

Installation and Operation Manual

X-DPT-RS232-4800-MFC-eng

Part Number 541B118AAG

July, 2010

Supplemental Manual for Brooks RS-232 Communication Protocol for the 4800 Series



Essential Instructions

Read this page before proceeding!

Brooks Instrument designs, manufactures and tests its products to meet many national and international standards. Because these instruments are sophisticated technical products, you must properly install, use and maintain them to ensure they continue to operate within their normal specifications. The following instructions must be adhered to and integrated into your safety program when installing, using and maintaining Brooks Products.

- Read all instructions prior to installing, operating and servicing the product. If this instruction manual is not the correct manual, please see back cover for local sales office contact information. Save this instruction manual for future reference.
- If you do not understand any of the instructions, contact your Brooks Instrument representative for clarification.
- Follow all warnings, cautions and instructions marked on and supplied with the product.
- Inform and educate your personnel in the proper installation, operation and maintenance of the product.
- Install your equipment as specified in the installation instructions of the appropriate instruction manual and per applicable local and national codes. Connect all products to the proper electrical and pressure sources.
- To ensure proper performance, use qualified personnel to install, operate, update, program and maintain the product.
- When replacement parts are required, ensure that qualified people use replacement parts specified by Brooks Instrument. Unauthorized parts and procedures can affect the product's performance and place the safe operation of your process at risk. Look-alike substitutions may result in fire, electrical hazards or improper operation.
- Ensure that all equipment doors are closed and protective covers are in place, except when maintenance is being performed by qualified persons, to prevent electrical shock and personal injury.

ESD (Electrostatic Discharge)

CAUTION

This instrument contains electronic components that are susceptible to damage by static electricity. proper handling procedures must be observed during the removal, installation or other handling of internal circuit boards or devices.

Handling Procedure:

1. Power to unit must be removed.
2. Personnel must be grounded, via a wrist strap or other safe, suitable means before any printed circuit card or other internal device is installed, removed or adjusted.
3. Printed circuit cards must be transported in a conductive container. Boards must not be removed from protective enclosure until immediately before installation. Removed boards must immediately be placed in protective container for transport, storage or return to factory.

Comments

This instrument is not unique in its content of ESD (electrostatic discharge) sensitive components. Most modern electronic designs contain components that utilize metal oxide technology (NMOS, SMOS, etc.). Experience has proven that even small amounts of static electricity can damage or destroy these devices. Damaged components, even though they appear to function properly, exhibit early failure.

Installation and Operation Manual

X-DPT-RS232-4800-MFC-eng

Part Number 541B118AAG

July, 2010

RS-232 Communications

Dear Customer,

We appreciate this opportunity to service your flow measurement and control requirements with a Brooks Instrument device. Every day, flow customers all over the world turn to Brooks Instrument for solutions to their gas and liquid low-flow applications. Brooks provides an array of flow measurement and control products for various industries from biopharmaceuticals, oil and gas, fuel cell research and chemicals, to medical devices, analytical instrumentation, semiconductor manufacturing, and more.

The Brooks product you have just received is of the highest quality available, offering superior performance, reliability and value to the user. It is designed with the ever changing process conditions, accuracy requirements and hostile process environments in mind to provide you with a lifetime of dependable service.

We recommend that you read this manual in its entirety. Should you require any additional information concerning Brooks products and services, please contact your local Brooks Sales and Service Office listed on the back cover of this manual or visit www.BrooksInstrument.com

Yours sincerely,
Brooks Instrument

*THIS PAGE WAS
INTENTIONALLY
LEFT BLANK*

<u>Section Number</u>	<u>Page Number</u>
Section 1 Definition of Terms	
1.1 Definition of Terms	1-1
Section 2 Introduction	
2.1 General Information	2-1
Section 3 Command Format	
3.1 Request	3-1
3.2 Checksum	3-1
3.3 Response	3-2
3.4 Transmission Errors	3-2
3.5 Example "send_n_data"	3-2
Section 4 List of Specific Commands	
4.1 Flow	4-1
4.2 Device Serial Number	4-1
4.3 Gas Information	4-2
Section 5 Variable Commands	
5.1 Variable Command Syntax	5-1
5.2 List of Variable Commands	5-1
5.2.1 Sensor Related Variable Commands	5.1
5.2.2 Controller Related Variable Commands	5.2
Warranty, Local Sales/Service Contact Information	Back Cover

