, output or Global Settings (port 9) which will be further described as provided in subsequent sections.

5.1.4 Identify Command

This command causes the addressed unit to respond with a string providing identity information about the instrument. This command is useful to determine a networked instrument complement. More detailed structural information is available in Section 6.0.

The responding unit checksum may be validated by the host who may request the information again should the received packet be in error.

HOST SEND

AZI <cr>	Non-network
AZ aaaaa I <cr>	Network

RESPONSE

AZ,00000,4,BROOKS,0254,08,01.01.13,FE00,<sum><cr><lf>

FIELDS

AZ	Pre-limiter
,00000	Unit address
,4	Response type
,Brooks Instrument	Make
,Model 0254	Model
,08	Port provision count
,V09.01.30	Code version date yy-mm-dd
,FE00	Start vector
,<sum>	Negated mod256 sum
<cr><lf>	Delimiter

5.1.5 Message Serial Character Pacing Controls

These commands provide for terminal or host to suspend character sending, or to re-enable the sending to continue. This facility is particularly useful when unit sends large data amounts such as logged information.

5.1.5.1 Serial Character Pacing

This command acts as an XOF to temporarily suspend unit from sending further characters.

HOST SEND

AZH<cr>	Non-network
AZ aaaaa <cr>	Network

RESPONSE – none

This command acts as an XON to allow or re-enable unit to continue sending characters.

HOST SEND

AZS<cr>	Non-network
AZ aaaaa S<cr>	Network

RESPONSE – none

5.1.6 Serial Message Error Control

Commands provide for error control of information packets sent by the unit. This is particularly useful when transferring information over wide area networks, and causes the unit to continue to send the next packet, or to resend a previous sent packet.

The send-resend is determined by the receiving host based on having computed a checksum from the received characters - then comparing it with the checksum sent by the unit. The unit must be pre-configured to enable the error control protocol.

5.1.6.1 Positive Acknowledge Command

This command must be issued by the receiving host to enable the unit to send its packet

which is next eligible. Should the unit not receive positive acknowledgement within four seconds, it will resend the previous packet up to four times before abandoning the send session.

```
HOST SEND
      AZA<cr>           Non-network
      AZ aaaaa A <cr>   Network
```

RESPONSE – none

5.1.6.2 Negative Acknowledge Command

This command may be issued from the terminal or host to cause the unit to resend its previous packet. Should the unit not receive negative acknowledgement prior to a lapse of four seconds - it will automatically resend the previous unacknowledged packet up to four times before abandoning the send session.

```
HOST SEND
      AZN<cr>           Non-network
      AZ aaaaa N <cr>   Network
```

RESPONSE – none

5.2 Channel Input Port Commands

5.2.1 Measured Channel Values

5.2.1.1 This command is used to gather all measured information from one or all channel input ports.

Protocol responses are compatible to existing published protocol formats. Frames noted below as low case 'x' remain <reserved> regardless of frame content.

```
HOST SEND
      Non-Networked
      AZ .pp K <cr>           Send one channel input ports values

      Networked
      AZ aaaaa.pp K <cr>     Send one channel input port values
```

RESPONSE - ONE CHANNEL INPUT PORT MESSAGE

```
AZ,00909.00,2,xxxxxxxx.xx,00162871.43,-0000003.27,xxxxxxxx.xx,xxxxx,X,X,X,X,X,<sum><cr><lf>
```

Transmission of the above string requires 96ms, which immediately follows receipt of the host request string terminator.

5.2.1.2 This command is used to gather only rate information from one or all channel input ports.

Protocol responses are compatible to existing published protocol formats. Frames noted below as low case 'x' remain <reserved> regardless of frame content.

HOST SEND

Non-Networked

AZ .pp R <cr>

Send one channel input ports values

Networked

AZ aaaaa.pp R <cr> Send one channel input port values

RESPONSE - ONE CHANNEL INPUT PORT MESSAGE

AZ,00909.01,4,xxxxxxx0.16,<sum><cr><lf>

Transmission of the above string requires 27ms, which immediately follows receipt of the host request string terminator.

