

**Multi Channel  
Flow Ratio/Pressure Controller**

**Type 647B**

**Instruction Manual**

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## 1. General

### 1.1 The Multi Gas Controller (MGC) Type 647B

The 647B is designed to control Mass Flow Controllers (MFC) with complex requirements to the process. It allows different configuration.

#### Warning



The safety instructions in this document must be kept. Please, take also a special note of all highlighted text in this document.

- Various master/slave configurations within several groups of channels.
- External control of mass flow controllers.
- Regulation of the pressure with a constant gas flow ratio.

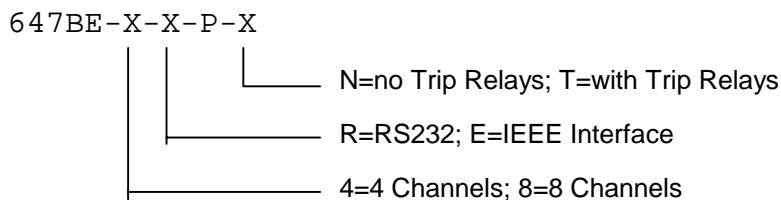
### 1.2 CE conformity

The device complies to the CE regulations and conformity is declared to the following standards:

- EN 55011 / 3.1991; Group 1; class B
- EN 50082-1 1992
- PrEN 50082-2 1992
- IEC 801-2, IEC 801-3, IEC 801-4
- EN 61010 ; 1993

### 1.3 Options

The following options are available for the 647B. Modules labeled with “(standard)” are part of the basic version:



(X = any available model code)

The basic version can be extended later on with every proper combination.

### 1.4 Software

This manual meets software version V2.2.

## 1.5 Technical Specifications

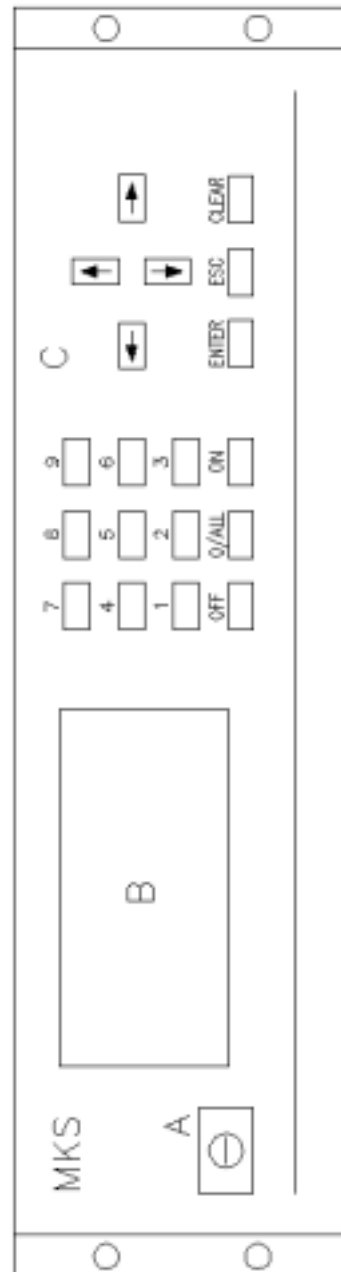
channels for gas flow <ul style="list-style-type: none"> <li>- max. number of channels</li> <li>- input voltage</li> <li>- output voltage</li> <li>- error range</li> <li>- temperature drift</li> </ul>	4 (optional 8) -0.5 ... 5.5 V -0.5 ... 5.5 V +/- 1 digit 0.075 % / °C (7)
pressure channel: <ul style="list-style-type: none"> <li>- input voltage</li> <li>- output voltage</li> <li>- resolution</li> <li>- error range</li> <li>- temperature drift</li> </ul>	max. 1 channel -0.5 ... 10 V -0.5 ... 5 V 16 bit +/- 3 digit 0.075 % / °C (7)
external setpoint	-0.5 ... 5.5 V
measuring rate output rate	20 Hz / channel 20 Hz / channel
operation temperature humidity	15 ... 40 °C (5) < 70 % (3) (4)
Power supply: <ul style="list-style-type: none"> <li>- voltage</li> <li>- fuse</li> <li>- frequency</li> <li>- consumed power</li> </ul> power supply for sensors: <ul style="list-style-type: none"> <li>- voltages</li> <li>- max. current per sensor</li> <li>- max. total current</li> </ul>	110/220 V; +/- 10 % F 5 A, 250 V (fast burn) 40 ... 70 Hz 300 W  +/- 15 V; +/- 5 % 500 mA (1) 4 A (2)
Dimensions Weight	19" x 3 HE x 342 mm (6) 8.8 kg 4 channel 9.2 kg 8 channel

- (1) Consider also the warming up period of the sensors.  
 (2) For all channels, i.e. gas flow and pressure  
 (3) Relative humidity within the specified temperature range.  
 (4) For use in closed heatable rooms, without condensation.  
 (5) Convective cooling is assumed.  
 (6) Without connectors.  
 (7) For max. signal, within the range of operation temperature.

Figure 1

## 1.6 Drawings

### 1.6.1 Front Panel



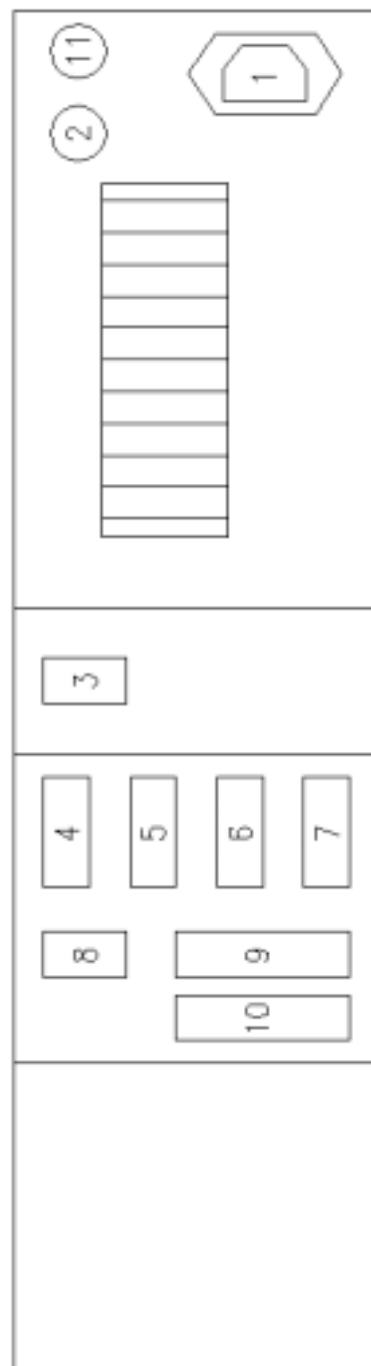
A = Key Switch

B = Monitor (LCD Display)

C = Keyboard

Figure 2

## 1.6.2 Rear Panel



1 = Power Supply Connector  
2 = Voltage Selector Switch  
3 = RS 232 Interface (IEEE optional)  
4 – 7 = Connectors for MFC's

Figure 3

8 = Connector PRESSURE for ext.  
pressure controller or transducer  
9 = Connector ACCESS  
10 = Connector RELAYS



---

## **1.7 Safety Information**

### **1.7.1 Symbols Used in this Instruction Manual**

Definitions of WARNING, CAUTION, and ATTENTION messages used throughout the manual.

---

#### **Warning**



The **WARNING** sign denotes a hazard. It calls attention to a procedure, practice, condition, or the like, which, if not correctly performed or adhered to, could result in injury to personnel.

---

---

#### **Caution**



The **CAUTION** sign denotes a hazard. It calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of all or part of the product.

---

---

#### **Attention**



The **NOTE** sign denotes important information. It calls attention to a procedure, practice, condition, or the like, which is essential to highlight.

---

## 1.7.2 Safety Instructions

**Attention:**

---

Please read this instruction carefully and follow it before using this device.

---

This device is state of the art and save. But danger may appear by the device, if not used according to the instructions or the professional knowledge.

Only spare parts of the manufacturer may be used for replacements.

The device must not be used in explosive environments.

Safety and reliability is only given in the following cases:

- the device is used according to the manual
- the device is serviced by personel of the manufacturer only.
- The installation of the device complies th the national derectives and standards.

Cleaning of the device must performed, if it is desconnected from power supply and if the cleaning is performed dry.

**Warning**

---

The device may be opened by MKS service personel only. If the device is open, danger for life (by high voltage) may occur.

---

## 1.8 Installation

The device must be used in a dry and heated room (see ambient temperature).

The device produces heat due to the power consumption. In order to avoid overheating the opening of the fan and all other openings in the case must not be closed. Air must circulate through this openings without any blocking.

**Attention:**

---

The correct setting of the power voltage setting must be checked before power is applied to the device.

---

Follow the steps below. For installation of the device:

- Hook the device to the power plug. If you use a transformer, it must be able to supply 300 Watt.
- Hook the instruments to the device, according to the pinout of the connectors or use the appropriate cables.
- Switch the device on, and perform the setup in the menues INSTRUMENT SETUP and SYSTEM SETUP.  
If the digital interface is used (RS232, IEEE), the setup in the SYSTEM SETUP menu is of special importance.

- If you have problems booting the system, you should read the chapter “Reset of System” and “Applications of the 647B”.