Figures

<u>Figure Number</u>	<u>Page</u>
3-1 Request Command Sequence	3-1
3-2 Calculation of Checksum	3-1
3-3 Response Command Sequence	3-2
3-4 Example "send_n_data"	3-2
4-1 Real Flow Calculation	4-1
4-2 Response on Serial Number Command	4-1
4-3 Response on Gas Information Command	4-2
5-1 Temperature Calculation	5-2

Tables

<u>Table Number</u>	<u>Page</u>
4-1 List of Gas Identification Numbers	4-2
5.1 Valve Override Priority	5-2

RS-232 Communications

*THIS PAGE WAS
INTENTIONALLY
LEFT BLANK*

1.1 General Information

Abbreviation	Description
MFC	Mass Flow Controller/Meter device
MSB	Most Significant Bit
LSB	Least Significant Bit
Uint16	16 bits wide Unsigned Integer
STP	Standard Temperature and Pressure, i.e. 273 K (0 degrees Celsius) and 1 atm (1013.25 mbar) pressure
sccm	Standard Cubic Centimeters per Minute, i.e. unit of flow @STP

*THIS PAGE WAS
INTENTIONALLY
LEFT BLANK*

2.1 General Information

The protocol which is used to communicate with the 4800 Series Mass Flow Controller/Meter device (MFC) over the RS-232 serial interface is based on master-slave communication, the slave being the MFC, and a computer (PC) as the master. Only one single device can be connected via the RS-232 serial interface with the PC. For communicating with the MFC the following RS-232 serial port settings are required:

- Baudrate: 57600 baud
- Number of databits: 8
- Parity: Odd
- Number of stopbits: 1
- No handshake

Note: The RS-232 serial interface is available on the 15 pin D-sub connector on top of the 4800 Series MFC.

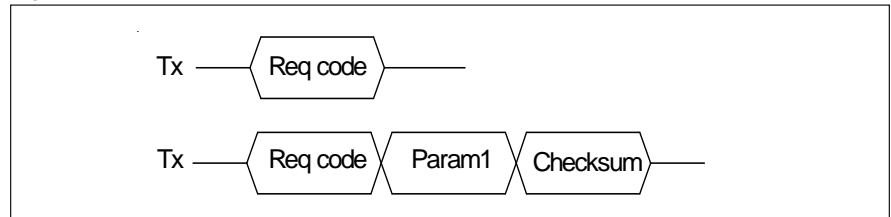
*THIS PAGE WAS
INTENTIONALLY
LEFT BLANK*

3.1 Request

Each request begins with a one-character code identifying the request. If parameters are required by the request, they are added after the code character. If the whole request consists of more than one character, a checksum is added at the end of the request.

Types of commands are the Specific commands, listed in Section 4. List of Specific Commands, and the Variable commands, listed in Section 5.2 List of Variable Commands.

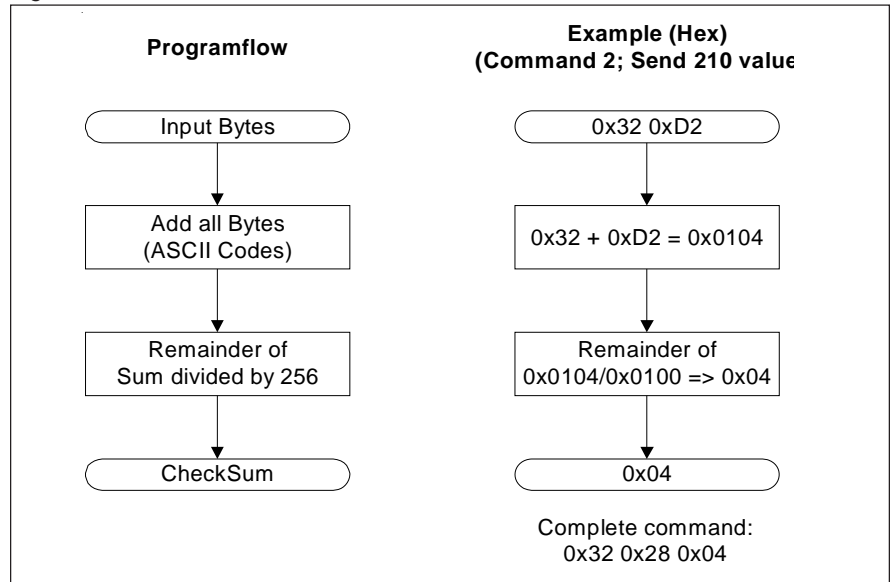
Figure 3-1 Request Command Sequence



3.2 Checksum

The checksum is the sum of all preceding byte values including the Request code. If the sum is greater than an 8-bit value (255), only the last 8 bits of the value are transmitted.

