2. QSR 101 / BPU 100 E

2.1 Application

The film and coating rate monitor QSR 101 is an accessory of BALZERS coaters and is used for measuring and controlling the layer thickness and coating rate depending on the design during the coating process.

Due to a direct determination of the mass change on the quartz crystal indirect measuring methods, such as resistance, transmission, reflection can be waived in many cases. Just for this reason, the fields of application in which this unit can be used are so diversified and even typical for the fields enumerated as follows:

- thin film components, such as metallic resitors, thin film capacitors, magnetic layers;
- semi-conductor applications, such as contact layers, conductors, insulating layers, mask production;
- optical applications, such as protective layers, anti-reflection layers, mirrors, multiple layers for interference filters.

When using additional modules, a complete coating process can be operated with automatic controls. The sequence, of operations with respect to time including the conditioning of the evaporation source, as well as several secondary functions, such as opening and closing shutters, rotating substrates, glow discharge, heating etc. are controlled in this way. The parameters are fed in via keyboard and can be read any time and modified, if necessary.

2.2. Measuring method

When using this method, the change of the natural frequency f in a quartz crystal whose thickness d has been increased by the amount of Δ d after applying a mass, e.g. by depositing a foreign layer on the quartz plate, is measured.

If

f = natural frequency of the quartz crystal

d = thickness of the quartz

ρq = density of the quartz

F = area of the quartz and

Δm = mass of a foreign layer covering the quartz plate homogeneously,

the following equation applies to the change in the natural frequency:

$$\frac{\Delta f}{f} = -\frac{\Delta d}{d} = -\frac{\Delta m}{\rho q \cdot F \cdot d}$$

from which the thickness of the coated layers can be obtained:

$$d_s = \frac{K}{\rho s} \cdot \left[\frac{1}{f} - \frac{1}{f_o}\right]$$

d_s = thickness of the layer

ρs = specific density of the coating material

f_o = starting frequency

f = actual frequency

K = constant

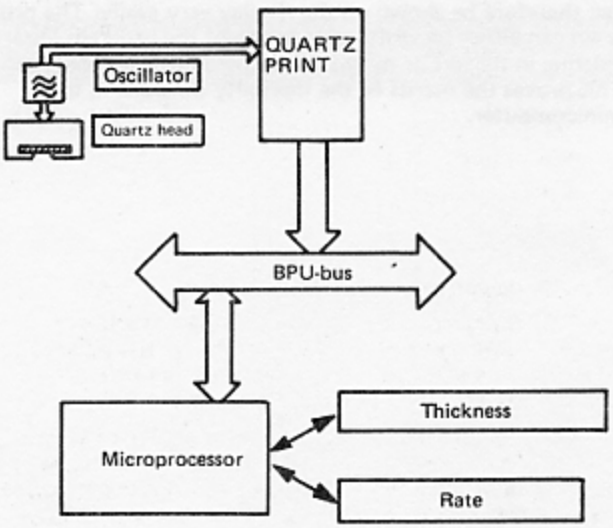


Fig. 2.1.

For better understanding, the BALZERS film thickness measuring unit QSR 101 is schematically shown. The quartz crystal is a 5 MHz-AT-fundamental crystal with a small temperature coefficient. Coated areas from gold, silver or aluminum are used as energizing electrodes. The measuring area is coated entirely with one of these materials.

The frequency emitted by the oscillator (quartz crystal) is electronically multiplied and measured several times per second.

The micro-computer calculates the thickness of the layer from the difference of the frequency and the coating rate from the change of the frequency as a function of time.

2.3. Description

The individual modules of the QSR 101 are mounted in a 19" rack adapter frame. The unit can be installed in any standard 19" rack cabinet or used as a bench model provided with a casing. The QSR 101 consits of the following plug-in modules:

2.3.1. Power supply EPS 101

This unit supplies the required voltages to the individual modules. A toggle switch for connecting and disconnecting the unit is located on the front panel. The operating state is indicated by a LED.

2.3.2. "BUS LOAD" module BL 101

In this module all RF-lines are terminated and their logical condition is signalled by LEDs. This information makes it possible to check the function of the micro-computer facilitating the trouble-shooting procedure. The operational modes "ATUTOMATIC" or "MANUAL" can be selected by two switches on the front panel.