## **1.9 Symbols at the case**

The device shows some symbols, which are explained here:

- The “!” (⚠) says to watch the documentation/manual.
- The type label gives information about the device type, the serial number and some technical data.
- The label close to the fuse holder tells the specification of spare fuses: F 5A, 250V.

## **1.10 Accessories**

The 647B comes with the following accessories:

- Sub-D connector sets for the instruments:

4 channel device:	ZB-19
8 channel device:	ZB-20
- Power cable: Y-0984492
- Manual: Y-1957647
- 2\*handles for the case: Y-5150011
- 4\*screws for the handles: Y-1600005

## **1.11 Cables**

Refer to the instruction manuals of the respective mass flow meters, mass flow controllers and pressure transducers for cable information.

## **1.12 Service**

In case of problems or failure of the device, please contact your local MKS representative. The last page of this manual contains a list of service and calibration centers.

## 2. Operating Instructions

### 2.1 The User Interface

The device is operated via menus. A menu consists of submenus, input fields or display fields. Submenus can be reached by typing the number labeling them on the screen or selecting them with the cursor and typing <0>. They can be exited pressing the <ESC> button. Input fields are highlighted by a cursor frame, when they are selected for input. Using the cursor keys different input fields can be selected (i.e. the cursor keys move the cursor on the screen). The input fields allow values to be edited or selected by scrolling up and down through a table. In some cases certain input fields are not active.

The top line of the screen (title) displays the device type (MGC = **M**ulti **G**as **C**ontroller) and software version. The status line on the bottom of the screen displays the number of errors, the status of the main valve and the input status of the keyboard (see also MAIN MENU).

MGC	647B	V2.2	← title
(1)	<u>USER DISPLAY</u>		
(2)	EXTENDED DISPLAY		
(3)	PRESSURE CONTROL		
(4)	DIAGNOSTICS		
(5)	INSTRUMENT SETUP		← datafield
(6)	SYSTEM SETUP		
(7)	PRESSURE SETUP		
(9)	INFORMATION		
00 ERRORS	FLOW OFF	INPUT DIRECT	← statusline

(comment: the cursor is shown as underline in this document)

Figure 4

If errors occurred, detailed error descriptions are available through the menu ERROR LISTING, see page 15.

In order to turn off all gas flows at once there are the main valve functions. The main valve is switched on with the key combination <ON><ALL> and switched off with key combination <OFF><ALL>. The current state of the main valve is displayed as FLOW ON (open) and FLOW OFF (closed), respectively.

The state of the keyboard is displayed in the "INPUT" field of the status line.

DIRECT	= input from keyboard enabled
ON	= last input was <ON>
OFF	= last input was <OFF>
LOCKED	= The keyboard is locked through RS232 or IEEE
MEMORY	= A stored gas menu is active

In the 8 channel version, it is not possible to display all channels simultaneously on the display. Therefore it is possible to scroll through the channels display horizontally.

## **2.2 The Menu Tree**

MAIN MENU

```

|
|-- (1) USER DISPLAY
|
|-- (2) EXTENDED DISPLAY
|
|-- (3) PRESSURE CONTROL
|
|-- (4) DIAGNOSTICS
|       |
|       |-- (4.1) ERROR LISTING
|       |
|       •-- (4.2) SIGNALS
|
|-- (5) INSTRUMENT SETUP
|       |
|       |-- (5.1) RANGE SELECTION
|       |
|       |-- (5.2) GAS SELECTION
|       |
|       |-- (5.3) MODE SELECTION
|       |
|       |-- (5.4) ZERO ADJUST
|       |
|       |-- (5.5) TRIP LIMITS
|       |
|       •-- (5.6) GAS COMPOSITION
|
|-- (6) SYSTEM SETUP
|
|-- (7) PRESSURE SETUP
|
•-- (8) INFORMATION

```

Figure 5

## **2.3 Reset of System**

There are four types of Reset:

- First Start Reset
- Power Up Reset
- Hardware Reset
- Reset to Default

---

**Attention:**

All of the above resets will switch off all gas flow controllers.

---

**First Start Reset** will appear if the system is started for the first time or if the RAM has been replaced. This has usually already taken place at the factory. All data in the RAM are initialized with this reset. A quick tap on keys <7> and <9> will force the system to First Start Reset.

If the device refuses to come up on power on, press button <8> while switching the device on in order to perform a total reset (equal to First Start Reset). This problem can have 2 reasons:

- Data in memory was destroyed through a transient. The described procedure will fix this problem.
- There is an error in the hardware. If the Start Up problem occurs more than once contact your local MKS service center.

**Power Up Reset** is performed everytime the system is switched on. It resets all data which are needed for system administration. Data of process parameters are not affected.

**Hardware Reset** is similar to Power Up Reset. It is triggered by the keys <OFF> and <cursor right> pressed at the same time. In any case Power Up or Hardware Reset leads to the MAIN MENU.

**Reset to Default** sets all process parameters to their default value. This reset is triggered in SYSTEM SETUP menu.

After the device has been turned off, one should wait for ca. 15 seconds before turning it on again.

## **2.4 Display adjustment**

The viewing angle of the LCD display and the timeout setting of its back light saver, may be set in SYSTEM BACKUP menu.

### 3. Functionality

#### 3.1 The MAIN MENU

After turning on the power switch (1) the MAIN MENU is displayed. From this menu the different submenus are accessible. (See also figure 4).

#### 3.2 The USER DISPLAY menu

MGC		647B		V2.2	
CH1	CH2	CH3	CH4		
0.000	1.750	1.400	0.000		
SCCM	SCCM	SLM	SLM		
CH5	CH6	CH7	CH8		
0.000	0.000	0.000	0.000		
SLM	SCCM	SCCM	SCCM		
PRESSURE	0000.0 mbar				
TOTAL FLOW:	001.4	SLM		GAS MENU:	<u>X</u>
00 ERRORS		FLOW ON		INPUT DIRECT	

Figure 6

The USER DISPLAY menu allows monitoring the system during operation. It displays all gas flows of the connected Mass Flow Controllers.

All gas flow values are displayed in a 4 digit format without limiting the resolution. Additionally the physical unit of the gas flow is shown below. The sum of all gas flow values (TOTAL FLOW) is displayed additionally. The unit of the total flow can be selected through the keyboard.

The user can select one out of five predefined composition ratios (see also GAS COMPOSITION menu) through the GAS MENU parameter. The stored composition ratios are labeled with numbers 1 to 5. X means that none of the stored ratios is activated. In this case the setpoints for the mass flow controllers are the ones defined in EXTENDED DISPLAY.

The displayed value of TOTAL FLOW is the sum of all single gas flows. Because flow units of different decades (e.g. SCCM and SLM) are added, it might come to discrepancies between the two displays, which are due to rounding errors. Step through the flow units of the TOTAL FLOW, in order to optimize TOTAL FLOW display.

Since negative flow values are not added to TOTAL FLOW, channels which are turned off can not cause errors.

### 3.3 The EXTENDED DISPLAY menu

MGC	647B			V2.2
	CH1	CH2	CH3	CH4
ACT.FLOW	0.000	1.750	1.400	0.000
SETPOINT	4.500	1.750	1.400	0.728
UNIT	SCCM	SCCM	SLM	SLM
RANGE FS.	5.000	5.000	1.4000	1.450
GAS	USER	AIR	CO <sub>2</sub>	He
MODE	INDEP.	INDEP.	INDEP.	SLAVE
STATUS	OFF	ON	ON	ON
PRESSURE	0000.0 mbar			
00 ERRORS	FLOW ON		INPUT DIRECT	

Figure 7

The EXTENDED DISPLAY menu allows controlling the system before and during operation. It contains the most important information needed to control the system.

Here the setpoints of all channels can be set and changed. The setpoints are selected by using the cursor keys. The input is done either numerically by typing in the values or by scrolling using the cursor keys. If MEMORY is displayed in the INPUT field of the status line, a predefined gas menu has been selected in the previously described USER DISPLAY menu. In this case the set points of the channels cannot be changed.

Due to instabilities at the lower end of MFC range, the lowest setpoint is limited to 1%. Setpoints less than that are displayed as zero and an output value of -0.5 V is transferred to the MFC.

The displayed full scale ranges (RANGE FS.) are the ranges of each controller scaled with the gas correction factors. E.g. channel 4 controls a MFC with a range of 1 slm, calibrated in nitrogen. The regulated gas is helium and has a correction factor of 1.450 with respect to the calibration gas nitrogen, i.e. the actual full scale range is: RANGE FS. = 1 \* 1.45 = 1.45 slm.

The actual gas flow of each channel is displayed in the line ACT.FLOW. Here the correction factors and ranges of the selected gases are also automatically taken into account. Values higher than 110% are displayed as an overflow through dashes: "-.---". The lowest displayed flow value is -10%. (See also Zero Adjust).

Typing <ON><x> turns on the valve of channel x and causes its set point to be sent to the mass flow controller. In addition to provide the possibility of turning on and off all controllers at the same time, there is the switch <ON/OFF><ALL>. The green LED (GAS ON) indicates that at least one mass flow controller is active.

A blinking red LED indicates that the software is working without problems (STAND BY).



