RS485 A-Protocol Supplemental Manual

GF40/GF80 Series
Mass Flow Controllers & Meters

BROOKS® INSTRUMENT

Beyond Measure

Contents

Figures

Tables

Introduction

The A-protocol is a digital communication protocol which provides a reliable, transaction oriented service between a master device, such as a PC, and one or more Brooks® Digital Series Mass Flow Controllers and Meters. The protocol is designed to allow a centralized controller to acquire measurement data from a Mass Flow device and, in case of Mass Flow Controllers, send setpoint values.

The Brooks RS485 on GF40/GF80 MFCs/MFMs support digital communications as defined by this manual. Communication is ASCII based and uses a command start and end byte. The physical layer supported is RS485 only.

This document is intended to give a user the means to implement the protocol structure into his own control system in order to establish communication between the control system and the RS485 based GF40/GF80 Series devices. It does not cover the non-communication functionality of these devices. For this description please refer to Installation and Operation Manual for this specific device.

The remaining sections of this document are summarized below:

- Section 2 – Definition of Terms
- Section 3 – Before Starting covers backgrounds and assumptions.
- Section 4 – Quick Start defines how to properly configure and wire RS485 on GF40/GF80 Series MFCs/MFMs for digital communications.
- Section 5 – Message Protocol Structure describes the AKT message protocol.
- Section 6 – Communicating With Slave describes the requirements of the Master.
- Section 7 – ID Related Commands describes the commands needed to retrieve the address ID of the device
- Section 8 – Read Commands describes the set of commands to read device attributes
- Section 9 – Set Commands describes the set of commands to configure device attributes.
- Back Cover – Warranty and Contact Information

Definition of Terms

Abbreviation	Description
MFC/MFM	Mass Flow Controller/Meter Device
MSB	Most Significant Bit
LSB	Least Significant Bit

Background & Assumptions

This manual is a supplement to the Brooks GF40/GF80 Series installation and operation manual. It is assumed that the owner of this RS485 GF40/GF80 MFC/MFM is thoroughly familiar with the theory and operation of this device. If not, it is recommended that the owner reads the installation and operation manual first before continuing with this supplement.

Numbers

Numeric values used throughout this manual will be clearly denoted as to the base numeric system it represents. All hexadecimal numbers (base 16) will be prefixed with a 0x, like 0xA4. All binary numbers (base 2) will be suffixed with a b, like 1001b. All other numbers not annotated this way will be assumed decimal (base 10).

This section assumes the owner of the Digital Series device has a fully operational and trouble-free RS485 communications network with appropriate power supplies.

Supported Baud Rates

Data communication can be performed at a number of baud rates: 9600, 19.2K and 38.4K baud. The baud rate can be changed using the SBR command. The device is shipped with the baud rate set to 19.2K baud.

Character Coding

A-protocol messages are coded as a series of 8-bit characters or bytes. These are transmitted serially, using a conventional UART (Universal Asynchronous Receiver/Transmitter). As in normal RS232 and other asynchronous communication links, a start bit, a parity bit and a stop bit are added to each byte. These allow the receiving UART to identify the start of each character and to detect bit errors due to electrical noise or other interference. An A-protocol character is built up from:

8 Databits No parity bit 1 Stop bit

Bus and Device LEDs

The device supports a Bus and Device LED to indicate the status of network communication and the device.

