

# High Frequency Generator and Reference Ballast HFG-03



## General Description

The High Frequency Generator and Reference Ballast (HFG-03) is suitable for measuring operating parameters of tubular fluorescent lamps (TFL) for general lighting purposes (IEC-81) and of one-head light tubes (IEC-901). The device was designed according to the conditions established by IEC-928 standard. The ballast unit in the HFG03 not same, like ballast unit in HFG-02. The difference: In the HFG-03 you can change the value of the ballast in 5 ohm steps, between 5 and 3100 ohm. The parasitic impedances may exceed the 1nF or 100µH. There are fix resistors (max. 10 pcs), their cabling and heating arrangement solve the low capacitance and inductance according the IEC 929.

Characteristic electric parameters of the output signs of the device:

- Frequency range: 20-100 kHz;
- Voltage range: 0...650 V;
- Load capacity: either max.1 A or max. 300 W;
- Reference ballast resistor: 10 fix value. According the IEC-929 standard.

The modular designed device consists of the following main parts:

### AC-DC converter module HFG03-300-1

The AC-DC module generates DC power from the 230 V mains. DC voltage power supply is providing a 0-250 V DC voltage (PS). Its load capacity exceeds 300 W over 80 V permanently. Its output is not isolated from the mains voltage.

### Generator Module HFG03-GEN-01

The Generator Module generates a 20-100 kHz frequency, max. 500 V amplitude square wave signal from the DC voltage. The other is a HF inverter (INV), which drives a transformer. The transformation ratio is 1:1.5. This transformer ensures the potential independence of the output of the unit. The module is a full bridge dc-ac inverter with MOS-FET elements and a high frequency transformer. The output is a square wave signal. The output amplitude depends on the input dc voltage.

### Filter Module HFG03-HG2-01

The module generates the base frequency sinus signal from the HF 20-100 kHz square wave coming from the power module filtering the harmonics. It measures the output voltage.

### Ballast Units HFG03-REF-1 and HFG03-REF-2

They have the built-in reference ballast resistors in 5 ohm steps.

### Cathode Heating Power Supply HFGCH-03

The implemented circuit generates two max 24 V independent supply voltages. It provides for the heater voltage of the cathode of the lamps with adequate conditions for stability and current loading. The isolation of its output potential independence is provided by a transformer.

The device requires 230 V, 50-60 Hz single-phase mains supply. Communication with the control host PC is possible through GPIB or via RS232 line. The BNC outlets for light tube supply are on the rear side.

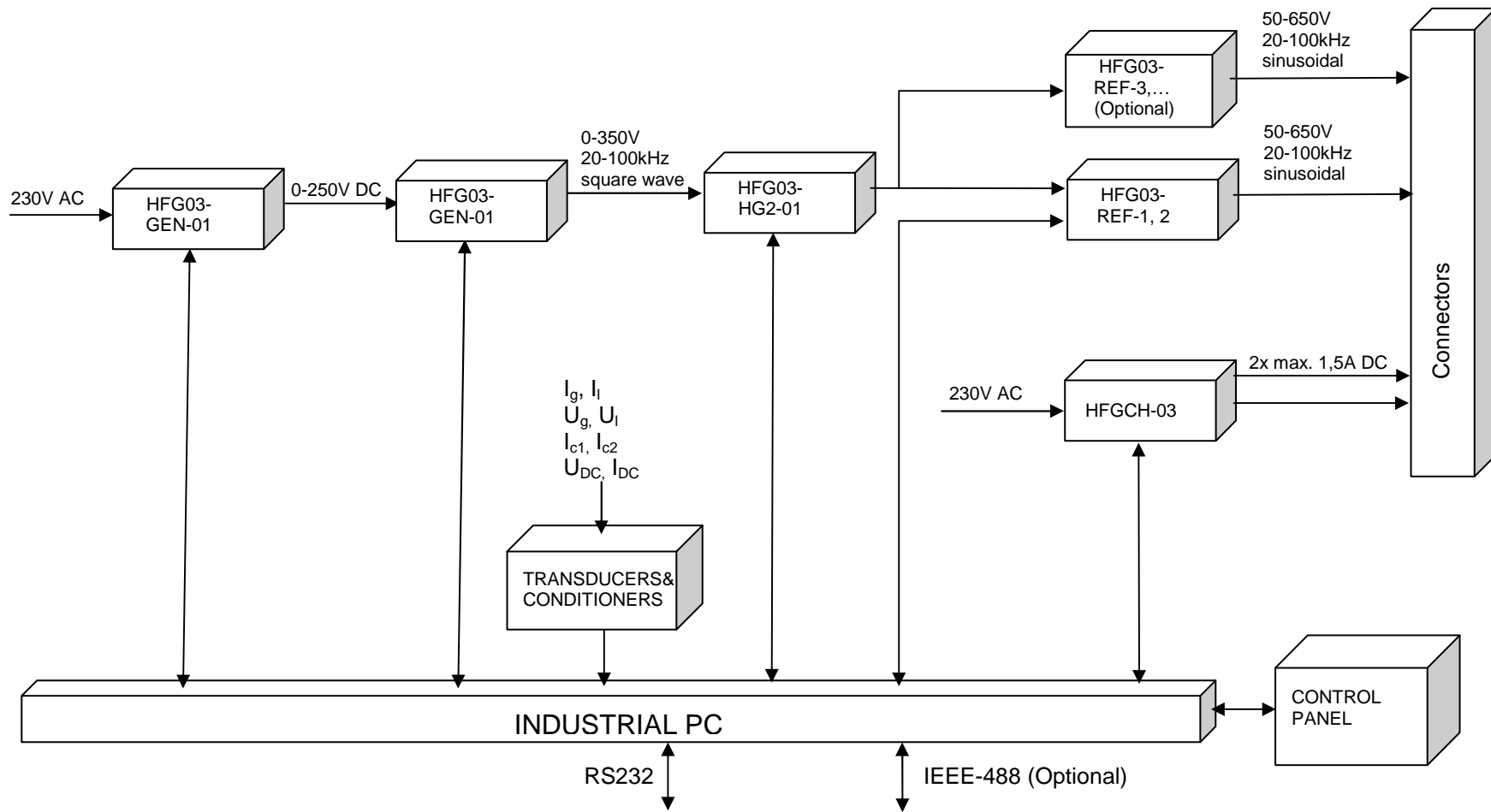
Options:

#### 1. GPIB interface

The base configuration not contains the GPIB interface. The interface joins the industrial pc in the equipment. The necessary software run on the pc.

#### 2. HFG03-REF-3, ... HFG03-REF-n

Each of these optional modules has 2-2 resistors with fix values. They are characterised by 1A or 300W load, low equivalent serial inductance (100µH) and parallel capacitance (1nF).



## Operation

There are four operational alternatives:

- Keeping constant voltage on the output of the generator;
- Keeping constant lamp current;
- Keeping constant lamp power;
- Ignition, then keeping constant generator voltage.

In case the user needs an external computer, the instrument can be connected by means of two different communication ports (RS-232 and IEEE-488). With simple commands, all parameters of the device are to be set or interrogated. For setting parameters or displaying measured values, in both cases of communication interfaces the same commands are used.

Optocoupler provide the isolation between the output of the generator and the PC-control. For the ease of handling, there are a push-button arrangement and a display on the front panel providing for the operation of the instrument, while the connections are located on the back panel.

The instrument measures the following operational parameters by means of computerized measuring channels:

- Generator Voltage  $U_g$
- Lamp Voltage: on the output of the ballast resistor;  $U_l$
- Lamp Current: in the measuring sphere with an external sensor;  $I_l$
- Generator Current: in the generator before the ballast resistor;  $I_g$
- Cathode Heating Current.  $I_{c1} I_{c2}$

Cabling in the power supply circuit is achieved through utilising low capacity coax cable, while in the heater and measuring circuits, by normal, low capacity coax cable. Tie-up of the DC calibration lamp, because of the high current loading, required high DC breakdown voltage isolated heavy feeder.

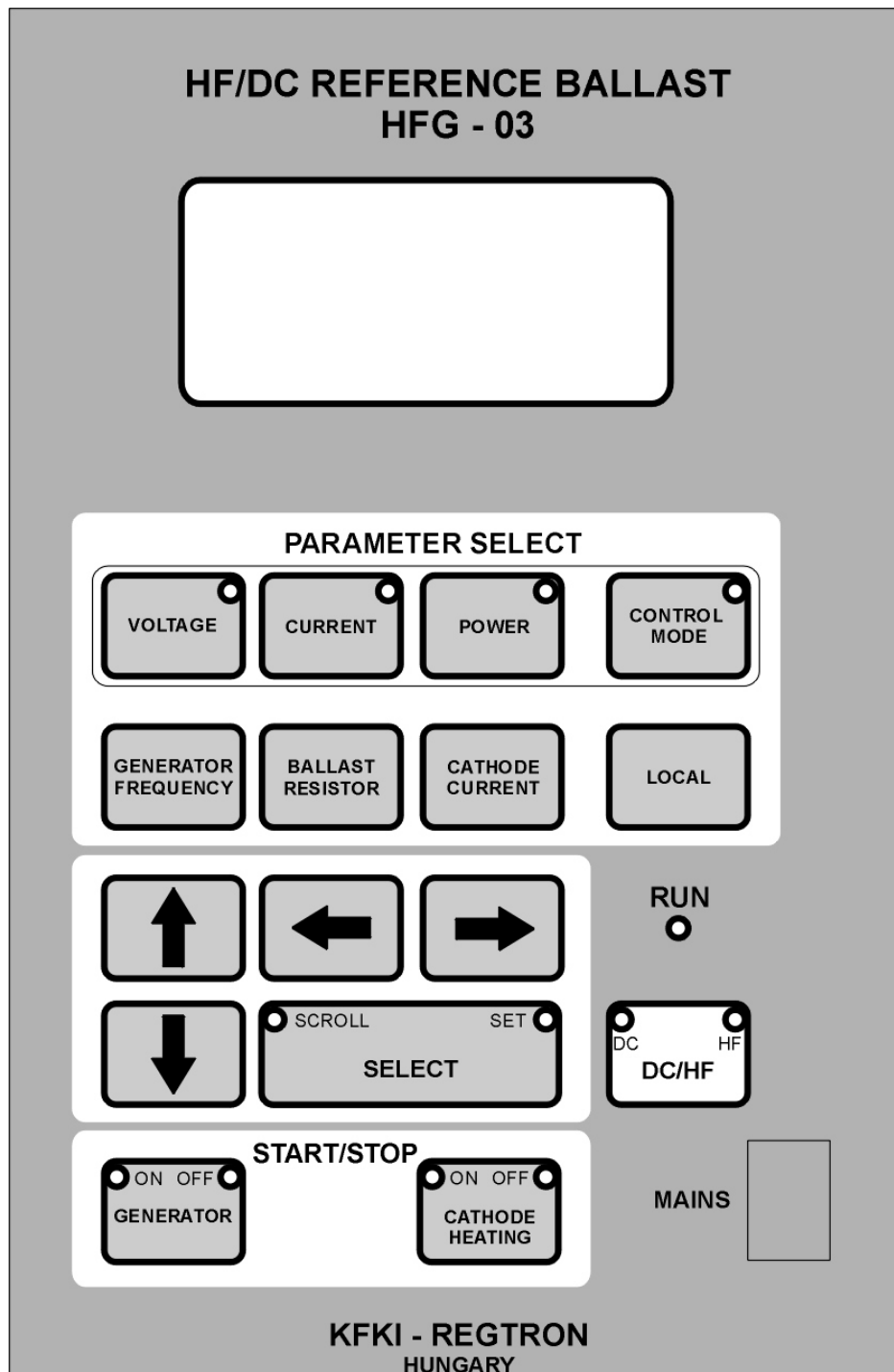
Because of the high dissipation of the ballast resistors fans positioned in the bottom part of the device ensure the removal of the heat.