### 3.4 The PRESSURE CONTROL menu

MGC		647B		V2.2	
CH1	0.000	CH2	1.750	CH3	1.400
				CH4	0.000
CH5	0.000	CH6	0.000	CH7	0.000
				CH8	0.000
GAIN	01.00	PRESSURE		UNIT	
INTEG	02.00			Torr	
LEAD	00.30		0.3501		
			SETPOINT	MODE	
PCS	0.467		0.3500	OFF	
00 ERRORS		FLOW ON		INPUT DIRECT	

Figure 8

The PRESSURE CONTROL menu displays the actual flows and the actual pressure with its unit. During an application with an external pressure controller, the corrective action is also shown in PCS (Pressure Control Signal).

The pressure is controllable through the pressure setpoint and the two pressure modes:

- OFF - set point for pressure regulation is turned off.
- AUTO - set point for pressure regulation is turned on.

All parameters are edited as usual.

### 3.5 Tuning the PID Controller

There are three additional parameters to setup the PID algorithm, with the PID optional only.

The best procedure to tune the PID controller, is to make the step response of the application, evaluate the parameters dead time (Tt) and rise time (Ts) and then calculate the PID parameters.

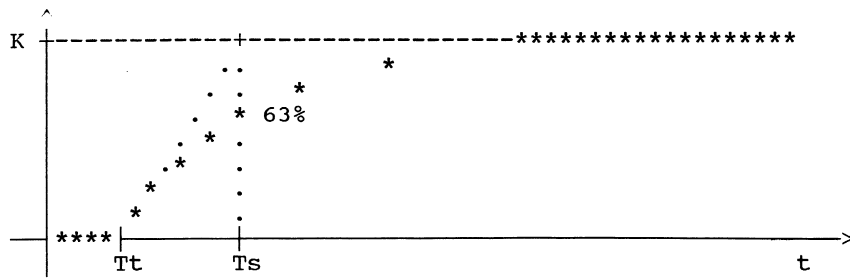


Figure 9

tuning for optimal step response:

- gain =  $0.6 / K$
- integral action =  $1 * Ts$
- lead =  $0.5 * Tt$

tuning for optimal disturbance response:

- gain =  $0.95 / K$
- integral action =  $2.4 * Ts$
- lead =  $0.42 * Tt$

K is the relation of actual pressure to actual total flow, both are to be taken as percent of full scale.

To improve the speed of your application, first increase the value of the gain parameter, then change the integral action.

If you cannot record a step response of your process, it is also possible to estimate the necessary values. Measure the time between the opening of the valves and the beginning change of the actual pressure as  $Tt$ . Then measure the time until pressure has gained 63% of the final pressure value.

Configuration of an Application:

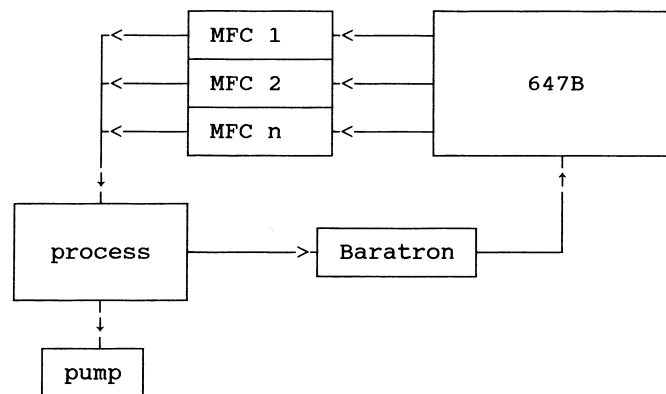


Figure 10

## 3.6 Diagnosis of System

### 3.6.1 The ERROR LISTING menu

If the status line indicates the occurrence of errors, details about these errors and the affected channels can be retrieved from the ERROR LISTING menu.

MGC	647B	V2.2
ERROR LISTING	CHANNELS	
TRIP LOW LIMIT	12	
TRIP HIGH LIMIT	2	
INPUT OVERFLOW		
INPUT UNDERFLOW		
OUTPUT OVERFLOW		
OUTPUT UNDERFLOW		
LIST MODE <u>HISTORY</u>		
03 ERRORS	FLOW ON	INPUT DIRECT

Figure 11

Error messages:

- TRIP LOW LIMIT  
The actual flow is lower than the low limit. (see also TRIP LIMITS menu, page 22)
- TRIP HIGH LIMIT  
The actual flow is higher than the high limit. (see also TRIP LIMITS menu, page 22)
- INPUT OVERFLOW / INPUT UNDERFLOW  
The input signal of the displayed channel is higher than 10V or lower than -10V.
- OUTPUT OVERFLOW / OUTPUT UNDERFLOW  
The output signal is higher than 10 V or lower than -10V.  
Since the calculated value cannot be transmitted to the controller, this can disturb the regulation behavior of closed loops.

Two display modes are possible in ERROR LISTING. The HISTORY mode stores all errors having occurred until leaving the error listing. In the ACTUAL mode only actual valid errors are displayed.

### 3.6.2 The SIGNALS menu

MGC	647B	V2.2
	OUTPUT	INPUT
CH1	-00250	-0250
CH2	001746	01746
CH3	005002	05002
CH4	-00500	-0500
CH5	-00500	-0500
CH6	-00500	-0500
CH7	-00500	-0500
CH8	-00500	-0500
PRES	-00250	-0015
PCS		-0250
SIGNAL PROCESSING <u>RUNNING</u>		
00 ERRORS	FLOW ON	INPUT DIRECT

Figure 12

#### Attention:



When stopping signal processing the process is also stopped.

This menu is designed for test and maintenance purposes only. It displays all signals of the interface to the process. The display unit is mV. It is possible to enter setpoints in mV directly, if the signal processing is stopped. If you leave the signals menu then signal processing is restarted. This avoids problems concerning general 647B usage.

### 3.7 Instrument Setup

MGC	647B	V2.2
(1)	<u>RANGE SELECTION</u>	
(2)	GAS SELECTION	
(3)	MODE SELECTION	
(4)	ZERO ADJUST	
(5)	TRIP LIMITS	
(6)	GAS COMPOSITION	
00 ERRORS	FLOW ON	INPUT DIRECT

Figure 13

The instrument setup contains all parameters which are related to the process.

### 3.7.1 Range Selection

MGC	647B			V2.2
	CH1	CH2	CH3	CH4
ACT.FLOW	0.000	1.750	1.400	0.000
UNIT	SCCM	SCCM	SLM	SLM
RANGE FS.	<u>5.000</u>	5.000	2.000	1.000
STATUS	OFF	ON	ON	ON
00 ERRORS	FLOW ON		INPUT DIRECT	

Figure 14

The following ranges are available:

1 sccm,	2 sccm,	5 sccm,		
10 sccm,	20 sccm,	50 sccm,		
100 sccm,	200 sccm,	500 sccm,		
1 slm,	2 slm,	5 slm,		
10 slm,	20 slm,	30 slm,	50 slm,	
100 slm,	200 slm,	300 slm,	400 slm,	500slm,
1 scmm,				
1 scfh,	2 scfh,	5 scfh,		
10 scfh,	20 scfh,	50 scfh,		
100 scfh,	200 scfh,	500 scfh,		
1 scfm,	2 scfm,	5 scfm,		
10 scfm,	20 scfm,	50 scfm,		
100 scfm,	200 scfm,	500 scfm,		

sccm	=	standard cubic centimeter per minute
slm	=	standard cubic liter per minute
scmm	=	standard cubic meter per minute
scfh	=	standard cubic feet per hour
scfm	=	standard cubic feet per minute

### 3.7.2 Gas Selection

MGC	647B			V2.2
	CH1	CH2	CH3	CH4
ACT. FLOW	0.000	1.750	1.400	0.000
UNIT	SCCM	SCCM	SLM	SLM
GAS	USER	AIR	CO <sub>2</sub>	He
FACTOR	1.000	1.000	0.700	1.450
STATUS	OFF	ON	ON	ON
00 ERRORS	FLOW ON		INPUT DIRECT	

Figure 15

This menu contains the table of Gas Correction Factors (GCF) for mass flow controllers, which are calibrated in nitrogen under standard conditions (DIN 1871). In this case standard pressure means 1013 mbar and standard temperature is 0 degree centigrade.

The cursor keys (UP/DOWN) are used to scroll through the table entries of each channel.

For gases which are not included in the table, there is the position USER, which allows a direct numerical input of the GCF of any gas. For a description how to calculate GCF see the manual of the mass flow controllers. A direct numerical input of the GCF is also allowed for the gases helium and hydrogen, which are normally calibrated directly with these gases.

The 647B automatically calculates the actual range of each mass flow controller (RANGE FS.) from the product GCF x RANGE. E.g. for a flow controller, which is calibrated in 1 slm nitrogen, at a correction factor of 0.72 (methane) the actual flow range (RANGE FS.) displayed in EXTENDED DISPLAY menu is 0.720 slm.

### 3.7.3 Mode Selection

MGC	647B			V2.2
	CH1	CH2	CH3	CH4
ACT.FLOW	0.000	1.750	1.400	0.000
UNIT	SCCM	SCCM	SLM	SLM
MODE INDEX	<u>INDEP.</u>	INDEP.	INDEP.	SLAVE 1
STATUS	OFF	ON	ON	ON
00 ERRORS	FLOW ON		INPUT DIRECT	

Figure 16

The Mode Selection defines the source of setpoint for each MFC channel. Possible modes are:

- INDEP = independent
- SLAVE = dependent to the actual flow of another channel
- EXTERN = external source for setpoint
- PCS = external controller
- PID = built in PID controller
- TEST = test for maintenance and installation

#### 3.7.3.1 Independent Mode

In the independent mode a MFC is driven by the entered setpoint which is constant.