Figure 3-2 Calculation of Checksum

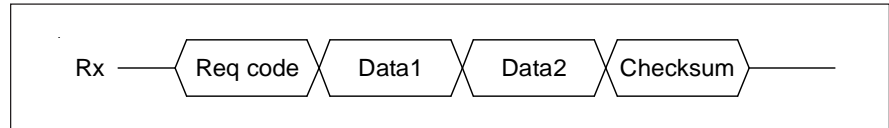


RS-232 Communications

3.3 Response

The response format is similar to the request format. The response sentence always begins with the Request code, followed by data. The sentence ends with a checksum. Note that the STOP request has no response.

Figure 3-3 Response Command Sequence



3.4 Transmission Errors

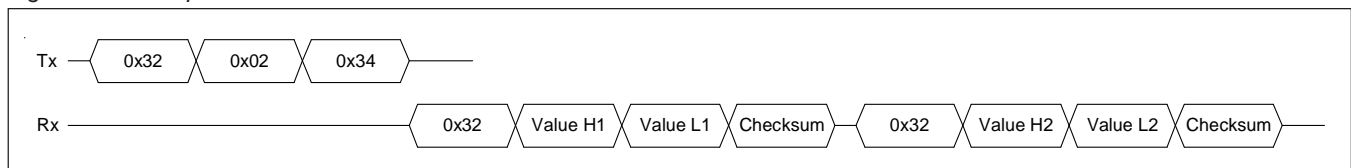
If an error occurs during transmission, the MFC device sends back an error code describing the error. The error code begins with 'E' (0x45) and is followed by a code identifying the error. No checksum is added after the error code.

Name	Code	Description
SEND_TIMEOUT	0x01	An internal error occurred and the sensor could not answer the last request.
SENSOR_BUSY	0x02	A request was started before the last one was finished. The error also occurs when the sensor is in the send continuous mode, and a request different from stop was started.
CHECKSUM_ERROR	0x03	The checksum received by the sensor was wrong
OVERRUN_ERROR	0x04	The sensor had not enough time to read the received bytes.
FRAME_ERROR	0x08	There was no stop bit.
PARITY_ERROR	0x10	The received parity bit was wrong
START_ERROR	0x20	There was no start bit
INVALID_REQ	0x40	The request code was wrong
UNKNOWN_VARID	0xC0	1) The variable identification is unknown 2) The variable with ID is not readable/ writeable with this request or the current access level is not sufficient. 3) The variable/parameter is out of range

3.5 Example "send_n_data"

The request code Send_n_data (0x32) is followed by the parameter N (number of values to read, limited to 255) and the checksum. The N flow measurement values are transmitted in N sentences identical to the send_one data sentence. In this example N=2.

Figure 3-4 Example "send_n_data"



4.1 Flow

Request	Code Hex/ 'Char'	Parameters	Access	Response
SEND_ONE_DATA	0x31 / '1'	None	WR	Flow Value
SEND_N_DATA	0x32 / '2'	N (1 byte): meas. count to send	WR	N Flow Values
SEND_CONTINUOUS	0x33 / '3'	None, terminate with STOP	WR	Flow Values
STOP	0x34 / '4'	None	WR	none

The flow value returned by one of the Flow commands will be a value between 0..10000 (0..100% flow). If e.g. 8000 is returned then the real flow will be 80% of the maximum flow. The maximum flow can be determined by using the gas info command, see Section 4.3 Gas Info. The real flow [sccm] can be calculated using the formula below.

Figure 4-1 Real Flow Calculation

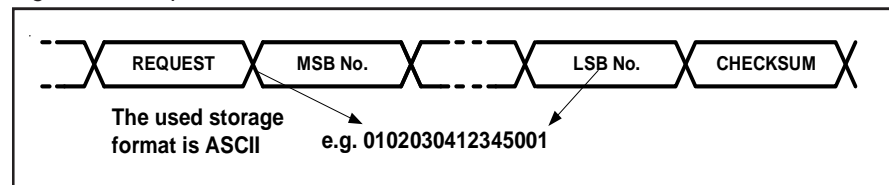
$$\text{real_flow [sccm]} = \frac{\text{flow}}{10000} \cdot \text{max_flow [sccm]}$$

4.2 Device Serial Number

Request	Code Hex/ 'Char'	Parameters	Access	Response
READ_SERIAL_MFC	0x68 / 'h'	None	RD	Serial no.

The Serial Number returned in the response is a 16 character string using no alpha or special characters, with the MSB first.