When testing different types of lamps, the manufacturer-specified parameters can be set before starting the test. An error message is displayed when a value is exceeds the accepted tolerance. During the measurement, all set and measured parameters can be checked by means of push buttons and display on the front panel. When it is switched on, the instrument takes the last-set parameters.

The mechanical structure complies with the conditions required by the industrial environment; the rack wide 19" demands an environmental arrangement compliant with the heat power requirements (reduction of heat, humidity, etc.).

## Keypad and Display Panel

The display is an LCD or plasma display of 4 rows, 20 characters in each row. The keypad is composed of micro switches, which are positioned right below the proper icons on the plastic. They work by pressing them gently; a touch is not enough.



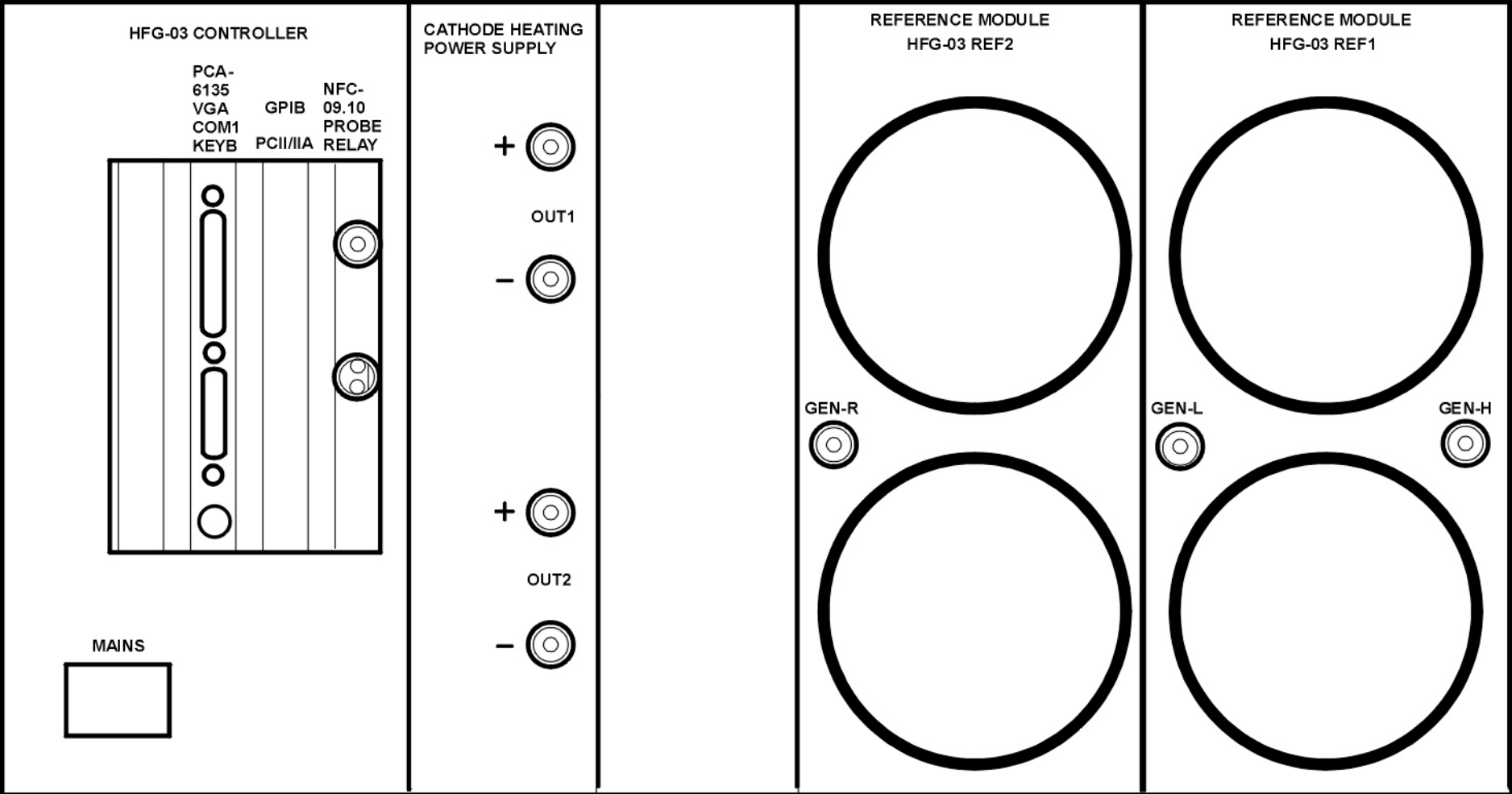
## Functions of Front Panel Controls

MAINS	Mains switch
HF GEN	HF generator switch on/off
CATHODE HEAT	Cathode Heating Module switch on/off
SELECT	Change between SCROLL and SET mode
CURSOR UP	Cursor to increase value or to shift parameters
CURSOR DOWN	Cursor to decrease value or to shift back parameters
CURSOR LEFT	Change digit to the left.
CURSOR RIGHT	Change digit to the right
LOCAL	Set "local" mode
BALLAST RESISTOR	Adjustment of value of ballast resistor
GEN. FREQ.	Adjustment of operating frequency of the generator
CATHODE CURRENT	Adjustment of current of Cathode Heating Module
ALL	Packed displaying
CTRL	Operating mode change after pressing key
VOLTAGE	Setting reference voltage or mode change after "CTRL"
CURRENT	Setting reference current or mode change after "CTRL"
POWER	Setting reference power or mode change after "CTRL"
LCD display 4x20 characters	Actual value of frequency, voltage, current, power; reference signals, time-out, operating modes, error messages
LEDs	
VOLTAGE	Generator works in voltage-controlled mode
CURRENT	Generator works in current-controlled mode
POWER	Generator works in power-controlled mode
SCROLL	Scroll parameters with cursors
SET	Set parameter value with cursors
LOC	Local mode
HF GEN, ON	HF generator works
CATHODE HEAT. ON	Cathode Heating Module works
REM	Remote mode
WORK	CPU works
REMOTE	Computer control

## Rear Panel Connectors

The connections of the instrument are on the left side of the back panel, the device controls are on the right part of the front panel.

R	supply voltage of the TFL, branch lead through the resistors
L	supply voltage of the TFL
H	measuring point of generator voltage, before resistors
HEATING OUT1-	first cathode heating negative pole (-24V1)
HEATING OUT1+	first cathode heating positive pole (+24V1)
HEATING OUT2-	second cathode heating negative pole (-24V2)
HEATING OUT2+	second positive pole (+24V2)
IEEE 488	IEE488 connector
RS-232	standard serial line port
PROBE	cathode heating relay control connector, 4 poles
PREAMP	measuring preamplifier connector; lamp current sign input, gain control output
MAINS	mains supply voltage input
MAINS OUT	mains supply voltage output to preamplifier



## Serial Line and GPIB Communication

Syntax of the commands of serial line and GPIB communication is the same. And now, the adjustment of serial line:

Characteristics of serial transmission

- Type of the line: RS-232
- 8 bits
- 2 STOP bits
- 9600 Baud rate
- no parity verification

A command always ends with a “;” character.

After entering a command:

    If it is executable, it returns “ok”;

    If not, it returns, “err” messages.

Setting REM/LOC Modes:

If the instrument detects a command from serial or GPIB line, it automatically changes into or remains in REMOTE mode (i.e. which makes possible the control from serial line). In REMOTE mode REM light is on. LOCAL mode (i.e. which makes possible the control from the front panel) can be set in two ways:

- From serial (GPIB) line by ordering “LOCAL;” command,
- Pressing LOCAL key on the front panel.

In LOCAL mode LOC light is on.

Start and Stop Commands

G:START;	Generator ON
G:STOP;	Generator OFF
C:START;	Heating ON
C:STOP;	Heating OFF