#### 3.7.3.2 Slave Mode

In the Master/Slave configuration the ratio between the setpoints of the slaves and the setpoint of the master is kept at the selected ratio of gas composition. If the setpoint of the master is changed, the 647B also changes the setpoints for the slaves according to this ratio. Additionally in this mode the master channel governs the gas flows of the slave channels. I.e. the setpoints for the slave channels are calculated from the ACTUAL FLOW of the master channel according to the desired composition ratio and transmitted to the controllers, instead of the setpoints displayed on the screen. If, for instance, the gas flow of the master decreases because of a fault in the process, the gas flows of the slaves are also brought down, as can be seen from the ACT.FLOW display. If the gas flow of a slave is disturbed, however, the composition ratio for this channel is incorrect.

E.g. a ratio of 5:1 (master:slave) means:

$$\text{Setpoint of slave} = \text{act. flow of master} * 0.2$$

The master channel is determined by the index which is associated with the slave channel. The advantages hereby are that the master remains free for declaration in other modes and more than one master is possible. With this declaration technique, however, useless circular reference chains, which might even be dangerous for the application, could appear. In order to avoid this, the software checks out each input and rejects it if necessary. Therefore, this solution offers full advantages without risks.

Example 1: (menu extract)

	CH1	CH2	CH3	CH4
MODE	INDEP.	SLAVE	SLAVE	INDEP.
INDEX		1	2	

In this example channel 1 is master of channel 2, which is master of channel 3. This is an open reference chain. The index number of a slave indicates its master channel. This declaration technique applied to channel 2 as master has the advantage, that this channel may be declared as slave while being a master. Channel 4 is independent.

Example 2: (menu extract)

	CH1	CH2	CH3	CH4
MODE	SLAVE	SLAVE	SLAVE	INDEP.
INDEX	3	1	2	

This example shows a circular reference chain, which will never appear on 647B screen. The software prevents its appearance by consequently rejecting wrong input. This is the reason why some of the user's input might be rejected.

### 3.7.3.3 External Mode

This mode enables external control of the MFCs through the auxiliary connector. The MFC's setpoint is calculated as the product of setpoint in menu EXTENDED MENU and the signal at the auxiliary input. E.g.

$$\text{Setpoint of MFC} = \text{setpoint in EXTENDED MENU} * \text{auxiliary input} / 5 \text{ V}$$

### 3.7.3.4 PCS Mode

In the PRESSURE CONTROL mode (PCS) the 647B serves as the regulating unit for a pressure controller (e.g. type 250). All gas flow channels which are configured in the PCS mode are regulated through the pressure control signal (PCS) according to the ratio of their set points.



### 3.7.3.5 PID Mode

In this mode MFCs are driven by a PID algorithm (see also menu: PRESSURE CONTROL). This mode is only available with the PID option.

### 3.7.3.6 Test Mode

In this mode the 647B generates a test signal, which may be useful for installation procedures. The test signal is a saw tooth between zero and 100% with a period of 4 sec.

### 3.7.4 Zero Adjustment

MGC	647B			V2.2
	CH1	CH2	CH3	CH4
ACT.FLOW	0.000	1.750	1.400	0.000
UNIT	SCCM	SCCM	SLM	SLM
ZERO VALUE	0.005	-.004	0.002	-.002
ZERO ADJUST	<u>EXEC</u>	EXEC	EXEC	EXEC
STATUS	OFF	ON	ON	ON
00 ERRORS	FLOW ON		INPUT DIRECT	

Figure 17

To trigger the Auto Zero function, the status needs to be changed from EXEC (executable) to ACT (active) through the cursor keys. The status DONE or FAIL displays the completion of the function. The status FAIL indicates that the offset was too large and a new zero value was not generated. FAIL status may also appear if the channel is switched on. The status ACT appears on the screen for a very short time, so that it is usually not noticed.

The measured value (the zero offset of the sensor of the mass flow controller) is displayed in the field ZERO VALUE. In order to correct the zero offset, this value is subtracted from actual flow and added to the setpoint output. This way the controller gets a corrected setpoint and thus equalizing the sensor signal's error.

If necessary, one can enter the zero offset directly.

### 3.7.5 Trip Limit Supervision

MGC	647B				V2.2
	CH1	CH2	CH3	CH4	
ACT.FLOW	0.000	1.750	1.400	0.000	
UNIT	SCCM	SCCM	SLM	SLM	
MIN.LIMIT	3.000	0.750	0.000	0.000	
MAX.LIMIT	4.000	0.250	1.400	1.450	
SUPERVIS.	<u>LIMIT</u>	BAND	SLEEP	SLEEP	
STATUS	OFF	ON	ON	ON	
00 ERRORS	FLOW ON		INPUT DIRECT		

Figure 18

There are three modes to supervise the process.

- SLEEP mode
- LIMIT mode
- BAND mode

In SLEEP mode no supervision is performed. In LIMIT mode the actual flow is supervised to remain between the trip limits. If the actual flow exceeds the high limit or falls below the low limit an error will be generated. The limits are considered as absolute values. The BAND mode is similar to LIMIT mode, but the limits are considered as deviation to the setpoint. The low limit represents negative deviation.

The supervision becomes active 1 second after the selection of a mode.

Two relays are driven by each channel, if the Relay Option is used. The logic of the relays depends on the actual Supervision Mode:

- SLEEP mode  
In this mode relay 1 represents the status of the channels's valve. Relay 2 is idle.
- BAND mode  
In this mode relay 1 also represents the status of the channel's valve. Relay 2, however, will become active if the actual flow is outside of the defined band.
- LIMIT mode  
If the actual flow is below low limit, relay 1 will become active, and if it is above high limit relay 2 will become active.

Truth Table:

Mode	Relay #	Valve	Low limit	High limit	Relay status
SLEEP	1	OFF	X	X	inactive
SLEEP	1	ON	X	X	active
SLEEP	2	X	X	X	inactive
BAND	1	OFF	X	X	inactive
BAND	1	ON	X	X	active
BAND	2	X	not exceeded	not exceeded	inactive
BAND	2	X	X	exceeded	active
BAND	2	X	exceeded	X	active
LIMIT	1	X	not exceeded	X	inactive
LIMIT	1	X	exceeded	X	active
LIMIT	2	X	X	not exceeded	inactive
LIMIT	2	X	X	exceeded	active

X = any condition

Figure 19

### 3.7.6 Gas Composition

MGC	647B			V2.2
	CH1	CH2	CH3	CH4
SET 1	1.000	1.700	0.000	0.000
SET 2	1.010	1.750	0.000	0.000
SET 3	1.020	1.800	0.000	0.000
SET 4	1.040	1.850	0.000	0.000
SET 5	<u>0.000</u>	0.000	0.000	0.000
UNIT	SCCM	SCCM	SLM	SLM
STATUS	OFF	ON	ON	ON
00 ERRORS	FLOW ON		INPUT DIRECT	

Figure 20

Up to 5 different gas compositions (SET 1 to SET 5) can be defined here, which can be selected in the menu USER DISPLAY through the item GAS MENU.

## 3.8 System Setup

### 3.8.1 IEEE 488 Setup

MGC	647B	V2.2
ADDRESS	13	
RESPONSE MODE	<u>REPEAT</u>	
INTERFACE STATUS	--- ---	
LCD VIEW ANGLE [°]	023	
LCD ON TIME [min]	010	
HOST MODE	C-MODE	
RESET	EXEC	
00 ERRORS	FLOW OFF	INPUT DIRECT

Figure 21

This menu is available instead of RS232 setup, if the IEEE option is installed only.

The IEEE interface is designed to meet the functional requirements for talker and listener functional requirements as specified by IEEE Standard 488-1978.

Functional capabilities:

- SH1                source handshake
- AH1                acceptor handshake
- L3                  listener
- T5                  talker
- RL1                remote/local
- DC1                device/clear

The implemented commands are the same as in a RS232 device.

#### 3.8.1.1 IEEE Address

The address setup specifies the IEEE address of the device. Possible addresses range from 0 to 30. An address value may only be used once in a bus system.

### 3.8.1.2 Response Modes

There are three modes, that specify the 647B's reaction to a data request of the bus controller.

- QUIET
- POLLING
- REPEAT

In the QUIET mode, the 647B only responds to a command if data are pending. There is no response if errors occur or if a command results in no data at all.

In the POLLING mode each command results in a response. Either data, an error string or an empty acknowledge (i.e. <CR><LF>) is sent back to the controller.

Both modes QUIET and POLLING do not respond if there has been no request through a previous command.

The REPEAT mode is similar to POLLING, but it responds to each data request of the bus controller. If the controller has not sent a command before the request, the 647B repeats the last given command. If there has been no last command e.g. after power up, the command "ID" is performed.

### 3.8.1.3 Interface Status

The interface status displays two flags, the address status and the communication status.

- address status: ---, TLK, LSN
- communication status: ---, RMT, LLO

TLK means that the device is addressed as talker, LSN means an addressing as listener. Three dashes (---) are displayed if any other device is addressed.

The bus controller is able to set the device to remote (RMT) or local (---) status. If the device is in remote status it is not possible to operate it through the keyboard, but it can be switched back to local by the <ESC> key until the next command appears. If the device is set to local lockout (LLO) status by the controller there is no reset to local status through the keyboard possible.