2.3.3. Quartz measuring module QM 101

The quartz measuring module provides readings on layer thickness and deposition rate during the coating process. It determines the frequency and transmits this value to the micro-computer. The high pulse frequency of the measurement as well as the high natural frequency of the quartz crystal assure an excellent measuring accuracy. Quartz measuring heads for plano-convex quartz materials discs are suitable as sensors. In the event of a quartz failure, this is immedidately detected by the micro-computer releasing an error message.

2.3.4. Micro-computer MC 101

The MC 101 process micro-computer is the central unit of the BPU 100 E system. It consits of the micro-processor IM 6100, a program memory, a data memory and an interface for the BPU 100 Bus.

The micro-processor operates with a word size of 12 bits and is software-compatible to the PDP 8. The program memory has a capacity of 3 K byte and consits of 18 fusible link PROMS of the size 512*4 bit. The data memory consits of 12 RAMS of the size 1024* bit and has a capacity of 1 K byte. In case of a power failure or when switching off the equipment, the power supply of the RAMS is assured by builtin storage batteries. In order to prevent a heavy discharge of the storage batteries during prolonged interruptions of the operation (e.g. transportation), they can be separated by means of a miniature switch. This switch is located between the two p.c. boards of the MC 101. The capacity of the storage batteries is sufficient for 30 days.

The MC 101 process micro-computer controls all processes on the BPU 100 bus. It can process all digital signals provided by the input units IU 101. It transmits its outputs to the digital output units OU 101 or to the digital D/A converters DA 101. In addition, the MC 101 serves the input and output unit KB 101 described in the following chapter thus creating the connection between man and machine. The quartz measuring unit QM 101 is equally monitored by the MC 101.

The manner in which the individual modules of the BPU 100 system are called up and controlled by the MC 101 depends on the program (software) only which is contained in the MC 101. This program is contained in plug-in PROMS (Programmable Read Only Memories) and can therefore be adapted to the exterior requirements. The data contents of the PROMS is absolutely protected against failures in the power supply so that no program loss can occur. The standard program contains 48 different control options for various plant configurations. The option to be used can be defined by a simple switch setting on the CPU bottom plate of the MC 101. The process parameters are stored in the RAMS (Random Access Memories) using a storage battery buffer and are therefore, protected against mains power failures.
The mode of the computer is indicated by a LED (RUN) on the front panel.

2.3.5. Digital output OU 101

Twelve switching commands can be transmitted to the plant via bus by means of the output units. Such functions include the opening and closing of shutters, the connection of the substrate heating etc. The metallic isolation is achieved over Reed-relays. The condition of each switching function is indicated by an indicator lamp. In manual operation, these functions can be initiated by means of a toggle switch on the front panel. The OU 101 is contained in the models QSR 101 B and QSR 101 C only.

2.3.6. Analog output DA 101

The converter has 4 parallel channels of 8 bits resolution each. The analog signal is emitted in a decoupled condition. These signals are used for the triggering of the evaporation sources. The signal level is marked on the LED-display. In manual operation, the signal level can be changed by means of a toggle switch.

The DA 101 is contained in the model QSR 101 C only.

2.3.7. Keyboard/Display KB 101

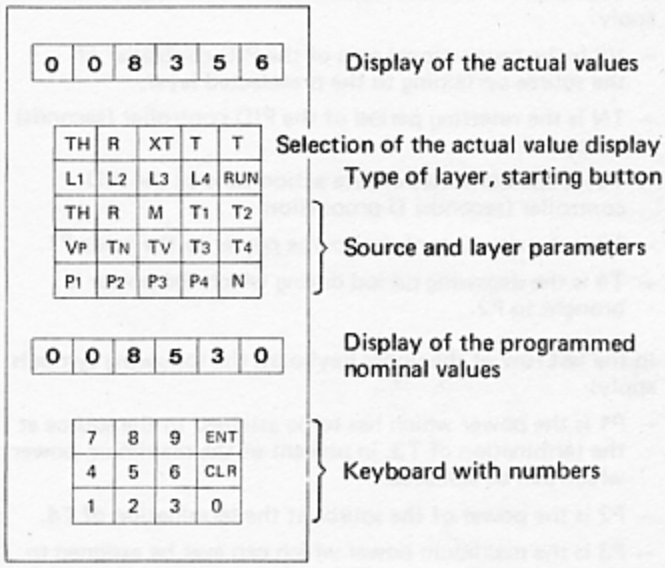


Fig. 2.2.