## Parameter Adjusting Commands

Command	Function	Operating range	
P00=XXX;	Setting control method	0 ... 3 *	
P01=XXX;	Setting voltage base signal (V)	50 ... max. gen. voltage (P10)	
P02=XXX;	Setting current base signal (mA)	50 ... max. gen. current (P11)	
P03=XXX;	Setting power base signal (W)	1...max. gen. power (P12)	
P04=XXX;	Setting ballast resistor value ( $\Omega$ )	5 ... 3200	
P05=XXX;	Setting generator frequency (kHz)	20,0...100,0	
P06=XXX;	Don't used		
P07=XXX;	Don't used		
P08=XXX;	Adjusting cathode heating current (mA)	0 ... 1500	
P09=XXX;	Setting cathode heating time (s)	0 ... 10000	
P10=XXX;	Max. generator voltage (V)	10 ... 650	
P11=XXX;	Max. generator current (mA)	10 ... 1000	
P12=XXX;	Max. generator power (W)	1 ... 300	
P13=XXX;	Initial current (mA)	1 ... 1000	
P14=XXX;	Following method of base signal	0:FIX; 1:AUT.	
P15=XXX	Loading previously stored parameters	0...10	
P16=XXX	Storing a complete parameter setting	0...10	
P17=XXX	Choosing measurement instrument	Current	Lamp voltage
		0 internal	internal
		1 external	internal
		2 internal	external **
		3 external	external
P18=XXX	GPIB address	0...30	
P19=XXX	Modify distortion correction factor.	0.1...2.0	

\* 0 : Simplified control. (without backward, hold the last parameters)

1 : Controlling by voltage base signal.

2 : Controlling by current base signal.

3 : Controlling by power base signal.

\*\* The external lamp voltage measurement not working in this case.

## Inquiry Commands

Command	Function	Possible values
?G;	Generator status	GEN:ON GEN:OFF
?C;	Cathode heating status	HEAT:ON HEAT:OFF

Command	A=(Actual value)	S=(Base Signal)
?00;	Control method	Control method
?01;	Actual value of Gen. Voltage (V)	Base signal of Gen. Voltage (V)
?02;	Actual Value of Gen. Current (external or internal current meter) (mA)	Adjusted value of Gen. Current (internal current meter)/lamp current (external current meter) (mA)
?03;	Actual Value of Gen. Power (W)	Adjusted value of Gen. Power (W)
?04;	Actual value of ballast resistor ( $\Omega$ )	Adjusted value of ballast resistor ( $\Omega$ )
?05;	Generator frequency actual value (kHz)	Generator frequency adjusted value (kHz)
?06;	Actual value of Lamp voltage (internal) (V)	Actual value of Lamp voltage (external) (V)
?07;	Actual value of Lamp current (internal) (mA)	Don't used
?08;	Actual value of cathode heating current (mA)	Adjusted value of cathode heating current (mA)
?09;	Actual value of cathode heating timer (s)	Adjusted value of cathode heating timer (s)
?10;		Adjusted value of max. generator voltage (V)
?11;		Adjusted value of max. generator current (mA)
?12;		Adjusted value of max. generator power (W)
?13;		Adjusted value of initial current (mA)
?14;		0:FIX; 1:AUT.

## Adjusting the Operating Mode of the Instrument

The following parameters have to be specified when the generator is used first (for the ignition of the lamp):

- Operating Mode
- Reference signal
- Ballast resistor
- Frequency
- Maximum voltage, current and power, according to the rated data of the lamp
- Heater current
- Initial current

When the required parameters are specified, you can start the generator. If stand-by heating is required, switch on the cathode heating, then (in general after a few seconds) the generator. When the lamp is on, you can switch off cathode heating. After measuring you can switch off the generator. If needed, after adjusting parameters, you can start a new measurement.

### Switching on the instrument

Use MAINS toggle switch placed on the right bottom corner of the front panel to apply voltage to the device. After 30 seconds (typical) initialisation the device is ready for use.

### Switching on the generator

After specifying all required parameters, by pressing HF GENERATOR key you can start the generator. "OFF LED" goes out and "ON LED" lights up. By pressing button once again, the generator turns off.

On serial line: G: START; and G: STOP;

### Switching on cathode heating

After specifying all required parameters, by pressing HEATING key you can start cathode heating. OFF led goes out and ON led lights up. By pressing button once again, the heating turns off.

On serial line: C: START; and C: STOP;

### Changing operating mode

There are four operational alternatives:

- Keeping constant voltage on the output of the generator;
- Keeping constant lamp current;
- Keeping constant lamp power;
- Ignition, then keeping constant generator voltage.

Between operating modes you can change at any time (even when the generator is on or off). The change can be done in two ways. The initial value of the new mode becomes either a pre-set value or the actual value at change over.

### Voltage-controlled mode

- Press "Control" button, led on "Control" button lights up, while the led signing the preceding mode stays alight
- Press "Voltage" button, led on "Voltage" button lights up, the led of the preceding mode goes out
- The reference voltage is the actual reference signal measured at change
- If initial current is not 0, the reference voltage will be effective only after reaching the specified current value
- On serial line: P00=1.

### Current-controlled mode

- Press "Control" button, led on "Control" button lights up, while the led signing the preceding mode stays alight
- Press "Current" button, led on "Current" button lights up, the led of the preceding mode goes out
- The reference current is the actual reference signal measured at change
- On serial line: P00=2.

#### Power-controlled mode

- Press “Control” button, led on “Control” button lights up, while the led signing the preceding mode stays alight
- Press “Power” button, led on “Power” button lights up, the led of the preceding mode goes out
- The reference power is the actual reference signal measured at change
- On serial line: P00=3.

#### Adjusting parameters

On the display, a row belongs to each parameter. On the left end of the row, the measured or actual value, on the right end, the specified value is shown. When in “Scroll” mode, use ↑ and ↓ buttons to move the cursor up and down between rows.