Regardless of the IEEE status, the keyboard is also disabled by the command "KD" and enabled by "KE". In order to work with the keyboard it must be enabled from command level (i.e. "KE") and bus level (i.e. local).

The status is updated 5 times a second, but as the communication could be faster than that, it is possible that not all changes of status will be visible.

### 3.8.1.4 Examples

The following examples show the usage of a 647B through the IEEE interface. The examples are given in HP85 basic.

Program to display the act. flow of channel 1 using QUIET mode:

```

10 LOCAL 7 ! keyboard remains enabled
20 OUTPUT 713; "ID" ! request for the advice ID
30 ENTER 713; A$ ! bus request for ID data
40 DISP A$ ! display ID on the HP85 screen
50 OUTPUT 713; "FS 1 0500" ! set setpoint to 50%
60 OUTPUT 713; "ON 1" ! switch channel on
70 OUTPUT 713; "ON 0" ! ditto
80 OUTPUT 713; "FL 1" ! request of 1st channels act.flow
90 ENTER 713; A$ ! bus request
100 DISP A$ ! display of act.flow
110 GOTO 80 ! repeat act flow request

```

Same program but with REPEAT mode and keyboard disabled:

```

10 REMOTE 7 ! keyboard remains enabled
20 OUTPUT 713; "ID" ! request for the advice ID
30 OUTPUT 713; "FS 1 0500" ! bus request for ID data
40 OUTPUT 713; "ON 1" ! switch channel on
50 OUTPUT 713; "ON 0" ! ditto
60 OUTPUT 713; "FL 1" ! request of 1st channels act.flow
70 WAIT 1000 ! wait until commands are accepted
80 ENTER 713; A$ ! bus request
90 DISP A$ ! display of act.flow
100 GOTO 80 ! repeat act flow request

```

For interface language see chapter Remote Control

### 3.8.2 RS232 Setup

MGC	647B	V2.2
BAUDRATE	9600	
PARITY	ODD	
BITS	8 bit	
STOPBITS	1 bit	
HANDSHAKE	NONE	
RS232 STATUS	-- -- --	
LCD VIEW ANGLE [°]	023	
LCD ON TIME [min]	010	
HOST MODE	C-MODE	
RESET	EXEC	
00 ERRORS	FLOW OFF	INPUT DIRECT

Figure 22

The 647B implements a standard V24, RS232 interface with standard parameters.

### 3.8.2.1 Baudrate

The baudrate defines the transfer speed of characters on the line. The transfer rate of commands and data is determined by this baudrate and by the processing speed of 647B. The first 30 commands will be directed to a buffer at maximum speed, while the transfer of further commands is controlled by a handshake protocol. The baudrate must fit to the baudrate of the host computer.

- supported baud rates:  
50, 75, 110, 150, 300, 600, 1200,  
1800, 2000, 2400, 3600, 4800, 7200, 9600 Baud

### 3.8.2.2 Data Link Parameters

The data link parameters must fit to setup of the host computer. Change it according to the setup of the host.

- word length  
7 bit  
8 bit
- parity  
NONE  
EVEN  
ODD
- stop bits  
1 bit  
2 bit

### 3.8.2.3 Handshake Protocol

The handshake protocol synchronizes different processing speeds of 647B and host computer. If the receiving device is busy with calculating and therefore not ready to accept more data it stops the transfer through a handshake protocol. The 647B can accept 30 commands at maximum speed until it stops the transfer.

There are three kinds of handshake modes for the communication with the host computer:

- no handshake
- software handshake (XON, XOFF)
- hardware handshake (RTS, CTS)

The usage of one of the above modes depends on the connection to the computer. If the communication is run without handshake and the calculating speed do not match, loss of data may appear.

### 3.8.2.4 Interface Connections

When the 647B software is booting (e.g. at power on or hardware reset) it detects the handshake mode through the cable type on the RS232 line. This mode is displayed in the menu.

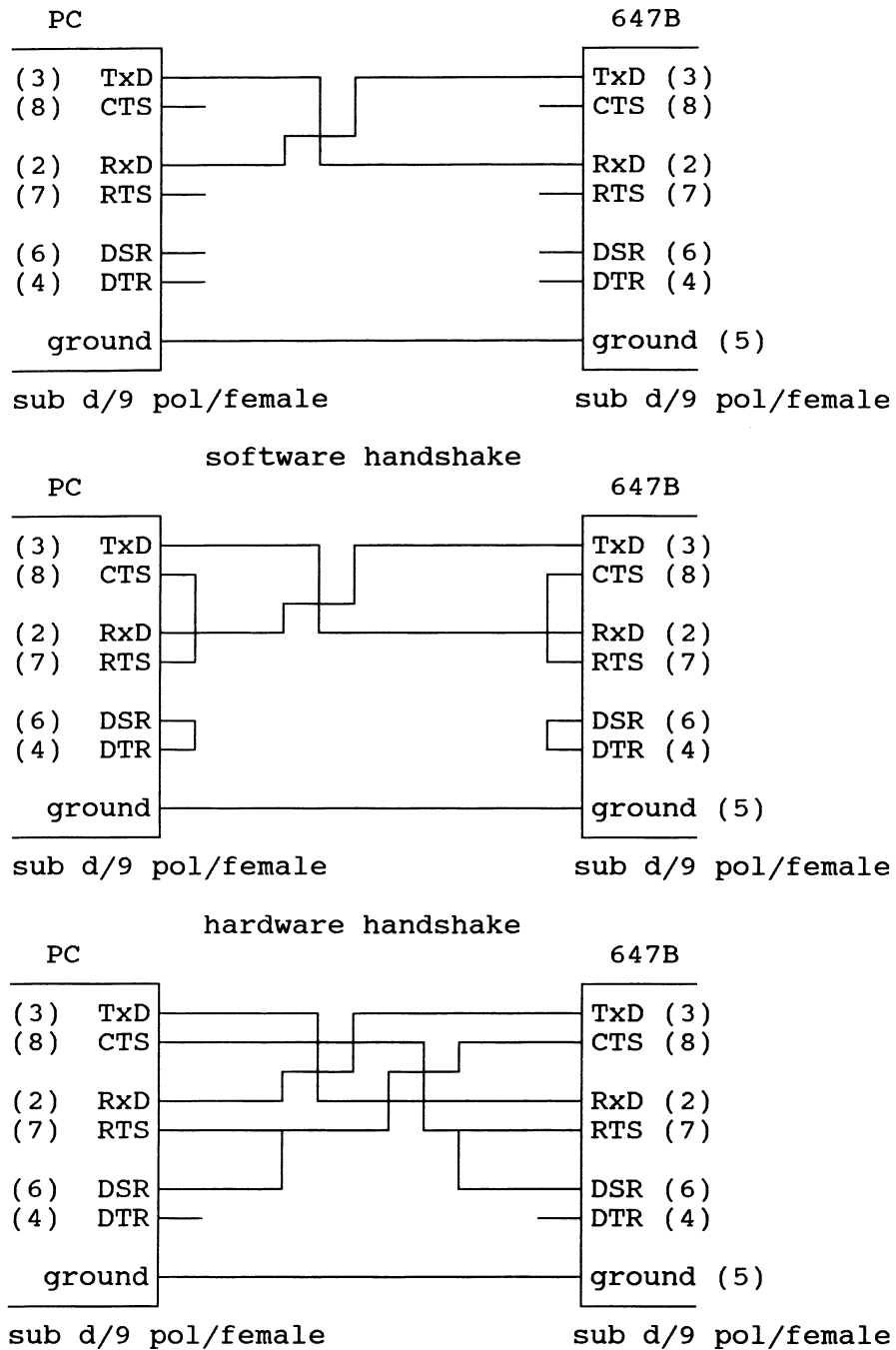


Figure 23

A typical error in handling the RS232 line is to plug in the cable, after having switched the device on before. As a result, the 647B works with no handshake although the host computer expects a handshaking. At installation time it may be helpful to check the actual handshake mode.



### 3.8.2.5 RS232 Line Status

In order to make the debugging of a RS232 installation easier, a status display is inserted in the SYSTEM SETUP menu. The so called RS232 STATUS display three events on the RS232 line:

- OE: overrun error: (bytes were lost)  
Bytes were lost on the input line of 647B. This is typical if the handshake protocol does not work. Check for the correct connection on the line and for fitting handshake protocols.
- PE: parity error: (the parity check failed)  
A byte was transferred with a parity error. This is typical for noise on the line. Check the ground line.
- FE: framing error: (recognition of stopbit failed)  
Synchronization of bytes did not work (i.e. stop bit was not present). This is typical for noise on the line. Check the ground line.
- "- -": "two dashes"  
no error occurred

### 3.8.2.6 Example

The following examples show the usage of a 647B through the RS232 interface. The examples are given in Power BASIC.

Program to display the act. flow of channel 1:

```

10 OPEN "COM2: 9600, 0, 8, 1" AS #1
20 PRINT #10, "ID"
30 INPUT #10, A$
40 PRINT A$
50 PRINT #10, "FS 1 0500"
60 PRINT #10, "ON 1"
70 PRINT #10, "ON 0"
80 PRINT #10, "FL 1"
90 INPUT #10, A$
100 PRINT A$
110 GOTO 80
120 END

```

### 3.8.3 System Parameters

For description of the parameter HOST MODE see chapter "Remote Control", page 30.

For the description of RESET function in SYSTEM SETUP menu, see the chapter "Reset of System", page 9.