The KB 101 is the connecting link between man and machine. Actual and nominal values of the process parameters can be preselected, verified and modified or read. Two separate displays allow the simultaneous representation of nominal and actual values.

On the top row of the keyboard, the actual values of the process can be shown on the upper display as follows:

TH = thickness of the layer just being deposited in Ångstroem.

R = actual deposition rate Å/sec.

XT = 5 Megahertz minus actual quartz frequency,

T = process period: prior to opening the shutter, a count-down of the totals of the time elements T1, T2, T3, T4 is in progress until 0 is reached. After opening the shutter, the coating period is counted up in seconds,

LT = lamp test. This button has no influence on the process flow. It is used only to prove that all 7-segment displays are functioning properly: all figures must indicate the number 8.

The next four rows of the keyboard are used for the verification and programming of the process nominal values.

L1, L2, L3, L4 select the four different layers with the pertinent parameters.

"RUN" actuates the start or termination of the program. By depressing the "RUN"-button, the program is started. When the program is in progress, the LED lights up. When the "RUN"-button is depressed again, the program is terminated and the LED extinguished.

In the third row the following symbols apply:

- TH indicates the nominal value of the thickness of the layers preselected with L1 to L4. Same as all other parameters, this value can be verified or modified during the coating process.
- R indicates the nominal rate of the preselected layer.
- M represents the specific density of the coating material in g/cm^3.
- T1 represents the glow-discharge period according to the description of the standard process flow as given below.
- T2 is the recovery period.

In the fourth row of the keyboard the following symbols apply:

- VP is the proportional gain of the PID-controller of the source pertaining to the preselected layer.
- TN is the resetting period of the PID-controller (seconds) I-proportion.
- TV- is the derivative or rate action time of the PID-controller (seconds) D-proportion.
- T3 is the rise time of the source power to the value P1.
- T4 is the degassing period during which the power is brought to P2.

In the last row of the upper keyboard the following symbols apply:

- P1 is the power which has to be assigned to the source at the termination of T3, in percent of the maximum power which can be achieved.
- P2 is the power of the source at the termination of T4.
- P3 is the maximum power which can ever be assigned to the appropriate source. This is a power limitation for safety reasons.
- P4 is the holding power of the source after the coating operation has been terminated.
- N in semi-automatic operation: number of layers to be deposited. As long as this number has not been reached, the evaporator boats are kept on holding power following the coating operation.

  In a fully automatic (cyclic) operation: the layer sequence. A maximum of 24 layers can be programmed successively.

2.3.8. Digital input 101

This unit allows the remote control and synchronization of several QSR 101 C thus assuring a simultaneous deposition of several materials, e.g. for alloys. It also allows to process the pressure and temperature monitoring signals of other units.
On the BPU 100 P, the back reports or acknowledgements are also processed in this unit.

2.3.9. Adapter unit QSA 101

The QSA 101 is a accessory of the units QSR 101 B and QSR 101 C, facilitating the adaptation of these units to the coating plant. It contains the required supply voltages for the shutters etc., as well as the 12 relays and 4 amplification channels for the adaptation of the control signals.

2.3.10. Quartz crystal mount

The frequency change of a quartz crystal does not only depend on the thickness of the foreign layer deposited on this quartz crystal, but to a considerable extent it is also determined by the temperature stability and the kind of holder used in this device. For this reason, BALZERS have designed a quartz crystal holder which:

1. exerts a minimum mechanical pressure on the quartz not affecting its frequency,
2. assures an extraordinarily high temperature stability on the quartz.

A water-cooled cooper shield protects a large area and leaves the part of the quartz open which is exposed to coating only. The impinging heat radiation affecting this part as well as the condensation heat of the coated substance are minimized, however, in their effects by the relatively high infrared reflection of the electrode material (Ag, Au) on the one hand and by the heat dissipation over the contacts on the other hand.

The quartz crystal holder QSK 300 accomodates a plano-convex quartz. It consists of the mount with contact, the measuring oscillator, the coaxial connector, the coaxial cable for connection to the triaxial test current feed-through, and a water-cooled housing.

See also the separately furnished instructions.