#### Adjusting generator voltage

- Press “Voltage” button, the row of the generator voltage becomes active on the display
- Press “Select” button, the cursor jumps from the measured value to the reference signal
- Use ← and → buttons to change digit, and ↑, ↓ buttons to change the value of the actual digit
- Changes become effective immediately (already when it is being changed)
- On serial line: P01=XXX; If XXX=200, the adjusted value is 200V.

#### Adjusting generator current

- Press “Current” button, the row of the generator current becomes active on the display
- Press “Select” button, the cursor jumps from the measured value to the reference signal
- Use ← and → buttons to change digit, and ↑, ↓ buttons to change the value of the actual digit
- Changes become effective immediately (already when it is being changed)
- On serial line: P02=XXX; If XXX=200, the adjusted value is 200mA.

#### Adjusting lamp power

- Press “Power” button, the row of the lamp power becomes active on the display
- Press “Select” button, the cursor jumps from the measured value to the reference signal
- Use ← and → buttons to change digit, and ↑, ↓ buttons to change the value of the actual digit
- Changes become effective immediately (already when it is being changed)
- On serial line: P03=XXX; If XXX=200, the adjusted value is 200W.

#### Adjusting ballast resistor

- Press “Ballast Resistor” button, the row of the ballast resistor becomes active on the display
- Press “Select” button, the cursor jumps from the actual value to the pre-set value
- Use ← and → buttons to change digit, and ↑, ↓ buttons to change the value of the actual digit
- It is adjustable only when the generator is off, if not, the adjustment is ineffective
- On serial line: P04=XXX; If XXX=200, the adjusted value is 200Ω.

#### Adjusting cathode heating current

- Press “Heating” button, the row of the cathode current becomes active on the display
- Press “Select” button, the cursor jumps from the actual value to the preset value
- Use ← and → buttons to change digit, and ↑, ↓ buttons to change the value of the actual digit
- It is adjustable only when the generator is off, if not, the adjustment is ineffective
- On serial line: P08=XXX; If XXX=200, the adjusted value is 200mA.

#### Adjusting cathode heating time

- Use ↑ and ↓ buttons to move cursor to “cathode heating time” row (Hint: Heating button and ↓ button is a quick move)
- Press “Select” button, the cursor jumps to the pre-set value
- Use ← and → buttons to change digit, and ↑, ↓ buttons to change the value of the actual digit
- On serial line: P09=XXX; If XXX=10000, the adjusted value is 10000s.

#### Adjusting maximum voltage

- Use ↑ and ↓ buttons to move cursor to “maximum voltage” row (Hint: Heating button and ↓ button is a quick move)
- Press “Select” button, the cursor jumps to the pre-set value
- Use ← and → buttons to change digit, and ↑, ↓ buttons to change the value of the actual digit
- Changes become effective immediately (already when it is being changed)
- On serial line: P10=XXX; If XXX=200, the adjusted value is 200V.

#### Adjusting maximum current

- Use ↑ and ↓ buttons to move cursor to “maximum current” row (Hint: Heating button and ↓ button is a quick move)
- Press “Select” button, the cursor jumps to the pre-set value
- Use ← and → buttons to change digit, and ↑, ↓ buttons to change the value of the actual digit
- Changes become effective immediately (already when it is being changed)
- On serial line: P11=XXX; If XXX=200, the adjusted value is 200mA.

#### Adjusting maximum power

- Use ↑ and ↓ buttons to move cursor to “maximum power” row (Hint: Heating button and ↓ button is a quick move)
- Press “Select” button, the cursor jumps to the pre-set value
- Use ← and → buttons to change digit, and ↑, ↓ buttons to change the value of the actual digit
- Changes become effective immediately (already when it is being changed)
- On serial line: P12=XXX; If XXX=200, the adjusted value is 200W.

#### Adjusting initial current

- Use ↑ and ↓ buttons to move cursor to “Ii” row (Hint: Heating button and ↓ button is a quick move)
- Press “Select” button, the cursor jumps to the pre-set value
- Use ← and → buttons to change digit, and ↑, ↓ buttons to change the value of the actual digit
- On serial line: P13=XXX; If XXX=200, the adjusted value is 200mA.

If the value of the initial current is not 0mA, then the reference signal set at switch-on will become effective only after the initial current has been reached.

#### Setting control mode

- Use ↑ and ↓ buttons to move cursor to “CTRL MODE” row (Hint: Heating button and ↓ button is a quick move)
- Press “Select” button, the cursor jumps to the pre-set value
- Use ↑ and ↓ buttons to scroll and choose between AUT and FIX alternatives
- On serial line: P14=XXX; If XXX=0, the set mode is FIX, if XXX=1, it is AUT.

In FIX mode, the pre-set reference signals do not change. In AUTO mode, the reference signals of the non-actual control mode are actualised by the appropriate measured value. Ex.: You are in current-controlled mode and you change (while the generator is on) into voltage-controlled mode. Now, the reference voltage will be the generator voltage measured at the moment of change. This applies to each mode changes.