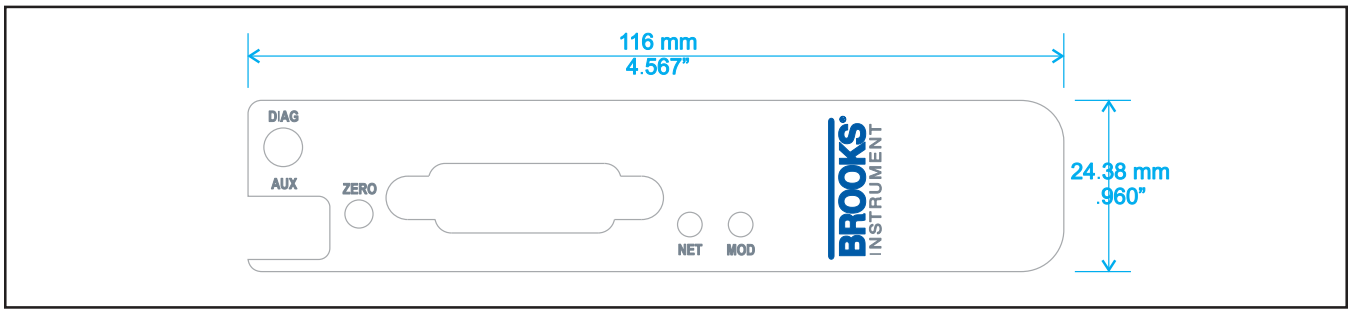

Figure 4-1 RS485 Label on Cover

The Bus LED will indicate the following:

Table 4-1 Bus LED Specification

Flash Code	Description
Off	No Network Connected
Solid Green	Communication Established at least once, reset-safter power cycle (no periodic check)

The Device LED will indicate the following:

Table 4-2 Device Led Specification

Flash Code	Description
Flashing Red/Green	The device is in the Self-Test/initializing mode
Solid Green	All self-tests/initialization have passed. No fault-shave been detected
Flashing Red	A recoverable fault has been detected.ex.: low/ high flow alarm
Solid Red	An unrecoverable fault has occurred.ex.: inter-nal power supply failure

Device Wiring

Electrical Connections

The RS485 on GF40/GF80 Series device has a 15-pin D-sub connector, for analog I/O, power supply and digital communication signals. See Table 4-3 for the pin-outs. For more detailed information refer to the instruction and operations manual.

Table 4 3 Pin-outs for D-Sub Connector

Pin No.	Function at Remote Connector
1	Setpoint Signal Ground
2	Flow Voltage Output
3	Alarm Output
4	Flow Current Output
5	Positive Supply Voltage
6	Not Used
7	Setpoint Current Input
8	Setpoint Voltage Input
9	Power Supply Common
10	Flow Signal Ground
11	Not Used
12	Valve Override Input
13	Auxiliary input
14	RXD/A-
15	TXD/A+

Multi Drop

The RS485 communications interface is a multi drop connection making it possible to connect up to 32 devices to a computer on a single multi drop line as shown Figure 4-2. Most Computers are NOT equipped with RS485 ports. In order to connect an RS485 to a computer, one will need an RS485 to RS232 converter. Figure 4-2 shows the interconnection diagram of an RS485 on GF40/GF80 MFC/MFM via an RS485 bus and an RS485 to RS232 converter to the RS232 serial port of a typical computer. The RS485 bus requires two matching resistors of 120W, one at the end of the bus and one at the beginning, near the converter. Note the control line from the PC to the converter necessary to control the data direction of the RS485 buffers. The RTS (“Request To Send”) line shown in Figure 4-2 because this line is used to control data direction in many of the commercially available converters. The actual line used depends on the converter selected.

Table 4-4 D-Connector Communication Pins

D-Connector Pin Number	RS485
Pin #14	B (inverted driver side)
Pin #15	A (non-inverted driver side)