2.4. Technical data

Measured values		**Measuring range**	**Resolution**
Layer thickness	TH	0 – 999 999 Å	1 Å
Rate	R	0 – 999 999 Å	1 Å/s
Time	T	0 – 999 999 S	1 s
Change of the quartz frequency	XT	0 – 999 999 Hz	1 Hz
Parameters			
Layer thickness	TH	0 – 999 999 Å	1 Å
Rate	R	0 – 999 999 Å/s	1 Å/s
Density of the material	M	0 – 99 999 g/cm^3	0,1 g/cm^3
Process periods	T1-T4	0 – 999 999 s	1 s
Gain	VP	0 – 99 999	0.1
Resetting period	TN	0 – 99 999 s	0.1 s
Derivative or rate action time	TV	0 – 99 999 s	0.1 s
Powers	P1-P4	0 – 100%	1%
Analog outputs			
for triggering a power control element for an evaporation source		0 – 10 V DC, 5 mA shortcircuit-proof	
Digital outputs			
for the control of secondary functions		Reed-relay, max. 48 V, 10 W	
Power supply			
power consumption		50 W	
line-voltage		220 V ± 10% (P+N+E)	
line-frequency		50 Hz	
Dimensions			
rack module		width: 19" height: 221.5 mm = 5 submodules depth: 400 mm weight: 18 kg	
bench model		width: 483 mm height: 226 mm depth: 440 mm weight: 40 kg	
Environmental temperature		0 – 50 °C	

2.5. Installation

2.5.1. Rack mounting

Model BG S02 750 (220 V AC). By means of 4 screws, the QSR can be accomodated in a 19" rack module.

2.5.2. Bench model

Model BG S02 757 (220 V AC). The QSR has been provided with an encasing.

2.5.3. Power supply

The power supply to the EPS 101 is effected by means of a European appliance connector. A three-wire instrument cable has to be inserted and connected according to figure 2.3. Regarding code colors, refer to existing local requirements.

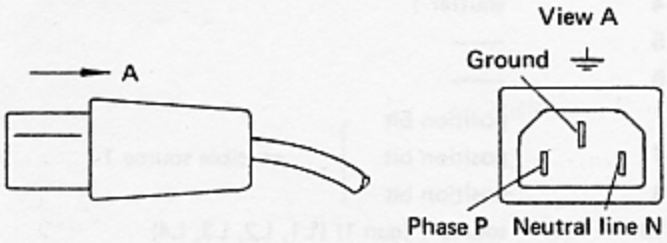


Fig. 2.3.

2.5.4. Connection of the quartz crystal holder

The connecting line may be up to 6 m long. The connection to the test current feedthrough of the quartz crystal on the plant and the quartz measuring module QM 101 is made by means of plug-connectors.

The thickness of the layer and the rate can now be measured with the QSR.

2.5.5. Connection to the power distributor EPC (BPU 100 E)

The main signal flow is conducted from the OU 101 or DA 101 respectively to the digital or analog adapter circuits in the power distributor via multiple-pole cables and connectors.

The models IU 101 can be used on the QSR 101 C and BPU 100 E. On the BPU 100 P, the models IU 101 and AD 101 are used. These digital or analog input cards receive their signals from the adapter cards for the inputs in the power distributor.

See also operating instructions of EPC, section 4.

2.6. Start of operation

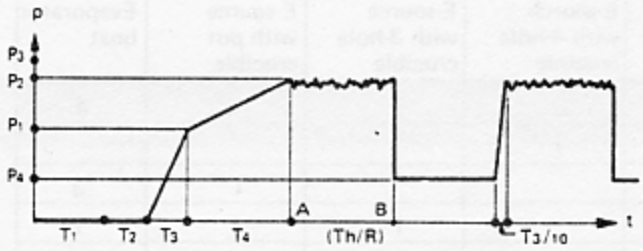


Fig. 2.4.