#### Loading from memory

- Use ↑ and ↓ buttons to move cursor to “MEMORY LOAD” row (Hint: Heating button and ↓ button is a quick move)
- Press “Select” button, the cursor jumps to the pre-set value
- Use ↑ and ↓ buttons to scroll and choose between stored settings
- Press “Select” button to load the selected settings

#### Saving to memory (There are 10 memory places).

- Use ↑ and ↓ buttons to move cursor to “MEMORY SAVE” row (Hint: Heating button and ↓ button is a quick move)
- Press “Select” button, the cursor jumps to the pre-set value
- Use ↑ and ↓ buttons to scroll and choose between stored settings
- Press “Select” button to save the settings

#### Selecting current meter

- Use ↑ and ↓ buttons to move cursor to “PREAMPP:” row (Hint: Heating button and ↓ button is a quick move)
- Press “Select” button, the cursor jumps to the pre-set parameter
- Use ↑ and ↓ buttons to scroll and choose between INT (internal current meter) and EXT (external current meter)

#### Setting GPIB address

- Use ↑ and ↓ buttons to move cursor to “GPIB ADDR” row (Hint: Heating button and ↓ button is a quick move)
- Press “Select” button, the cursor jumps to the pre-set parameter
- Use ↑ and ↓ buttons to find the required value (default 23)

## Specification

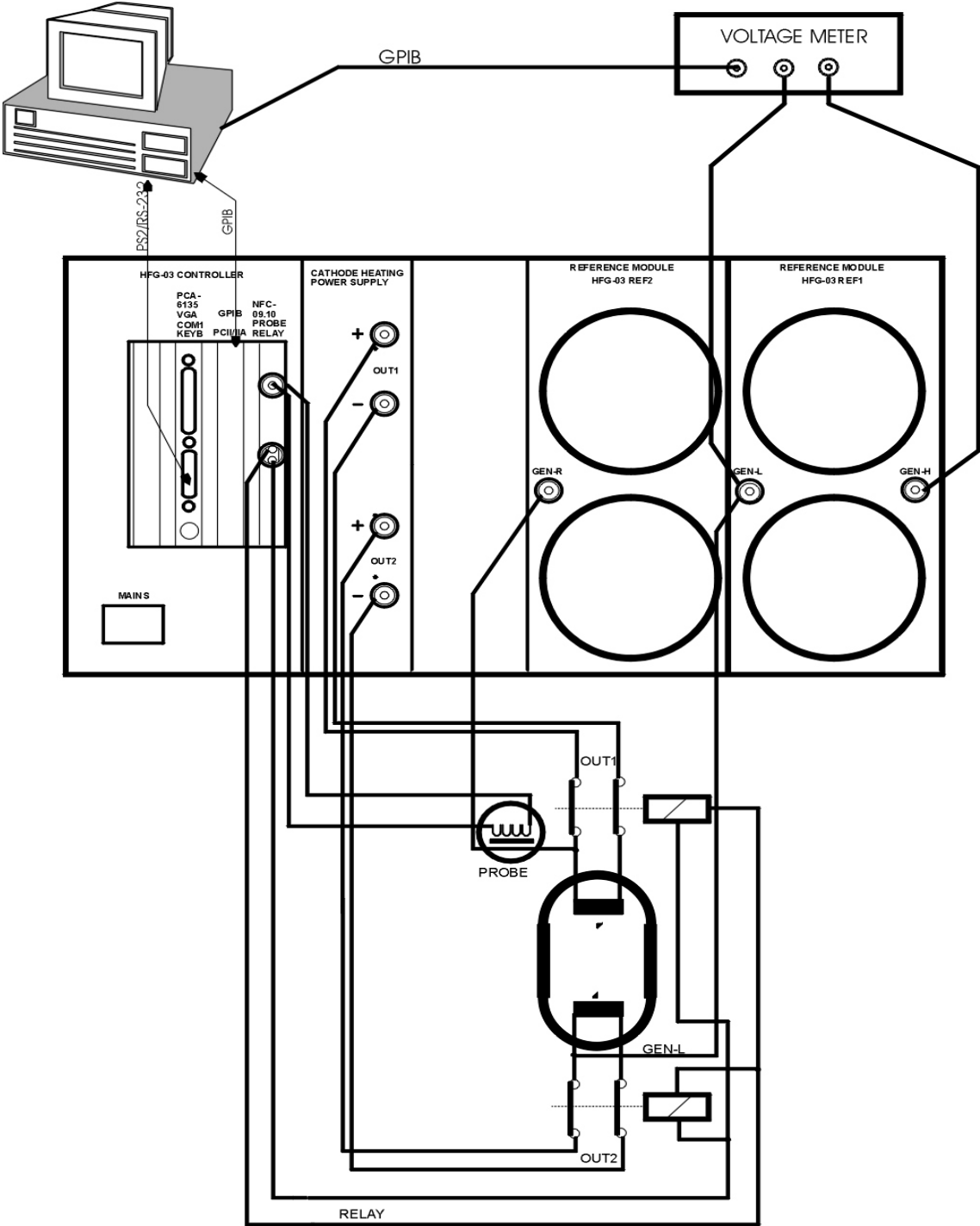
1		High Frequency Generator	
1.1	Frequency		
	- Range	20 kHz...100 kHz	Adjustable
	- Deviation	$\pm 0.01 \%$	
	- Resolution	0.1 kHz	Minimal frequency step
1.2	Amplitude		
	- Range	100 V <sub>eff</sub> ...650 V <sub>eff</sub>	Adjustable
	- Max. 3s (optional)	800V <sub>eff</sub>	
	- Deviation	$\pm 3 \%$	Rated to adjusted value
	- Resolution	$\pm 1$ V <sub>eff</sub>	Min. voltage step
	- Distortion	3 %	Min. 150 $\Omega$ ballast resistor
1.3	Maximum load capacity	Max. 300 W	The max. current 1A.