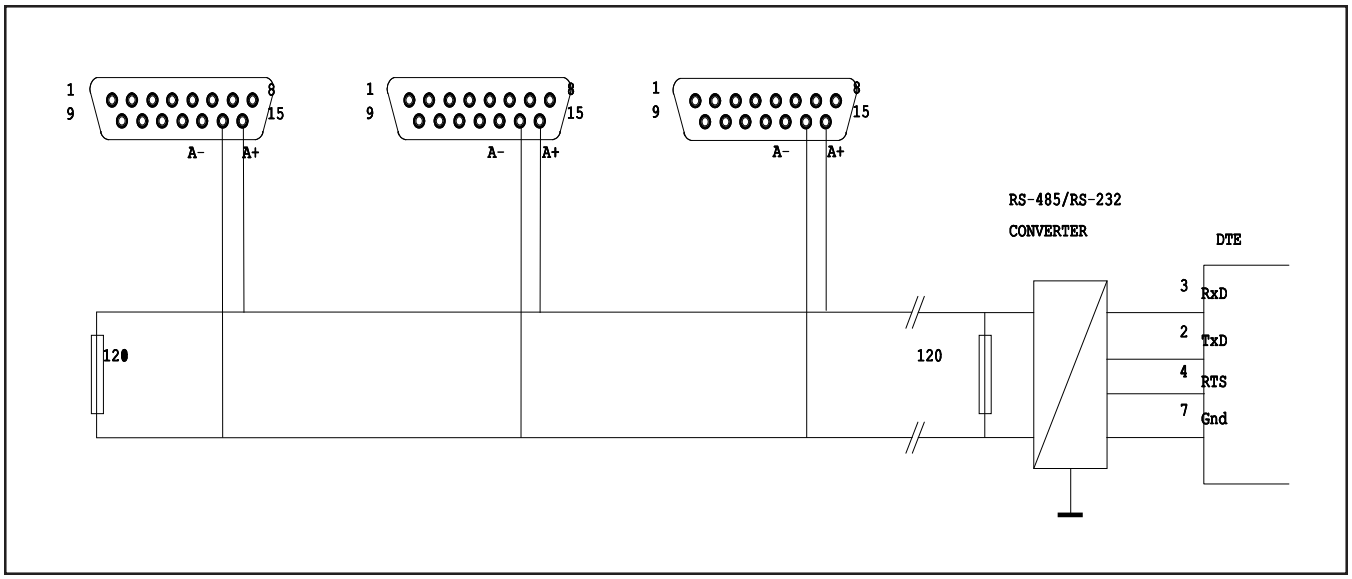

Figure 4-2 RS485 Multi Drop Interconnection DMFM/C and PC

Introduction

The A-protocol is a “master-slave” protocol: each message transaction is originated by the master (central) station, whereas the slave (field) device only replies when it receives a command message addressed to it. The reply from the slave device will acknowledge that the command has been received and it may contain the data requested by the master.

Request Message

The request message, sent from master to slave, consists of the fields indicated in Figure 5-1, these fields will be described in the sections below.

Figure 5-1 A-protocol Command Request Structure

Start Character

The start transmission character, [STX] 0x02, signals that a communication transaction is beginning.

Addressing Concept

The ID field is the unit network address set by software. The unit ID is a 2 byte ASCII field and indicates a hexadecimal number in the range 0x00-0x63 (0-100). ID 0x00 is used as a broadcast address. In case the broadcast address is used, all MFCs in the network will execute the command, but no MFCs will send a response. This doesn’t yield for commands SID and RID.

Command

The Command field consists of three ASCII bytes. Read commands start with R and the Set commands start with S. For more information on commands see Section 7 ID related commands, Section 8 Read commands and Section 9 Set commands.

Data

The Data field varies in length depending upon the command and will be empty if there is no data.

End Character

Carriage return is a single byte, [CR] 0x0D, which signals that thecommunication transaction is complete. If there is no data, [CR]immediately follows the command field.

Response Message

There are two possible responses to a transmission packet:

- a response that contains no data (an acknowledgement or negative acknowledgement)
- a response that contains data.

Response Without Data

OK (Acknowledgement)

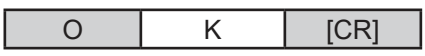

Figure 5-2 Positive Acknowledgement

If the response packet contains the 2 bytes ASCII text OK, then the transmission packet has been received and the command acknowledged.

NG (Negative Acknowledgement)

Figure 5-3 Negative Acknowledgement

If the response packet contains the 2 bytes ASCII text NG, then the transmission has not been received, or the transmission ordered or requested an action or reading that is out of parameters.

Response With Data

A data response contains both a Status field and a Data field

Figure 5-4 Response With Data

Status

The status field is a single ASCII byte, possible notations are:

N = No alarm or error
Z = Executing zero point calibration
A = Alarm exists
E = Error exists
X = Alarm(s) and error(s) exist

Note: The Status field is indicated as [Status] in the communication command tables starting at Section 7 ID Related Commands.

Data

The Data field contains the data requested by the read command.

Broadcast

It is possible to transmit the same command to all MFCs by using ID 0x00. All MFCs in the system, regardless of their network address, will execute the command, but none of the networked MFCs will send a response. The SID and RID commands are special in that they will address the device using the serial nr, passed along as data. Only the device with the specified serial number will respond, irrespective of the ID passed along with the command.