T1:	glow discharge or heating of the substrates
T2:	period of pumping down to HV
T3:	rise time
T4:	degassing time
P1:	rise power
P2:	degassing power
P3:	maximum power
P4:	holding power
Point A:	shutter open
Point B:	shutter closed

2.6.1. Program flow

The program can be started and interrupted by actuating the button "RUN". With the program running, the indicator diode of the "RUN" button lights up. As soon as the program has been started, the output 0 (normally rotary drive) and the output 1 (normally glow discharge or heating) is switched on in the output unit OU 101. For the program options of the electron beam sources the position code for the crucible control unit ETS 110 is available at the corresponding outputs (see information on connections). The output 0 remains in the on-position until the program has been terminated. The output 1 will switch off again after the time T1 has expired. At the expiration of T1, the time T2 will start which after a glow discharge operation can be used as a recovery time for the pressure in the vacuum chamber. At the expiration of the time T2, the source will be switched on and the power run up linearly to the rise power P1 during the time T3. During the time T4 which now follows, the power is brought from P1 to P2 linearly with time.

The degassing power P2 may be above or under P1 during this step. After expiration of the time T4, The signal for the opening of the shutter pertaining to the source will be provided on the output unit OU 101. As the shutter opens, the rate and film thickness operation is energized. For the rate which has been set, the rate regulation transmits the required analog control signal to the D/A converter DA 101. This control signal may be limited to the maximum power P3. After the desired thickness of the layer TH has been reached, the shutter closes and the control signal for the power is lowered to the holding power P4.

The times T1 to T4 and the powers P1 to P4 can be preselected for each source.

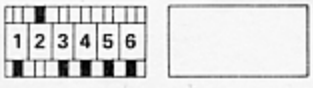
2.6.2. Adaptation of the computer program to various plant configurations

Various combinations of resistance-heated sources and electron beam evaporators with a maximum of 4 different materials are possible. The desired combination is selected by means of a miniature switch. This affords maximum flexibility also assuring the addition of any later equipment.

The table below shows six possible combinations.

	E-source with 4-hole crucible	E-source with 3-hole crucible	E-source with pot crucible	Evaporator boat
1				4
2	1			
3			1	3
4		1		1
5			2	2
6		1	1	

Two six-way miniature switches are located on the pc-board of the MC 101. The miniature switch on the left hand side must be in the following position:



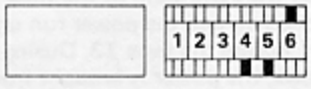
dark: button depresst

The programs 1 to 6 can be selected at the positions 4, 5 and 6 of the miniature switch on the right hand side.

BPU 100 E outputs

Program no. 1: 4 evaporator boats

Switch position of the miniature switches on the MC 101 pc-board:



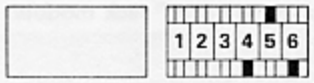
Digital outputs on the OU 101

Bit no.	Signal
0 (top)	rotation of substrate
1	glow discharge
2	source 3 (boat 3) (L3)
3	source 4 (boat 4) (L4)
4	shutter no. 1
5	shutter no. 2
6	---
7	---
8	shutter no. 3
9	shutter no. 4
10	source 1 (boat 1) (L1)
11 (bottom)	source 2 (boat 2) (L2)

Analog channels: 1 = source 1 (L1)
2 = source 2 (L2)
3 = source 3 (L3)
4 = source 4 (L4)

Program no. 2: gun with 4-way crucible

Switch position of the miniature switches on the MC 101 pc-board:



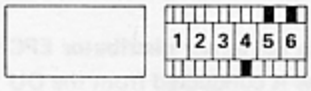
Analog channels used: 1 = L1, L2, L3, L4

Digital outputs on the OU 101

Bit no.	Signal	
0 (top)	rotation of substrate	
1	glow discharge	
2	---	
3	---	
4	shutter 1	
5	---	
6	---	
7	position bit	crucible source 1
8	position bit	
9	position bit	
10	source 1 (gun 1) (L1, L2, L3, L4)	
11 (bottom)	---	

Program no. 3: gun with pot crucible and 3 evaporator boats.