1.4	Voltage controlled operation		
	- Range	100 V <sub>eff</sub> ...650 V <sub>eff</sub>	
	- Load stability	$\pm 3 \%$	Rated to adjusted value
	- Temperature stability	$\pm 0,1 \%/^{\circ}\text{C}$	
1.5	Current controlled operation		
	- Range	0,01 A...1 A	
	- Current stability	$\pm 3 \%$ ( $I > 0,1\text{A}$ )	Rated to adjusted value
	- Load stability	$\pm 3 \%/1 \text{ A}$	
	Temperature stability	$\pm 0,1 \%/^{\circ}\text{C}$	
1.6	Power controlled operation		
	- Range	0.1 W...100 W	Lamp power
	- Power stability	$\pm 3 \%$ ( $P > 10\text{W}$ )	Rated to adjusted value
	- Load stability	$\pm 3 \%/1 \text{ A}$	
	Temperature stability	$\pm 0,1 \%/^{\circ}\text{C}$	
1.7	Adjustable Parameters	- Frequency - Voltage - Current - Power - On/Off	
1.8	Measuring channels	- Generator voltage - Generator current	10 V <sub>eff</sub> ...650 V <sub>eff</sub> / $\pm 2 \%$ 0,01 A...1,5 A/ $\pm 2 \%$
2		Reference Ballast	
2.1	Type	resistive	Serial inductance: max. 0,1 mH. Parallel capacity: max. 2 nF.
	Range	5...3100 ohm	Adjustable 5 ohm steps.
	Accuracy	$\pm 0,5 \%$ $\pm 1 \%$	at calibration current. At 50-115% of calibration current
2.2	Adjustable Parameters	- Resistor value - On/ Off	
2.3	Measuring channels	- Lamp voltage (int) - Lamp voltage (ext) - Lamp current (ext)	10 V <sub>eff</sub> ...650 V <sub>eff</sub> / $\pm 2 \%$ 10 V <sub>eff</sub> ...650 V <sub>eff</sub> / $\pm 2 \%$ 0,01 A...1,5 A/ $\pm 2 \%$
3		Cathode Heating PS	
3.1	Type	Dual, potential free	Controlled ON/OFF
	Current range	0,1 A...1,5 A	Adjustable
	Output voltage	Max. 24 V	
	Isolation voltage between outputs	1 kV	
	Overload protection	Max. 2 A	
	Resolution	10 mA	
3.2	Adjustable Parameters	- Current - On/Off	
3.3	Measuring channels	- Cathode current	0,01 A...2A/ $\pm 2 \%$