### 3.9 Pressure Setup

MGC	647B	V2.2
PRESSURE		0.0000
RANGE FS.		<u>1.0000 Torr</u>
ZERO VALUE		0.001
ZERO ADJUST		EXEC
CONTROLLER		STD
GAIN		01.00
INTEG.ACT. [s]		02.00
LEAD [s]		00.30
00 ERRORS	FLOW OFF	INPUT DIRECT

Figure 24

The 647B supports several pressure ranges listed below:

1.0000 mTorr,	10.000 mTorr,	100.00 mTorr,	1000.0 mTorr,
1.0000 Torr,	10.000 Torr,	100.00 Torr,	1000.0 Torr,
1.0000 kTorr,	10.000 kTorr,	100.00 kTorr,	
1.0000 uBar,	10.000 uBar,	100.00 uBar;	1000.0 uBar,
1.0000 mBar,	10.000 mBar,	100.00 mBar,	1000.0 mBar,
1.0000 Bar,	10.000 Bar,	100.00 Bar,	
1.0000 Pa,	10.000 Pa,	100.00 Pa,	
1.0000 kPa,	10.000 kPa,	100.00 kPa,	1000.0 kPa,

The zero adjust works similar to that of an MFC channel (see chapter "Zero Adjust", page 20).

Different external pressure controllers such as 250, 152, 153, 652 or 146 type may be used. The setup must show the applicated controller type. (652 is valid also for 651 controller).

For the parameters of the PID controller see chapter Pressure Control, page 13.

### **3.10 Information about the System**

MGC	647B	V2.2
MKS Instruments            Nov 02 1992 IC86		
00 ERRORS	FLOW ON	INPUT DIRECT

Figure 25

This menu gives information about the device such as:

- company
- software release code
- internal code

If you call MKS for support in case of problems, please be prepared to give this information to MKS.

## **4. Remote Control**

### **4.1 Compatibility**

The 647B offers more functionality than the 147B, which leads to some incompatible constructs in the remote control syntax. To avoid this incompatibility, the 647B distinguishes two host modes:

- C-MODE offers actual 647B commands
- B-MODE offers 147B commands

In B-MODE the device is compatible with 147B, so it is possible to use old configuration software without any changes. The full 647B functionality is only available in C-MODE.

In the beginning the C-MODE will be initialized and the device will act like an actual 647B. If a 147B command is used, the 647B will switch to B-MODE (e.g.: MO c 1, PL 1 3). It is also possible to switch to B-MODE through menu SYSTEM SETUP and vice versa.

For setup see chapter System Parameters, page 28.

## 4.2 Command Syntax

In general all commands are transmitted in ASCII format. Each command string must be terminated by a carriage return and there is no discrimination between upper and lower case letters. In order to improve readability, blanks (20 hex) may be included as delimiters between command, channel number and command parameters, however, this is not necessary. All parameters can be read by the host. For this purpose a "R" (for "Request") is transmitted instead of the command parameter.

**Cmd cn {R | p1 [p2] [p3]} <cr> [<nl>]**

Cmd	= command, 2 bytes (see table of commands)
Cn	= channel number (1 - 4/8)
P1, p2, p3	= parameters, numerical input is always in decimal ASCII format
R	= request of the parameters
<cr>	= carriage return (0D hex) for termination
<nl>	= new line (0A hex) optional

### 4.3 Table of Commands

GM s	Select gas menu
s = 0	gas menu X, normal setpoints are used
s = 1..5	gas menu 1-5
GM R	check for gas menu, result: s
FS c xxxx	enter setpoint of a channel
c = 1..8	channel
x = 0..1100	setpoint in 0.1 percent of full scale
FS c R	check for setpoint, result: xxxxxx
FL c	check for actual flow of a channel, result: xxxxxx
c = 1..8	channel
x = 0..1100	actual flow in 0.1 percent of full scale
PS xxxx	enter pressure setpoint
x = 0..1100	setpoint in 0.1 percent of full scale
PS R	check for pressure setpoint, result: xxxxxx
PR	check for pressure, result: xxxxxx
x = 0..1100	actual pressure in 0.1 percent of full scale
PC	check for PCS, result: xxxxxx
x = 0..1100	actual PCS signal in 0.1 percent of full scale
PM m	enter pressure mode
m = 0	mode = off
m = 1	mode = auto
PM R	check for pressure mode, result: m
RA c rr	enter range
c = 1..8	channel
r = 0..39	range code:
	0 = 1.000 SCCM,   20 = 1.000 SCFH
	1 = 2.000 SCCM,   21 = 2.000 SCFH
	2 = 5.000 SCCM,   22 = 5.000 SCFH
	3 = 10.00 SCCM,   23 = 10.00 SCFH
	4 = 20.00 SCCM,   24 = 20.00 SCFH
	5 = 50.00 SCCM,   25 = 50.00 SCFH
	6 = 100.0 SCCM,   26 = 100.0 SCFH
	7 = 200.0 SCCM,   27 = 200.0 SCFH
	8 = 500.0 SCCM,   28 = 500.0 SCFH
	9 = 1.000 SLM,    29 = 1.000 SCFM
	10 = 2.000 SLM,   30 = 2.000 SCFM
	11 = 5.000 SLM,   31 = 5.000 SCFM
	12 = 10.00 SLM,   32 = 10.00 SCFM
	13 = 20.00 SLM,   33 = 20.00 SCFM
	14 = 50.00 SLM,   34 = 50.00 SCFM
	15 = 100.0 SLM,   35 = 100.0 SCFM
	16 = 200.0 SLM,   36 = 200.0 SCFM
	17 = 400.0 SLM,   37 = 500.0 SCFM
	18 = 500.0 SLM,   38 = 30.00 SLM
	19 = 1.000 SCMM,   39 = 300.0 SLM
RA c R	check for range, result: rr
GC c fff	enter gas correction factor
c = 1..8	channel
f = 10.180	factor in percent
GC c R	check for gas correction factor, result: fffff

```

MO c m [i]      enter mode
  c = 1..8      channel
  m = 0         mode = independent
  m = 1         mode = slave
  m = 2         mode = extern
  m = 3         mode = PCS
  m = 9         mode = test
  i = 1..8      modeindex, reference to master
                  (only if m equal 1)
MO c R          check for mode, result: m [i]

AZ c           zero adjust MFC, result: xxxxxx
  c = 1..8      channel
  x = -500..500 offset value in mV
  x = "E5"      error occurred

HL c xxxx      enter high limit
  c = 1..8      channel
  x = 0..1100   high limit in 0.1 percent of full scale
HL c R          check for high limit, result: xxxxxx

LL c xxxx      enter low limit
  c = 1..8      channel
  x = 0..1100   low limit in 0.1 percent of full scale
LL c R          check for low limit, result: xxxxxx

TM c m         enter mode for trip limits
  c = 1..8      channel
  m = 0         mode = SLEEP
  m = 1         mode = LIMIT
  m = 2         mode = BAND
TM c R          check for trip limit mode, result: m

GP c s xxxx    enter setpoint in a gas set
  c = 1..8      channel
  s = 1..5      gas set 1 to 5
  x = 0..1100   setpoint in 0.1 percent of full scale
GP c s R        check for setpoint in gas set, result: xxxxxx

PZ             zero adjust pressure, result: xxxxxx
  x = -500..500 offset value in mV
  x = "E5"      error occurred

GT c           pressure controller
  c = 0..5      controller code
                  0 = STD (i.e. standard)
                  1 = 250
                  2 = 152
                  3 = ---
                  4 = 652
                  5 = 146
CT R           check for pressure controller, result: c

PU uu          pressure unit
  u = 0..28     unit code:
                  0 = 1.0000 mTorr
                  1 = 10.000 mTorr
                  2 = 100.00 mTorr
                  3 = 1000.0 mTorr
                  4 = 1.0000 Torr
                  5 = 10.000 Torr
                  6 = 100.00 Torr
                  7 = 1000.0 Torr
                  8 = 1.0000 kTorr
                  15 = 1.0000 mBar
                  16 = 10.000 mBar
                  17 = 100.00 mBar
                  18 = 1000.0 mBar
                  19 = 1.0000 Bar
                  20 = 10.000 Bar
                  21 = 100.00 Bar
                  22 = 1.0000 Pa
                  23 = 10.000 Pa

```

---

	9 = 10.000 kTorr	24 = 100.00 Pa
	10 = 100.00 kTorr	25 = 1.0000 kPa
	11 = 1.0000 uBar	26 = 10.000 kPa
	12 = 10.000 uBar	27 = 100.00 kPa
	13 = 100.00 uBar	28 = 1000.0 kPa
	14 = 1000.0 uBar	
PU R	check for pressure unit, result: rr	
ON c	open valve	
c = 0	main valve (corresponds to: ON ALL)	
c = 1..8	channel valve	
OF c	close valve	
c = 0	main valve (corresponds to: OFF ALL)	
c = 1..8	channel valve	
ST c	check for status of a channel, result: xxxxxx	
	(incompatible)	
c = 1..8	channel	
x = 0..FFFFH	status value: bit 0 <- 0/1 channel off/on	
	bit 4 <- trip limit low	
	bit 5 <- trip limit high	
	bit 6 <- overflow in	
	bit 7 <- underflow in	
	bit 8 <- overflow out	
	bit 9 <- underflow out	
	bit 15 <- not used	
KD	keyboard disable, display is switched to user menu	
KE	keyboard enable, display is switched back to previous menu	
DF	sett all parameters to default	
RE	perform a hardware reset (like power up)	
ID	check for indetification,	
	result: MGC 647B V2.2 - mm dd yyyy	
mm	month of release	
dd	day of release	
YYYY	year of release	

The following host commands, respectively the command extensions, are only available with the PID option.

```

GN xxxx          enter PID parameter, gain
  xxxx = 0..9999  gain in percent
GN R             check for PID parameter gain, result: xxxxx

IA xxxx          enter PID parameter, integral action
  xxxx = 0..9999  integral action in 10 ms
IA R             check for PID parameter integ. act.,
  result: xxxxx

LD xxxx          enter PID parameter, lead
  xxxx = 0..9999  lead in 10 ms
LD R             check for PID parameter lead, result: xxxxx

MO c m [i]       enter mode (extended command)
  c = 1..8        channel
  m = 0           mode = independent
  m = 1           mode = slave

```

and new line. If no result value is available also an empty response (<cr> <nl>) is possible.