Start Communicating With Slave

In order to start communicating with a slave device the first thing to do is to retrieve the IDs of the connected devices. The RID command shall be used to perform this task. It accepts a serial number (max 12 digits) as data and the broadcast ID. This serial number is derived from the serial number of the device, it will contain the last 12 (or less) numerical [0..9] digits of the device's serial number.

Examples

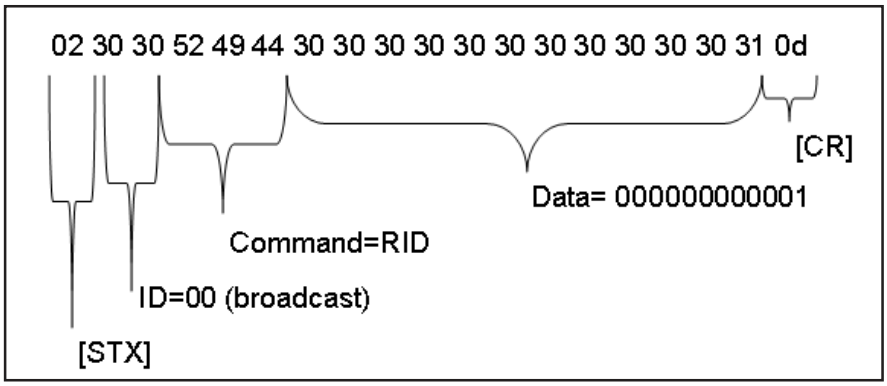

Figure 6-1 RID Command Request

Figure 6-1 RID Command Request shows the hexadecimal byte sequence of the RID command issued by a master application.

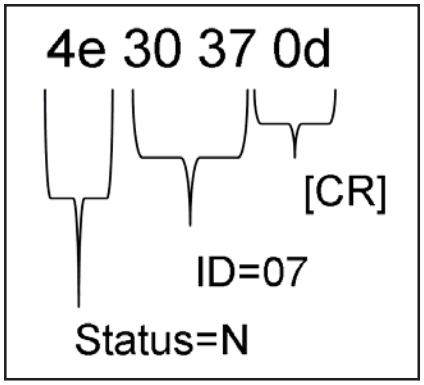

Figure 6-2 RID Command Response

Figure 6-2 RID Command Response shows the hexadecimal byte response transmitted by the slave device on the RID command request.

Table 7-1 ID and Serial Number Commands

Command	Command Descriptions
SID set unit ID	Sets the unit ID number. The ID consists of 2 ASCII bytes indicating a hexadecimal number in the range [0x00..0x63] (0-100). To set the unit ID, you must address the command to all MFCs on the network (ID field = 00) and enter the serial number followed by the new unit ID number. Format = [STX] 00**SID** [serial number [1]] [new two-digit unit ID] [CR] Response data = OK [CR]
RID read unit ID	Reads the unit ID number. The ID consists of 2 ASCII bytes indicating a hexadecimal number in the range [0x00..0x63] (0-100). To read the unit ID, you must address the command to all MFCs on the network (ID field = 00) and enter the serial number. Format = [STX] 00**RID** [serial number[1] [CR] Response data = [Status] xx [CR]
RSR read serial number	Read the serial number. Format = [STX] id**RSR** [CR] Response data = [serial number] [CR]

[1] This serial number is derived from the serial number of the device, it will contain the last 12 (or less) numerical [0..9] digits of the device's serial number.