Switch position of the miniature switches on the MC 101 pc-board:



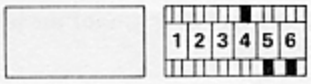
Digital outputs on the OU 101

Bit no.	Signal
0 (top)	rotation of substrate
1	glow discharge
2	source 3 (boat 2) (L3)
3	source 4 (boat 3) (L4)
4	shutter no. 1
5	shutter no. 2
6	---
7	rotation of crucible
8	shutter no. 3
9	shutter no. 4
10	source 1 (gun 1) (L1)
11 (bottom)	source 2 (boat 1) (L2)

Analog channels: 1 = source 1 (L1)
2 = source 2 (L2)
3 = source 3 (L3)
4 = source 4 (L4)

Program no. 4: gun with 3-way crucible and 1 evaporator boat

Switch position of the miniature switches on the MC 101 pc-board:



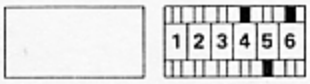
Digital outputs on the OU 101

Bit no.	Signal	
0 (top)	rotation of substrate	
1	glow discharge	
2	---	
3	---	
4	shutter no. 1	
5	shutter no. 2	
6	---	
7	position bit	crucible source 1
8	position bit	
9	position bit	
10	source 1 (gun 1) (L1, L2, L3)	
11 (bottom)	source 2 (boat 1) (L4)	

Analog outputs: 1 = source 1 (L1, L2, L3)
2 = source 2 (L4)

Program no. 5: 2 guns with pot crucible and 2 evaporator boats

Switch position of the miniature switches on the MC 101 pc-board:



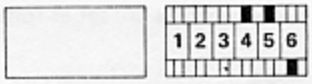
Digital outputs on the OU 101

Bit no.	Signal
0 (top)	rotation of substrate
1	glow discharge
2	source 3 (boat 1) (L3)
3	source 4 (boat 2) (L4)
4	shutter no. 1
5	shutter no. 2
6	rotation of crucible source 1
7	rotation of crucible source 2
8	shutter no. 3
9	shutter no. 4
10	source 1 (gun 1) (L1)
11 (bottom)	source 2 (gun 2) (L2)

Analog channels: 1 = source 1 (L1)
2 = source 2 (L2)
3 = source 3 (L3)
4 = source 4 (L4)

Program no. 6: gun with pot crucible and gun with 3-way crucible

Switch position of the miniature switches on the MC 101 plate:



Digital outputs on the OU 101

Bit no.	Signal	
0 (top)	rotation of substrate	
1	glow discharge	
2	---	
3	---	
4	shutter no. 1	
5	shutter no. 2	
6	rotation of crucible, source 1	
7	position bit	crucible, source 2
8	position bit	
9	position bit	
10	source 1 (gun 1) (L1)	
11 (bottom)	source 2 (gun 2) (L2, L3, L4)	

Analog outputs: 1 = source 1 (L1)
2 = source 2 (L2, L3, L4)

The positions, 1, 2 and 3 of the miniature switch on the right hand side allow the following operational modes:

Position	Function	
1	Program flow, cyclic	
	acyclic	
2	Power, contant	
	Rate regulation	
3	Pressure locking (PC 101)	
	no locking	

Initilializing the memory of the micro-computer:

The micro-computer must be initialized if the memory of the RAM with storage battery buffer has been erased by disconnecting or by a heavy discharge of the storage batteries.

In this step the miniature switches are set as follows:

The unit has to be switched on for 5 seconds. The initialization is not indicated. The flickering of the indicator lights of the BL 101 encountered in normal operation will not occur, in this case.

After the initialization has been completed, the two miniature switches are set at the desired mode of operation.

2.6.3. Programming

In order to assure an automatic program flow, several parameters have to be defined. A complete set of parameters has been assigend to each layer (L 1 to L 4). The input of these parameters has to be done as follows:

1) Selection of the layer (L1 to L4)
2) Selection of the parameter to be defined
3) Input of the numerical value
4) Actuation of "ENTER" button.

These parameters are stored in a memory which is protected against failures of the power supply and may be called up any time for verification or modification by proceeding with the steps (1) and (2) of the above summary only.

The following parameters must be selected:

(see description of the program flow)

TH	layer thickness in Å
R	rate in Å/sec
M	material constant (density of the material * geometry factor)
T1 to T4	process time elements in sec.
P1 to P4	Power in % of the available power
VP, TN, TV	PID-parameters of the source regulation. These parameters differ from source to source. Reasonable starting values are:

Source	P	I	D
Evaporator boats	0.5	2.0	0.2
E-gun	0.8	0.5	0.0

If a cyclical program flow has been selected, the layer thickness must be defined as follows:

1) Selection of L1
2) Selection of N
3) Input of the first 6 layers by means of the buttons with q numbers and "ENTER"
4) Selection of L2
5) Selection of N
6) Input of the layers 7 to 12 etc.