Figure 4-2 Response on Serial Number Command



RS-232 Communications

4.3 Gas Information

Request	Code Hex/ 'Char'	Parameters	Access	Response
READ_GASINFO	0x72/ 'r'	Array of 3x uint16	RD	Gasinfo table

The gas information has a structure of three unsigned integers, i.e. Maximum Flow [sccm], Gas Identification and Gas Density [gm/m³@STP]. Another gas can be selected by using the Selected Process Gas command, see Section 5.2.1 Sensor related variable commands.

See Figure 4-3 below for the Gas Info data available in the response of the Gas Info command.

Figure 4-3 Response on Gas Information Command

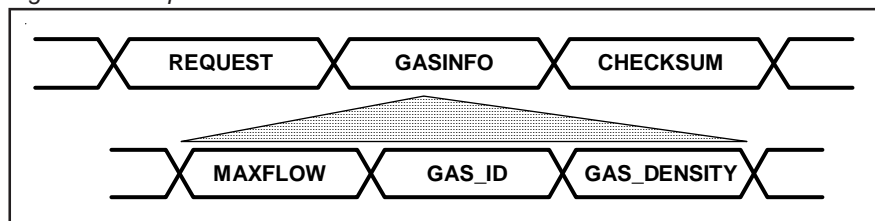


Table 4-1 List of Gas Identification Numbers

Gas Identification	Gas Symbol	Gas Name
1	He	Helium
4	Ar	Argon
7	H2	Hydrogen
8	Air	Air
9	CO	Carbon Monoxide
13	N2	Nitrogen
15	O2	Oxygen
25	CO2	Carbon Dioxide
27	N2O	Nitrous Oxide
28	CH4	Methane
69	C3H6	Propene
89	C3H8	Propane

5.1 Variable Command Syntax

Next to the Request commands described in the previous paragraph MFC related data can also be read and written via the generic variable command interface.

Request	Code Hex/ 'Char'	Parameters	Access	Response
READ_VAR_INT16	0x61 / 'a'	Variable ID	Separate access level for each variable	Variable Value
WRITE_VAR_INT16	0x62 / 'b'	Variable ID + VALUE (2 bytes): value to be written (higher bit first)		Req. Code
READ_VAR_CHAR	0x63 / 'c'	Variable ID		Variable Value
WRITE_VAR_CHAR	0x64 / 'd'	Variable ID + VALUE (1 byte): value to be written (higher bit first)		Req. Code

5.2 List of Variable Commands

5.2.1 List of Variable Commands

Functionality	Variablename	Datatype [Bit]	EEPROM persistence	Variable ID (decimal)	Access	Information
Serial Number	Serialnumber_PCB	uint16	yes	00	RD	Serial number for hw- identification.
Software Version	SWVersion	uint16	yes	01	RD	Embedded SW Version number has two decimal places (e.g. 1012 → 10.12)
Zero	Offset_zero ¹	uint8	no	03	RW	WR: 0:= none 1:= activate auto zeroing 2:= Reset RD: 0:= zeroing/Reset done 1:= zeroing ongoing 3:= Error offset out of range
Zero offset value	Offset_value ²	int16	yes	04	RD	Offset zero calibration value
Selected Calibration Gas	CalibGas	uint8	yes	05	RD	Selected calibration gas 1:= N ₂ 2:= gas2 etc.
Selected Process Gas	GasType ³	uint8	yes	06	RW	Selected process gas 1:= N ₂ 2:= gas2 etc.
Temperature	ADC_Temp	uint16	no	15	RD	Temperature of the LM50 Sensor, see Figure 8 Temperature calculatio.

¹ The maximum offset compensation value is limited to ±2% of maxflow (e.g. ±4sccm@maxflow 200sccm).

² *Offset value*: Data range is -32'768...0...+32'767. Calculation of offset value in sccm
 → Positive offsets (0...32'767) $Offset_{sccm} = 1,1 * Offset_value * MaxFlow / 32'767$
 → Negative offsets (-32'768...-1) $Offset_{sccm} = 1,1 * Offset_value * MaxFlow / 32'768$

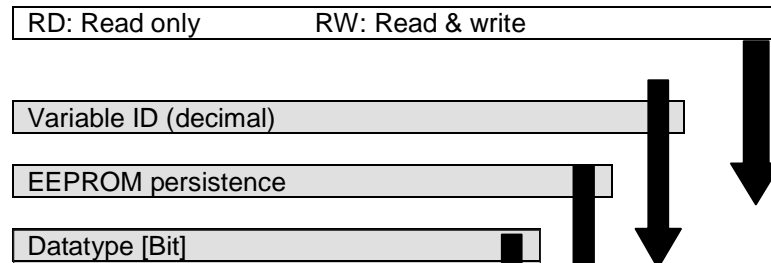
³ Limited to max. 10 gases

RS-232 Communications

Figure 5-1 Temperature Calculation

$$Temperature[{}^{\circ}C] = 100 \cdot \left(\frac{ADC_Temp}{65535} - 1 + \frac{5}{6} \right) [{}^{\circ}C]$$