5.2.2 Send Channel Input Port Programmed Values

This command enables a terminal operator or host to acquire the present state of input port programmed values.

HOST SEND

AZ .pp V <cr>

Non-network

AZ aaaaa.p V <cr>

Network

RESPONSE

PROGRAM VALUES - Channel 1 - Port 01

<04>	Measure Units	ml
<10>	Time Base	min
<03>	Decimal Point	x.xx
<27>	Gas Factor	1.000
<28>	Log Type	Off
<00>	PV Signal Type	0-20mA
<09>	PV Full Scale	20.00 ml/m

5.2.3 Program Channel Input Port Values

Each of the input port programmed operating values can be individually queried or changed in accordance with Section 6.0 using the <xx> value index.

5.2.4 Clear Accumulated Values

This command allows any one channel input port accumulated value to be independently reset to zero, or all unit programmed values to be set to factory default.

HOST SEND

AZ .pp Z n <cr>

Non-network

AZ aaaaa.pp Z n <cr>

Network

n=0,2,3,5,6 <reserved>

n=1 Measured Quantity for one channel input port

n=4 Set all channels to be set to Factory default program values

RESPONSE – none

5.3 Channel Output Port Control Commands

5.3.1 Channel Control Output Port Values

This command enables terminal operator or host to acquire the present state of a channel output port programmed values.

HOST SEND

AZ .pp V <cr>

Non-network

AZ aaaaa.p V <cr>

Network

RESPONSE

PROGRAM VALUES - Channel 1 - Port 02

<00> SP Signal Type 0-20mA

<09> SP Full Scale 20.00 ml/m

<02> SP Function Rate

<01> SP Rate 0.00 ml/m

<29> SP VOR Normal

<44> SP Batch 0.00 ml

<45> SP Blend 0.000 %

<46> SP Source Keypad

5.3.2 Program Channel Output Port Values

Each channel output port programmed operating values can be individually queried or changed in accordance with Section 6.0 using the ".pp" value index.

5.3.3 Batch and Blend Control Commands

These commands are provided to conduct output port control operations that require starting and stopping.

5.3.3.1 Batch Command

This command is used to start a new batch quantity process, or stop a batch process that

may currently be in processing.

5.3.3.1.1 Bulk Batching

Bulk batching starts all qualified batch processes for all qualified channel ports at the same time.

Qualified channel output ports [Control Function] must be programmed to [Batch] and [Batch Quantity] set greater than zero; with [Link] to the channel input port programmed to accumulate quantity.

HOST SEND

AZ F*<cr>	start all channel batches
AZ F<cr>	stop all channel batches

RESPONSE(S)

AZ, aaaaa.pp ,5 ,FOK, DA, <cr><lf>	batch started and in process
AZ, aaaaa.pp ,5 ,FDONE, 4E, <cr><lf>	batch(s) completed
AZ, aaaaa.pp ,5 ,FERROR,5D, <cr><lf>	command error

5.3.3.2 Blend Command

This command is used to select a blend master channel and thereafter start the desired blending operation. At least one, or more, slaves output rates are controlled to be a proportion of the selected masters delivery rate.

Qualified channel output port must have its [Control Function] set to [Blend]. The required master channel input port is specified in the start command by having inserted its port sub-address ".pp" in the command, and must be one of the following:

Channel	Sub-Address
1	1
2	3
3	5
4	7

HOST SEND

AZ .pp B<cr>	Start blending
AZF<cr>	Stop blending

RESPONSE – none

5.4 Global Settings Services

5.4.1 Global Setting Values

This command enables terminal operator or host to acquire the present state of the Global programmed values. The Global Settings port number is one greater than the maximum number of available ports which is nine (9) for an 0254 instrument.