Table 8-1 Read Commands

Command	READ Command Descriptions
RBR read baud rate	Reads the baud rate of the communication interface Format = [STX] id**RBR** [CR] Response data = [Status] x [CR] x=0 for baud rate is 9600 x=1 for baud rate is 19200 x=2 for baud rate is 38400
RVM read valve control mode	Reads the valve control mode (open, closed, or controlled). Format = [STX] id**RVM** [CR] Response data = [Status] x [CR] O = Valve open C = Valve closed N = Valve controlled by set point
RMD read set point mode	Reads the set point input mode (digital or analog). Format = [STX] id**RMD** [CR] Response data = [Status] x [CR] D = Digital mode A = Analog mode
RFX red flow output	Reads flow output as a percentage of full-scale flow. Range is from 0% to 100% (in 0.01% increments). Format = [STX] id**RFX** [CR] Response = [Status] [±xxxx]x.xx [CR]
RDC read set point	Range is from 0 to 100 (in 0.01 increments). Format = [STX] id**RDC** [CR] Response data = [Status] [xxxx]x.xx [CR]
RVD read valve voltage	Reads the valve voltage as a percentage of full rated valve voltage. Range is 0% to 100% (in 1% increments). Format = [STX] id**RVD** [CR] Response = [Status] xxx [CR]
RFK read user full scale flow	Reads the user full scale flow (in sccm). Format = [STX] id**RFK** [CR] Response data = [Status] [±xxxx]x.xx [CR]
RGN read gas name	Reads the gas name. Range is from 1 to 20 characters. Format = [STX] id**RGN** [CR] Response data = [Status] [1 to 20 characters] [CR]
RGT read gas table	Sets the gas table number. Range is from 1 to 8. Format = [STX] id**RGT** [CR] Response data = [Status] [1 to 8 characters] [CR]
RFW read flow alarm range	Reads the flow alarm range as a percentage of full-scale flow. Range is 0% to 98% (in 0.01% increments). Format = [STX] id**RFW** [CR] Response data = [Status] [±xxxx]x.xx [CR]
RFT read flow alarm latch time	Reads the flow alarm latch time. Range is 0 s to 99 s (in 1s increments). Format = [STX] id**RFT** [CR] Response data = [Status] xx [CR]

Table 8-1 Read Commands (Continued)

RFI read flow alarm state	Reads the flow alarm enable state. Format = [STX] id**RFI** [CR] Response data = [Status] x [CR] 0 = Disabled 1 = Enabled
RVA read flow alarm set point	Reads the valve alarm set point as a percentage of full-scale flow. Range is 0% to 100% (in 1% increments). Format = [STX] id**RVA** [CR] Response data = [Status] [xx]x [CR]
RVW read flow alarm bandwidth	Reads the valve alarm bandwidth as a percentage of full-scale flow. Range is 0% to 98% (in 1% increments). Format = [STX] id**RVW** [CR] Response data = [Status] [xx]x [CR]
RVT read valve alarm latch time	Reads the valve alarm latch time. Range is 0 s to 99 s (in 1s increments). Format = [STX] id**RVT** [CR] Response data = [Status] xx [CR]
RVI read flow alarm state	Reads the valve alarm enable state. Format = [STX] idRVI [CR] Response data = [Status] x [CR] 0 = Disabled 1 = Enabled
RAS read alarm status	Reads the alarm status. The response data is in a hexadecimal ASCII format representing bit flags. If a bit is set (i.e., = 1), then the corresponding condition is true. Format = [STX] idRAS [CR] Response data = [status] xx [CR] Bit 0 = Flow alarm high Bit 1 = Flow alarm low Bit 2 = Valve alarm high Bit 3 = Valve alarm low Bits 4 through 7 = Not used
RER read error status	Reads the error status. The response data is in a hexa-decimal ASCII format representing bit flags. If a bit is set (that is, = 1), then the corresponding condition is true. Format = [STX] idRER [CR] Response data = [status] xx [CR] Bit 0 = Communication error Bit 1 = None Bit 2 = EEPROM error Bit 3 = Zero Point Correction Error 1. Zero point deviation is > ±10% of the last calibrated value. Bit 4 = Zero Point Correction Error 2. Zero point deviation is > ±10% of the default value set at shipment. Bits 5 through 7 = Not used