If an error has been detected in the command string, an error message is sent before the acknowledge signal. In this case the command has not been executed.

```
[ {v1 [v2]} | {E ec} ] <cr> <nl>
```

```

v1, v2          = result values
E               = indicator for an error
ec             = error code
  0 = Chnnel error:
      A invalid channel number was specified in the
      command or the channel number is missing.
  1 = Unknown Command:
      A command has been transmitted which is unknown
      to the 647B.
  2 = Syntax error:
      Only one character has been sent instead of
      the expected 2 byte command.
  3 = Invalid expression:
      The command parameter does not have decimal
      form, or invalid characters were found
      within the parameter (e.g. 100.3: the decimal
      point is an invalid character).

```



- 4 = Invalid value:  
The transmitted parameter is outside the parameter range (e.g. 1200 is outside the range of a set point)
- 5 = Autozero error:  
There was a trial to set the zero offset of an active channel. Before setting the zero offset, either the channel (OF #) or the gas (OF 0) has to be switched off.

<cr> = carriage return (0D hex) for termination  
<nl> = new line (0A hex)

## **5. Application of the 647B**

### **5.1 Mass Flow Controllers**

The mass flow controllers must have a linear DC voltage output of 0 – 5 V. The input impedance must not be lower than 1 MOhms. Some mass flow controllers of other manufacturers can be damaged by a constant set point < 0 V. Other possible symptoms are undesired oscillations, when the setpoint is varied, or disturbances of the regulation loop.

To operate mass flow controllers it is important, that the allowed maximum of input signals are not exceeded. The mass flow controllers must have a linear DC voltage input and output of 0 – 5 V. MKS mass flow controllers types 0258A/B/C, 0358B/C , 179A can be operated with the connector cables for MKS mass flow controllers types 259, 1259, 2259, 1159, 1179A, 2179A, 1479A, 1359, 1559 and 2159.

## **5.2 Trouble Shooting**

Symptom	Possible Causes and Remedies
1. No display.	Power Failure <ul style="list-style-type: none"> <li>- Wrong position of voltage selector switch.</li> <li>- Loose mains connection.</li> <li>- No power in the outlet</li> <li>- Fuse is defective</li> <li>- Power supply is broken.</li> </ul>
2. Display of gas flow is close to zero or not correct.	<ul style="list-style-type: none"> <li>- Loose connecton.</li> <li>- Power supply is broken.</li> <li>- Mass flow controller is warming up.</li> <li>- Set point is not being transmitted.</li> <li>- Valve in the supply line is closed.</li> </ul>
3. Display of gas flow is on for a short time and goes back to zero.	Defect in the pipe line system. <ul style="list-style-type: none"> <li>- Supply line valve is closed.</li> <li>- Pressure is down (check gas supply).</li> <li>- No differential pressure (e.g. pump is turned off).</li> </ul>
4. There are periodical peak pulses at constant gas flow.	<ul style="list-style-type: none"> <li>- Pressure regulator is defect, (frequent defect, varying supply pressure may help. It is recommended to replace the pressure regulator)</li> <li>- Disturbance by external sources (change the path of power lines, sreen sources of disturbance).</li> </ul>
5. Entering data is not possible or there are unreadable characters on the display	<ul style="list-style-type: none"> <li>- There is probably inconsistant data in battery backuped RAM. The First Start Reset will fix this problem.</li> </ul>

If the trouble is limited to a part of the eight possible channels, it is recommended to localize the source of trouble by exchanging mass flow controllers and their connecting cables.

In any case check the setup of the device.

## 6. Pin Assignment of rear connectors

### 6.1 RS232 connector

Sub-D male 9 pol.

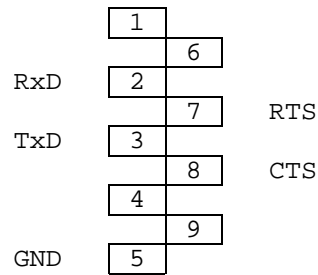


Figure 26

### 6.2 IEEE 488 connector

DIO 0	1	13	DIO 4
DIO 1	2	14	DIO 5
DIO 3	3	15	DIO 6
DIO 4	4	16	DIO 7
EOI	5	17	REN
DAV	6	18	ground
NRFD	7	19	ground
NDAC	8	20	ground
IFC	9	21	ground
SRQ	10	22	ground
ATN	11	23	ground
shield	12	27	ground

Figure 27

### **6.3 RELAYS connector**

Two relays are available for each channel. The relay data are:

- type of relay: 1 switch with n.o. and n.c. position (SPDT)
- max. switch voltage: 100 V
- max. power: 3 W
- max. switch load: 250 mA
- max. response time: 55 ms

Sub-D female 25 pol.

relay 11, nc	1	chassis
	14	relay 11, cmn
relay 11, no	2	
	15	relay 12, nc
relay 12, cmn	3	
	16	relay 12, no
relay 21, nc	4	
	17	relay 21, cmn
relay 21, no	5	
	18	relay 22, nc
relay 22, cmn	6	
	19	relay 22, no
relay 31, nc	7	
	20	relay 31, cmn
relay 31, no	8	
	21	relay 32, nc
relay 32, cmn	9	
	22	relay 32, no
relay 41, nc	10	
	23	relay 41, cmn
relay 41, no	11	
	24	relay 42, nc
relay 42, cmn	12	
	25	relay 42, no
chassis	13	

legend: nc = normally closed  
no = normally open  
cmn = common pin

relay 12 = relay 2 of channel 1

Figure 28

## 6.4 VIDEO connector

Sub-D female 9 pol.

GND	1	6	intensity
GND	2	7	video signal
---	3	8	H-Sync.
---	4	9	V-Sync.
---	5		

Figure 29

## 6.5 MFC connector: CH1 to CH8

Sub-D female 15 pol.

---	1	9	chassis
flow signal	2	10	---
/valve close *	3	11	flow feedback
/valve open *	4	12	signal-GND
PGND	5	13	signal-GND
-15V	6	14	---
+15V	7	15	---
setpoint output	8		chassis

\* = for use with cable type CB147-1

Figure 30

## **6.6 ACCESS connector**

Sub-D female 25 pol.

reserved	1	chassis
	14	external setpoint 1
/valve open 1	2	
	15	external setpoint 2
/valve close 1	3	
	16	external setpoint 3
flow signal 1	4	
	17	external setpoint 4
/valve open 2	5	
	18	+15V
/valve close 2	6	
	19	-15V
flow signal 2	7	
	20	PGND
/valve open 3	8	
	21	PGND
/valve close 3	9	
	22	AGND
flow signal 3	10	
	23	---
/valve open 4	11	
	24	---
/valve close 4	12	
	25	chassis
flow signal 4	13	

Figure 31

## **6.7 PRESSURE connector**

Sub-D female 9 pol.

pressure signal	1	chassis
	6	PGND
pressure setpoint	2	
	7	remote zero
+15V	3	
	8	range switch
-15V	4	
	9	AGND
PCS	5	

Figure 32

## 7. Gas Correction Table

Conversion factors are related to calibration in nitrogen or air.

GAS	SYMBOL	SPECIFIC HEAT, Cp cal/g°C	DENSITY g/l @ 0°C	CONVERSION FACTOR
Acetylene	C <sub>2</sub> H <sub>2</sub>	0.383	1.171	0.58
Air	- - -	0.240	1.293	1.00
Ammonia	NH <sub>3</sub>	0.492	0.760	0.73
Argon	Ar	0.1244	1.782	1.39 <sup>1</sup>
Arsine	AsH <sub>3</sub>	0.1167	3.478	0.67
Boron Trichloride	BCl <sub>3</sub>	0.1279	5.227	0.41
Bromine	Br <sub>2</sub>	0.0539	7.130	0.81
Carbon Dioxide	CO <sub>2</sub>	0.2016	1.964	0.70 <sup>1</sup>
Carbon Monoxide	CO	0.2488	1.250	1.00
Carbon Tetrachloride	CCl <sub>4</sub>	0.1655	6.86	0.31
Carbon Tetrafluoride (Freon - 14)	CF <sub>4</sub>	0.1654	3.926	0.42
Chlorine	Cl <sub>2</sub>	0.1144	3.163	0.86
Chlorodifluoromethane (Freon - 22)	CHClF <sub>2</sub>	0.1544	3.858	0.46
Chloropentafluoroethane (Freon - 115)	C <sub>2</sub> ClF <sub>5</sub>	0.164	6.892	0.24
Chlorotrifluoromethane (Freon - 13)	CClF <sub>3</sub>	0.153	4.660	0.38
Cyanogen	C <sub>2</sub> N <sub>2</sub>	0.2613	2.322	0.61
Deuterium	D <sub>2</sub>	1.722	0.1799	1.00
Diborane	B <sub>2</sub> H <sub>6</sub>	0.508	1.235	0.44
Dibromodifluoromethane	CBr <sub>2</sub> F <sub>2</sub>	0.15	9.362	0.19
Dichlorodifluoromethane (Freon - 12)	CCl <sub>2</sub> F <sub>2</sub>	0.1432	5.395	0.35
Dichlorofluoromethane (Freon - 21)	CHCl <sub>2</sub> F	0.140	4.592	0.42
Dichloromethylsilane	(CH <sub>3</sub> ) <sub>2</sub> SiCl <sub>2</sub>	0.1882	5.758	0.25