4		DC PS	
4.1	Type	Potential free	Controlled ON/OFF
	Current range	0,1A...10A	Adjustable
	Stability	0.1%	
	Output voltage	10...125PDV	Adjustable
	Stability	0.1%	
4.2	Adjustable parameters	Current Voltage On/Off	
5	Device specific settings	- Rem/loc operation - Xitron On/Off	
6	Communication	GPIO, RS 232A	
7	Dimensions	Height 221,5 mm (5U) Width 482 mm (19 ) Depth 660 mm	Without handler
8	General Parameters		
	Weight	Kb. 30 kg	
	Operating temperature range	10 °C...30 °C	
	Relative humidity	Max. 80 %	
	Mains	230 V ± 10 %/ Max. 600 W	



# Installation at Measuring Stations

Cabling a measuring station



Id: HFG0301-RACK-00-W-01-1

Highly recommend for you: Use the external current sensor, because that sense the real lamp current.

The "Rel1" and "Rel2" disconnect the cables of cathode heating if the generator working (on state) AND the cathode heating power supply is off state. This way the parasitic capacitance may decrease.

#### Connectors

The connections of the instrument are on the left side of the back panel, the device controls are on the right part of the front panel.

GEN-R	supply voltage of the TFL, branch lead through the resistors
GEN-L	supply voltage of the TFL
GEN-H	measuring point of generator voltage, before resistors
OUT1-	first cathode heating negative pole (-24V1)
OUT1+	first cathode heating positive pole (+24V1)
OUT2-	second cathode heating negative pole (-24V2)
OUT2+	second cathode heating positive pole (+24V2)
IEEE 488	IEE488 connector (optional)
RS-232	standard serial line port
RELAY	cathode heating relay control connector, 2 poles
PROBE	external current sensor
MAINS	mains supply voltage input
DC OUT+	dc calibration lamp supply voltage + (optional)
DC OUT-	dc calibration lamp supply voltage - (optional)
VGA	standard vga monitor (service)
Keyboard	standard PS2 keyboard (service)