HOST SEND

```

AZ .09 V <cr>                                Non-Network
      <or>
AZ .9 V <cr>

AZ aaaaa.09 V <cr>                            Network
AZ aaaaa.9 V <cr>

```

RESPONSE

PROGRAM VALUES - Channel Global

```

<39> Audio Beep      On
<32> Zero Supress   On
<33> Pwr SP Clear   Off
<43> Record Count   000000 (view only)      log option
<25> Sample Rate    535 sec                  log option
<22> Date-Time      00Jan00 00:00:00        log option
<17> Network Addr   00000

```

5.4.2 Set Global Settings Values

Each of the system port programmed operating values can be individually queried or changed in accordance with Section 6.0 using the <xx> value index.

5.5 Communication Message Basics

Messages between host and unit are either polled (solicited) or un-polled (un-solicited), where the host is normally the polling (soliciting) party.

5.5.1 Message Structure

A packet is a group of information from channel input ports. A group of packets sent together are a block message as shown in examples below. Protocol responses are compatible to existing published protocol formats. Frames noted below as low case 'x' remain <reserved> regardless of frame content.

MESSAGE

```
AZ,00909.00,2,xxxxxxxx.xx,00162871.43,-0000003.27,xxxxxxxx.xx,xxxxx,X,X,X,X,X,<sum><cr><lf>
```

5.5.2 Message Format

BLOCK PRELIMITER

```
<dle><stx>
```

Start of multi-port block

PACKET PRELIMITER

```
AZ
```

Start of a port packet

ADDRESS - unit and port(s) providing the information

,xxxxx
.xx

unit address
port sub-address

TYPE - message purpose

Un-pollled Types

,0
,1
,2
,3
,6

<reserved>
<reserved>
<reserved>
<reserved>
<reserved>

Polled Types

,4
,5
,6
,7
,8
,9

Information request response
Control batch status
<reserved>
<reserved>
<reserved>
<reserved>

MEASURE - channel input port values - sign convention as (+), space(+), or minus (-)

,xxx
,QTY
,RATE
,xxx
,xxx

<reserved>
Quantity
Rate-Value
<reserved>
<reserved>

CHECKSUM

,<sum>

Negated mod256 sum

PACKET DELIMITER

<cr><lf>

Packet end - must be detected by
host before sending next command

BLOCK DELIMITER

<dle><etx>

Block end

6.0 Serial Value Programming

This section is organized into reading and programming values. The <index> value is a numeric designator unique to each programmable value - except Port Type.

6.1 Read a Programmed Value

HOST SEND

AZ .pp P <index> ? <cr>

Non-network

AZ aaaaa.pp P <index> ? <cr>

Network

RESPONSE

<200ms delay>

AZ,xxxxx.xx,4,Py,<present value>,<cksm><cr><lf>

A received response indicates that no error was detected.

EXAMPLE

AZ,00123.08,4,P08,04.000,DF<cr><lf>

6.2 Program a New Value

HOST SEND

AZ .pp P <index> = <new value> <cr>

Non-network

AZ aaaaa.pp P <index> = <new value> <cr>

Network

RESPONSE

<200ms delay>

AZ,aaaaa.pp,4,Py,<new value>,<cksm><cr><lf>

A correct received response indicates that no error was detected. It is recommended that host software validate the responding message check-sum, followed by the unit message address, port number, value index, and new programmed value to be certain that the desired value change was programmed successfully.

6.3 Channel Input Port Values

Port Type is the input signal type and is the first serial character received when programming a new Type. An optional second character may be received after Port Type with a range from 0-2 and has no operational effect. The second character is always returned when Port Type is serially interrogated.