(Table continued on next page)



GAS	SYMBOL	SPECIFIC HEAT, Cp cal/g°C	DENSITY g/l @ 0°C	CONVERSION FACTOR
Dichlorosilane	SiH <sub>2</sub> Cl <sub>2</sub>	0.150	4.506	0.40
1,2-Dichlorotetrafluoroethane (Freon - 114)	C <sub>2</sub> Cl <sub>2</sub> F <sub>4</sub>	0.160	7.626	0.22
1,1-Difluoroethylene (Freon - 1132A)	C <sub>2</sub> H <sub>2</sub> F <sub>2</sub>	0.224	2.857	0.43
2,2-Dimethylpropane	C <sub>5</sub> H <sub>12</sub>	0.3914	3.219	0.22
Ethane	C <sub>2</sub> H <sub>6</sub>	0.4097	1.342	0.50
Fluorine	F <sub>2</sub>	0.1873	1.695	0.98
Fluoroform (Freon - 23)	CHF <sub>3</sub>	0.176	3.127	0.50
Freon - 11	CCl <sub>3</sub> F	0.1357	6.129	0.33
Freon - 12	CCl <sub>2</sub> F <sub>2</sub>	0.1432	5.395	0.35
Freon - 13	CClF <sub>3</sub>	0.153	4.660	0.38
Freon - 13 B1	CBrF <sub>3</sub>	0.1113	6.644	0.37
Freon - 14	CF <sub>4</sub>	0.1654	3.926	0.42
Freon - 21	CHCl <sub>2</sub> F	0.140	4.592	0.42
Freon - 22	CHClF <sub>2</sub>	0.1544	3.858	0.46
Freon - 23	CHF <sub>3</sub>	0.176	3.127	0.50
Freon - 113	C <sub>2</sub> Cl <sub>3</sub> F <sub>3</sub>	0.161	8.360	0.20
Freon - 114	C <sub>2</sub> Cl <sub>2</sub> F <sub>4</sub>	0.160	7.626	0.22
Freon - 115	C <sub>2</sub> ClF <sub>5</sub>	0.164	6.892	0.24
Freon - 116	C <sub>2</sub> F <sub>6</sub>	0.1843	6.157	0.24
Freon - C318	C <sub>4</sub> F <sub>8</sub>	0.1866	8.93	0.164
Freon - 1132A	C <sub>2</sub> H <sub>2</sub> F <sub>2</sub>	0.224	2.857	0.43
Helium	He	1.241	0.1786	--- 2
Hexafluoroethane (Freon - 116)	C <sub>2</sub> F <sub>6</sub>	0.1843	6.157	0.24
Hydrogen	H <sub>2</sub>	3.419	0.0899	--- 2
Hydrogen Bromide	HBr	0.0861	3.610	1.00

(Table continued on next page)

GAS	SYMBOL	SPECIFIC HEAT, Cp cal/g°C	DENSITY g/l @ 0°C	CONVERSION FACTOR
Hydrogen Chloride	HCl	0.1912	1.627	1.00
Hydrogen Fluoride	HF	0.3479	0.893	1.00
Isobutylene	C <sub>4</sub> H <sub>8</sub>	0.3701	2.503	0.29
Krypton	Kr	0.0593	3.739	1.54
Methane	CH <sub>4</sub>	0.5328	0.715	0.72
Methyl Fluoride	CH <sub>3</sub> F	0.3221	1.518	0.56
Molybdenum Hexafluoride	MoF <sub>6</sub>	0.1373	9.366	0.21
Neon	Ne	0.246	0.900	1.46
Nitric Oxide	NO	0.2328	1.339	0.99
Nitrogen	N <sub>2</sub>	0.2485	1.250	1.00
Nitrogen Dioxide	NO <sub>2</sub>	0.1933	2.052	-. - -2
Nitrogen Trifluoride	NF <sub>3</sub>	0.1797	3.168	0.48
Nitrous Oxide	N <sub>2</sub> O	0.2088	1.964	0.71
Octafluorocyclobutane (Freon - C318)	C <sub>4</sub> F <sub>8</sub>	0.1866	8.93	0.164
Oxygen	O <sub>2</sub>	0.2193	1.427	1.00
Pentane	C <sub>5</sub> H <sub>12</sub>	0.398	3.219	0.21
Perfluoropropane	C <sub>3</sub> F <sub>8</sub>	0.194	8.388	0.17
Phosgene	COCl <sub>2</sub>	0.1394	4.418	0.44
Phosphine	PH <sub>3</sub>	0.2374	1.517	0.76
Propane	C <sub>3</sub> H <sub>8</sub>	0.3885	1.967	0.36
Propylene	C <sub>3</sub> H <sub>6</sub>	0.3541	1.877	0.41
Silane	SiH <sub>4</sub>	0.3189	1.433	0.60
Silicon Tetrachloride	SiCl <sub>4</sub>	0.1270	7.580	0.28
Silicon Tetrafluoride	SiF <sub>4</sub>	0.1691	4.643	0.35
Sulfur Dioxide	SO <sub>2</sub>	0.1488	2.858	0.69

(Table continued on next page)

GAS	SYMBOL	SPECIFIC HEAT, Cp cal/g°C	DENSITY g/l @ 0°C	CONVERSION FACTOR
Sulfur Hexafluoride	SF <sub>6</sub>	0.1592	6.516	0.26
Trichlorofluoromethane (Freon - 11)	CCl <sub>3</sub> F	0.1357	6.129	0.33
Trichlorosilane	SiHCl <sub>3</sub>	0.1380	6.043	0.33
1,1,2-Trichloro - 1,2,2-Trifluoroethane (Freon - 113)	CCl <sub>2</sub> FCClF <sub>2</sub> or (C <sub>2</sub> Cl <sub>3</sub> F <sub>3</sub> )	0.161	8.360	0.20
Tungsten Hexafluoride	WF <sub>6</sub>	0.0810	13.28	0.25
Xenon	Xe	0.0378	5.858	1.32

<sup>1</sup> Empirically defined

<sup>2</sup> Consult MKS Instruments, Inc. for special applications.

NOTE: Standard Pressure is defined as 760 mmHg (1013.25 mbar). Standard Temperature is defined as 0°C.

Note: This table may contain more (or less) gases than that of the unit.

Figure 33

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## Customer Support Centers

### **UNITED STATES**

**MKS Instruments, Inc.**  
**Corporate Service Center**  
651 Lowell Street  
Methuen, MA 01844  
Fon: (978) 682-4567  
Fax: (978) 682-8543

**MKS Instruments, Inc.**  
**HPS Division,**  
**Vacuum Components,**  
**Valves & Gauging**  
5330 Sterling Drive  
Boulder, CO 80301  
Fon: (303) 449-9861  
(800) 345-1967  
Fax: (303) 442-6880

### **CANADA**

**MKS Instruments, Canada Ltd.**  
30 Concourse Gate  
Nepean, Ontario, Canada K2E 7V7  
Fon: (613) 723-3386  
(800) 267-3551 (CAN only)  
Fax: (613) 723-9160

### **FRANCE**

**MKS Instruments, France s.a.**  
43, Rue du Commandant Rolland  
B.P. 41  
F-93352 Le Bourget, Cedex,  
France  
Fon: 33(1)48.35.39.39  
Telex: 233817 F  
Fax: 33(1)48.35.32.52

### **GERMANY/BENELUX**

**MKS Instruments,**  
**Deutschland GmbH**  
Schatzbogen 43  
D-81829 München  
Fon: 49-89-420008-0  
Fax: 49-89-42-41-06  
E-Mail: mks49@aol.com

### **ITALY**

**G. Gambetti Kenologia Srl.**  
Via A. Volta No. 2  
20082 Binasco (MI), Italy  
Fon: 39-2-90093082  
Fax: 39-2-905.2778

### **JAPAN**

**MKS Japan, Inc.**  
Harmonize Building  
5-17-13, Narita-Higashi  
Suginami-Ku, Tokyo 166, Japan  
Fon: 81-3-3398-8219  
Fax: 81-3-3398-8984

### **KOREA**

**MKS Korea Co., Ltd.**  
2<sup>nd</sup> Floor Shin Young Bldg.  
257-4 Yangjae-Dong  
Seocho-Ku  
Fon: 82-2-529-0713/4  
Fax: 82-2-529-0715

### **UNITED KINGDOM**

**MKS Instruments, U.K. Ltd.**  
2 St. George's Court  
Dairyhouse Lane  
Altrincham, Cheshire  
WA14 5UA, England  
Fon: 44-161-929-5500  
Fax: 44-161-929-5511