In this way, a sequence of up to 24 layers can be preselected. The termination of a layer sequence is effected by the input of the figure 0. Free space on the display must be filled with zeros.

Example: Programming the layer sequence 1, 2, 3, 2.

1) depress button L1
2) depress button N
3) depress button 1
4) depress button 2
5) depress button 3
6) depress button 2
7) depress button 0, over
8) depress button 0, fill
9) depress button "ENTER".

					1
				1	2
			1	2	3
		1	2	3	2
	1	2	3	2	0
1	2	3	2	0	0
1	2	3	2	0	0

This input option is availabe only if the operational mode "PROGRAM FLOW, CYCLIC" has been selected by means of the miniature switch on the right hand side of the MC 101.

After actuating the "RUN" button, the preselected layer sequence is automatically processed.

In an acyclic program flow, each layer L1 to L4 must be selected individually and started by actuating the "RUN" button. In any event, the sequence of the layers can be selected as desired.

Operation with constant power

If a rate regulation is not required, the miniature switch, position 2, on the right hand side must be set at the operational mode "CONSTANT POWER". In this way, coating takes place at the constant power P3 at the termination of T4 when the shutter is opened. The coating period is a function of the layer divided by the rate.

Pressure interlock via pumping station control system "Vacuum Controller PC 101"

The start of the coating process and the operation of the source can be locked by means of the pressure conditions. If this is desired, the operational mode "PRESSURE LOCKING" must be selected by position 3 of the miniature switch on the right hand side of the MC 101.

In this way, the start of the program ("RUN") is released only when the plate valve of the "Vacuum Controller PC 101" has been acknowledged as open. If this acknowledgement is lacking, the flashing display with the error code 0100 will appear.

After expiration of the time elements T1 and T2, the pressure back report P4 is verified. If P4 has not bee acknowledged as ok, the source will not be switched on. The flashing display of the error code 0011 will appear.

2.7. Error messages

Various errors which can be detected by the control computer MC 101 are signalled on the display of the KB 101 by flashing error codes. These errors will release various operational modes depending on the mementary operational condition.

2.7.1. Error code | | 0 0 0 1 | :

Quartz does not oscillate

a) if the program flow has not been started, the start is prevented,

b) after starting, but prior to the opening of the shutter, the process is interrupted,

c) if the coating operation is already in progress, the required coating period is extrapolated. In this step, the source is operated at the power P2. The coating period still required is a function of the layer thickness still lacking, divided by the rate defined for this source. Hence, this calculation is based on the fact that the defined rate is reached at the defined power P2.

2.7.2. Error code | | 0 0 0 2 | :

Quartz frequency smaller than 4 M Hz, the thickness of the layer on the quartz is excessive. The control behavior is identical with the error code 0001.

2.7.3. Error code | | 0 0 0 3 | :

Quartz frequency greater than 5 M Hz, incorrect quartz or defective quartz. The control behavior is identical with the error code 0001.

2.7.4. Error code | | 0 0 1 1 | :

Pressure P4 has not been reached.
This error code will appear only when the operational mode PRESSURE INTERLOCK PC 101 has been programmed on the MC 101. The pressure P4 will be verified after expiration of the time element T2. The time element T3 will be started only when P4 has been reached.

2.7.5. Error code | | 0 0 2 1 | :

Layer thickness is not reached properly.
The theoretical coating period is obtained by the desired thickness of the layer divided by the desired rate. If this period is exceeded by 50%, the coating process will be interrupted.

2.7.6. Error code | | 0 0 3 0 | :

Programming error
In the set of parameters for the layer to be coated, the thickness of the layer has been defined, but the material constant or the rate has been set at zero.

2.7.7. Error code | | 0 1 0 0 | :

Plate valve closed.
This error message appears only when the interlock over the Vacuum controller PC 101 has been programmed. This error will interrupt the process immediately.

The error code 0100 can also be displayed in conjunction with any other error code. If, as an example, it has been determined simultaneously that the quartz does not oscillate, the code 0101 will appear as a combination of (1) and (7).