Index	Value Title	Value	Range	Notes
0	Port Type			1 or 2 ascii chars with second char range 0-2 not affecting proper operation
		0	Off	
		1-6		<reserved>
		7	0-20mA	1 ascii char
		8	4-20mA	
		9	0-10V	
		:	2-10V	

		;	0-5V	
		<	1-5V	
	Excitation Type			1 ascii char optional
		0-2	<reserved>	
Measurement magnitude range				
3	Decimal Point	0	xxx.	1 ascii char
		1	xx.x	
		2	x.xx	
		3	.xxx	
Character string identifying the physical measurement type				
4	Measure Units			fixed indexed strings
		0	ml	
		1	mls	
		2	mln	
		3	l	
		4	ls	
		5	ln	
		6	cm^3	
		7	cm^3s	
		8	cm^3n	
		9	m^3	
		10	m^3s	
		11	m^3n	
		12	g	
		13	lb	
		14	kg	
		15	ft^3	
		16	ft^3s	
		17	ft^3n	
		18	scc	
		19	sl	
		20	bar	
		21	mbar	
		22	psi	
		23	kPa	
		24	Torr	
		25	atm	
		26	Volt	
		27	mA	
		28	oC	
		29	oK	
		30	oR	
		31	oF	
		32	g/cc	
		33	sg	

34	%
35	lb/in ³
36	lb/ft ³
37	lb/gal
38	kg/m ³
39	g/ml
40	kg/l
41	g/l

Analog interpolator representing the engineering units of the greater measured signal

9	PV Full Scale	xxxxxx	0 to ±999.999	1-7 ascii chars var dp
---	---------------	--------	---------------	------------------------

Measurement per unit time relationship

10	Rate Time Base	0	none (Scalar)	1 ascii char
		1	sec	
		2	min	
		3	hrs	
		4	day	

Scale Factor by which interpolated channel units are multiplied

27	Gas Factor	xxx.xxx	0 to ±999.999	1-7 ascii chars fix dp
----	------------	---------	---------------	------------------------

6.4 Channel Output Port Values

Port Type is the output signal type and is the first serial character received when programming a new Type. An optional second or third character may be received after Port Type with a range of 0-99 and has no operational effect. These characters represent port number of the linked input and are always returned when Port Type is serially interrogated.

Index	Value Title	Value	Range	Notes
0	Port Type			1 or 3 ascii chars with second or third chars range 0-99 not affecting proper operation.
		0	Off	1 ascii char min
		1	0-20mA	
		2	4-20mA	
		3	0-10V	
		4	2-10V	
		5	0-5V	
		6	1-5V	
	Link Input Port	0-99		1 or 2 ascii char optional

Rate (Manual) output set-point				
1	SP Rate	xxxxxx	0 to ±999.999	1-7 ascii char var dp

Select output control service				
2	SP Function	1	Rate	1 ascii char
		2	Batch	
		3	Blend	

Analog De-Interpolate representing the engineering units of the greatest signal allowed				
9	SP Full Scale	xxxxxx	0 to ±999.999	1-7 ascii chars var dp

Valve Override valve state selection				
29	SP VOR		0-2	1 ascii char
		0	Normal	tri-state
		1	Closed	vo < -4v
		2	Open	vo > +8v

Batch Delivery Set-Point				
44	SP Batch	xxxxxx	0 to ±999.999	1-7 ascii chars var dp

Blend Mixing Set-Point				
45	SP Blend	xxxxxx	0 to ±999.999	1-7 ascii chars var dp (% units automatic)

Set-Point Programming Source				
46	SP Source		0-1	1 ascii char
		0	Keypad	
		1	Serial	keypad prohibit

6.5 Global Setting Values

These settings affect all aspects of the system - not port or channel associated.

Index	Value Title	Value	Range	Notes
<hr/>				
32	Zero Suppress		0-1	1 ascii char
		0	Off	
		1	On	
33	Pwr SP Clear		0-1	1 ascii char
		0	Off	
		1	On	

Audio Annunciate Control - ON enables annunciate key activation and alarms

39	Audio Beep	0-1	1 ascii char
		0	Off
		1	On