5.2.2 Controller Related Variable Commands



Functionality	Variablename				Access	Information
Setpoint	CtrlNominal	uint16	No	20	RW	PID controller nominal value 0 := min. flow 65'535 := max. flow
Valve Override	V_OverrideState	uint8	yes	30	RW	Allow to override the valve position. The analog has priority (see table Table 1 Valve override priority table)
Setpoint Source Select	NomFlowInputSel	uint8	yes	31	RW	Selects the input for Setpoint: 0:= per RS232 1:= voltage input 2:= current input
Valve State	PID_CtrlActive	uint8	no	33	RD	Real controller state. It depends on Valve Override. 1:= active
Output Select	DA_Out_Sel	uint8	yes	100	RW	Select analog out 0:= voltage 0...5V 1:= current 4...20mA

Table 5-1 Valve Override Priority

Analog Valve Override	V_override_state(WR):	V_override_state(RD):
normal	normal/open/close	normal/open/close
open	normal/open/close	open
close	normal/open/close	close
0:= normal	1:= valve close	2:= valve open

TRADEMARKS

Brooks Brooks Instrument, LLC

RS-232 Communications

LIMITED WARRANTY

Seller warrants that the Goods manufactured by Seller will be free from defects in materials or workmanship under normal use and service and that the Software will execute the programming instructions provided by Seller until the expiration of the earlier of twelve (12) months from the date of initial installation or eighteen (18) months from the date of shipment by Seller. Products purchased by Seller from a third party for resale to Buyer ("Resale Products") shall carry only the warranty extended by the original manufacturer.

All replacements or repairs necessitated by inadequate preventive maintenance, or by normal wear and usage, or by fault of Buyer, or by unsuitable power sources or by attack or deterioration under unsuitable environmental conditions, or by abuse, accident, alteration, misuse, improper installation, modification, repair, storage or handling, or any other cause not the fault of Seller are not covered by this limited warranty, and shall be at Buyer's expense.

Goods repaired and parts replaced during the warranty period shall be in warranty for the remainder of the original warranty period or ninety (90) days, whichever is longer. This limited warranty is the only warranty made by Seller and can be amended only in a writing signed by an authorized representative of Seller.

BROOKS SERVICE AND SUPPORT

Brooks is committed to assuring all of our customers receive the ideal flow solution for their application, along with outstanding service and support to back it up. We operate first class repair facilities located around the world to provide rapid response and support. Each location utilizes primary standard calibration equipment to ensure accuracy and reliability for repairs and recalibration and is certified by our local Weights and Measures Authorities and traceable to the relevant International Standards.

Visit www.BrooksInstrument.com to locate the service location nearest to you.

START-UP SERVICE AND IN-SITU CALIBRATION

Brooks Instrument can provide start-up service prior to operation when required.

For some process applications, where ISO-9001 Quality Certification is important, it is mandatory to verify and/or (re)calibrate the products periodically. In many cases this service can be provided under in-situ conditions, and the results will be traceable to the relevant international quality standards.




CUSTOMER SEMINARS AND TRAINING

Brooks Instrument can provide customer seminars and dedicated training to engineers, end users and maintenance persons.

Please contact your nearest sales representative for more details.

HELP DESK

In case you need technical assistance:

Americas	 1 888 554 FLOW
Europe	 +31 (0) 318 549 290
Asia	 +81 (0) 3 5633 7100

Due to Brooks Instrument's commitment to continuous improvement of our products, all specifications are subject to change without notice.



Brooks Instrument
407 West Vine Street
P.O. Box 903
Hatfield, PA 19440-0903 USA
T (215) 362 3700
F (215) 362 3745
E-Mail BrooksAm@BrooksInstrument.com
www.BrooksInstrument.com

Brooks Instrument
Neonstraat 3
6718 WX Ede, Netherlands
T +31 (0) 318 549 300
F +31 (0) 318 549 309
E-Mail BrooksEu@BrooksInstrument.com

Brooks Instrument
1-4-4 Kitasuna Koto-Ku
Tokyo, 136-0073 Japan
T +81 (0) 3 5633 7100
F +81 (0) 3 5633 7101
E-Mail BrooksAs@BrooksInstrument.com

BROOKS[®]
INSTRUMENT