Table 9-1 Set Commands

Command	READ Command Descriptions
SBR set the baud rate	Sets the baud rate of the communication interface Format = [STX] id**SBR** x[CR] Response data = OK[CR] x=0 for baud rate is 9600 x=1 for baud rate is 19200 x=2 for baud rate is 38400
SVO open valve	Sets the control valve fully open. Format = [STX] id**SVO** [CR] Response data = OK [CR]
SVC close valve	Sets the control valve fully closed. Format = [STX] id**SVO** [CR] Response data = OK [CR]
SVN enable valve control	Enables valve control. When valve control is enabled, flow is controlled by the set point (set by command SDC). Format = [STX] id**SVN** [CR] Response data = OK [CR]
SDM set digital set point control	Sets digital (RS-485 input) set point control mode. Format = [STX] id**SDM** [CR] Response data = OK [CR]
SAM set analog set point control	Sets analog (analog input) set point control mode. This mode is the default mode at reset. Format = [STX] id**SAM** [CR] Response data = OK [CR]
SDC set flow set point	Sets the flow set point as a percentage of full scale flow. Range is from 0 to 100 (in 0.01 increments). Format = [STX] id**SDC** [xxxx]x.xx [CR] Response data = OK [CR]
SZP start zero point adjustment	Starts the zero point adjustment function. Format = [STX] id**SZP** [CR] Response data = OK [CR] After the initial OK response, the MFC will reply to all status commands with a specially formatted message: Zxx [CR]. When the zero calibration is complete the reply ormat will return to normal (Nxx [CR]).
SGN set gas name	Sets the gas name. Range is from 1 to 20 characters. Format = [STX] id**SGN** [1 to 20 characters] [CR] Response data = OK [CR]
SGT set gas table	Sets the gas table number. Range is 1 to 8. Format = [STX] id**SGT** x [CR] Response data = OK [CR]
SAF enable flow alarm	Enables the flow alarm. Format = [STX] id**SAF** [CR] Response data = OK [CR]
SFI disable flow alarm	Disables the flow alarm. Format = [STX] id**SFI** [CR] Response data = OK [CR]

Table 9-1 Set Commands (Continued)

SFW set flow alarm range	Sets the flow alarm range as a percentage of full-scale flow. Range is 0% to 98% (in 0.01% increments). An alarm will occur when the flow is not within ±(range/2) of the alarm set point. Format = [STX] id**SRW** xx.xx [CR] Response data = OK [CR]
SFT set flow alarm latch time	Sets the flow alarm latch time. Range is 0 s to 99s (in 1 s increments). The alarm will not occur until the flow exceeds the specified limits for the flow alarm latch time period. Format = [STX] id**SFT** xx [CR] Response data = OK [CR]
SVA set valve alarm set point	Sets the valve alarm set point as a percentage of full scale flow. Range is 0% to 100% (in 1% increments). Format = [STX] id**SVA** xxx [CR] Response data = OK [CR]
SVW set valve alarm bandwidth	Sets the valve alarm bandwidth as a percentage of full-scale flow. Range is 0% to 98% (in 1% increments). The alarm will occur when the valve voltage is not within ±(bandwidth/2) of the valve alarm value. Format = [STX] id**SVW** xxx [CR] Response data = OK [CR]
SVT set valve alarm latch time	Sets the valve alarm latch time. Range is 0 s to 99s (in 1s increments). The alarm will not occur until the flow exceeds the specified limits for the flow alarm latch time period. Format = [STX] id**SVT** xx [CR] Response data = OK [CR]
SAC clear alarm(s)	Clears the flow alarm. Format = [STX] id**SAC** [CR] Response data = OK [CR]
SEC clear error(s)	Clears the error status. Format = [STX] id**SEC** [CR] Response data = OK [CR]
SAV enable valve alarm	Enables the valve alarm. Format = [STX] id**SAV** [CR] Response data = OK [CR]
SVI disable valve alarm	Disables the valve alarm. Format = [STX] id**SVI** [CR] Response data = OK [CR]

LIMITED WARRANTY

Visit www.BrooksInstrument.com for the terms and conditions of our limited warranty.

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.

SEMINARS AND TRAINING

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

Please contact your nearest sales representative for more details.

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

RS485-A-Protocol-GF40-GF80-EN/541B176AAG/2012-09

Global Headquarters
Brooks Instrument
407 West Vine Street
Hatfield, PA
19440-0903 USA

Toll-Free (USA): 888-554-FLOW
T: 215-362-3500
BrooksAM@BrooksInstrument.com

A list of all Brooks Instrument locations and contact details can be found at www.BrooksInstrument.com

BROOKS® INSTRUMENT
Beyond Measure