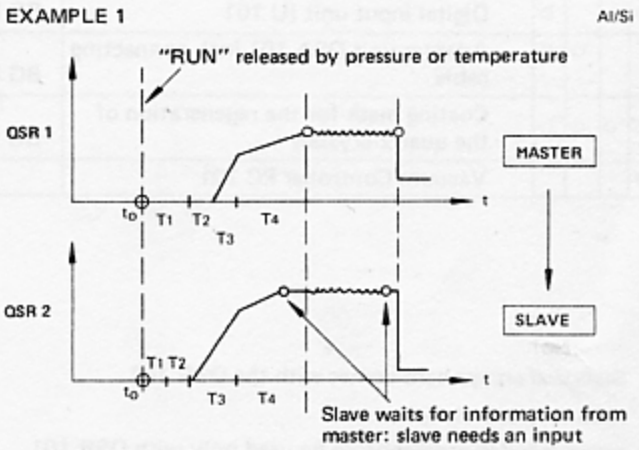
2.8. Remote control via input unit IU 101

An additional input unit IU 101 allows the remote control of some functions:

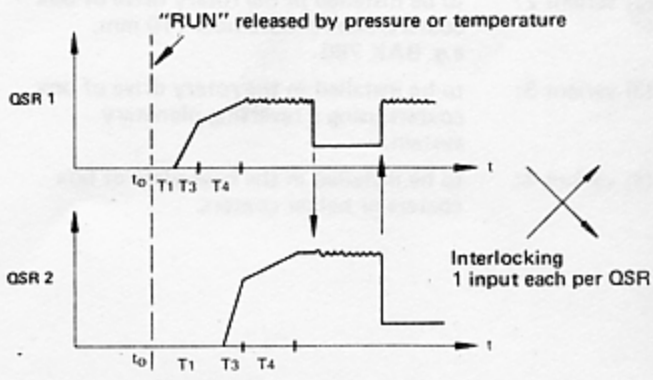
- starting the run: a pulse with a minimum duration of 1.0 s at the input 0 of the IU 101 provides the same function as would be obtained by starting with the "RUN" button.
- stopping the run: a pulse with a minmum duration of 1.0 s at the input 3 provides the same function as would be obtained by interrupting the run with the "RUN" button.
- delaying the coating operation: If the input 1 of the IU 101 is active, the shutter will not be opened at the termination of the time element T4. The source remains at the power P2.
- extending the coating operation: if the input 2 is active, the shutter will be kept open after the thickness has been reached, until input 2 has disappeared. The rate regulation continues.

By these remote control options the operation of two units can be synchronized.

EXAMPLE 1



EXAMPLE 2



2.9. Ordering information

BPU 100 E	QSR 101 A	QSR 101 B	QSR 101 C		
●	●	●	●	Power supply EPS 101	BG M29 000
●	●	●	●	Bus load module BL 101	BG 525 417 -T
●	●	●	●	Quartz measuring module QM 101	BG 525 636 -T
●	●	●	●	Micro-computer MC 101	BG 526 001 -T
●		●	●	Digital output OU 101	BG 525 460 -T
●			●	Analog output DA 101	BG 525 473 -T
●	●	●	●	Keyboard / Display KB 101	BG 525 613 -T
				Quartz measuring heads for layer thickness	
■	■	■	■	QSK 300 installation kit variant 1 (1)	BB 160 052 -T
■	■	■	■	QSK 300 installation kit variant 2 (2)	BB 160 053 -T
■	■	■	■	QSK 300 installation kit variant 3 (3)	BB 160 054 -T
■	■	■	■	QSK 300 installation kit variant 4 (4)	BB 180 020 -T
■	■	■	■	Quartz crystals QS 010, set of 10 pcs.	BN 845 104 -T
				Accessories	
○			○	Digital input unit IU 101	BG 525 476 -T
		○	○	Adapter unit QSA 101 incl. connecting cable	BG M42 250
○	○	○	○	Coating mask for the regeneration of the quartz crystals	BG 522 768 -T
●				Vacuum Controller PC 101	

- ● Standard component comes with the QSR 101
- ■ necessary accessory
- ○ recommended accessory; to be used only with QSR 101 models marked

(1) variant 1: to be installed in the rotary drive of box coaters, central bore-hole 55 mm, e.g. BAK 550.

(2) variant 2: to be installed in the rotary drive of box coaters, central bore-hole 110 mm, e.g. BAK 760.

(3) variant 3: to be installed in the rotary drive of box coaters using a reversing planetary system.

(4) variant 4: to be installed in the base plate of box coaters or belljar coaters.