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G4-143x Millimetre Wave Oscillator

(With BWO Modules and Plug-in BWO Section Installed)

Operation manual
(1st edition, 10.01.2000)

G4-143x Millimeter Wave Generator.
(With BWO Modules and Plug-in BWO Section Installed)

User Manual.

Contains.

1. GENERAL REMARKS.....3
2. EXPLOITATION.....3
3. PARAMETERS.....3
4. RELIABILITY.....4
5. CONSTRUCTIVE PARAMETERS.....4
6. PRINCIPLE OF OPERATION.....4
7. OPERATION MANUAL.....7
8. HOW TO TURN ON THE GENERATOR.....7
9. PURSUANCE OF MEASUREMENTS.....8
10. GPIB INTERFACE.....13
11. EXAMPLE OF OPERATION USING GPIB INTERFACE.....14

Supplements.....19
1. Front panel of the Generator.....19
2. Front panel of the Generator.....20
3. Disposition of the units in the Generator.....21
4. Block diagram of the control unit.....22
5.The structure of the calibration files.....23
6. The diagram of the Control Voltage and strobes.....24
7. Output power versus frequency…….25-27
8. Frequency versus Control voltage, Frequency versus High voltage monitor…….28-30
9. Electrical Scheme of BWO Tube…….31
10. Example of programming……..32
11. Step by step instruction: Setting Power Level and Fixed Frequency……34
12. Support BWO Module in plug-in BWO section……..…37

1. GENERAL REMARKS

1.1. Microwave generator G4-143x, hereinafter called Generator, is intended to be used as a signal source in the millimetre range of wavelengths for tuning and adjustment of the radio-electronic device.
1.2. The Generator may be used in laboratory conditions.

2. EXPLOITATION

Conditions:

operations temperature:	5°-40° C°
relative air humidity :	up to 95% at the temperature 30° C°
primary power:	AC(220±10)V/(50±0.5)Hz
atmospheric pressure:	84-112 kPa.

Some abbreviation, used hereinafter:

BWO - Backward Wave Oscillator
VSWR - Voltage Standing Wave Ratio
CW - Continuous Wave
OA - Operating Amplifier
LCD - Liquid Crystal Display

3. PARAMETERS

3.1. Frequency range is determined by BWO Modules installed in plug-in BWO section. Three BWO Modules provide the following frequency bands: 50-75GHz, 75-110GHz and 110-170GHz. Device has a reserve more then 1% at the edges of the range.
3.2 Full one band sweep time: less then 200 microseconds with external frequency control, 10 milliseconds with internal frequency control.
3.3. Admissible variation of the frequency of unmodulated oscillation, if primary power voltage changes up to ±10% for AC 50Hz, is no more than ±0.05%.
3.4. Relative variation of frequency of the output signal is no more than 10^{-4}, if the load VSWR changes from 1.1 to 1.3 at the output power 1mW. Output power should be installed using an external attenuator.
3.5. Limit of instability of the frequency of unmodulated oscillations at the unchanged primary power voltage during any 15 min of work is 0.01% (the warm-up time after adjustment from one frequency to another must be no less than 5 min).
3.6. 50 Hz deviation of the frequency of the CW output signal is no more than 0.002% in the mode with the frequency control by means of an external voltage.
3.7. Guaranteed power level of unmodulated oscillations is no less than 30 mW at the load VSWR no larger than 1.3 within frequency region 50-170 GHz.
3.8. The limit of instability of the output power level of unmodulated oscillation at the unchanged environment and primary power voltage during any 15 min of work is ±0.3dB (the warm-up time after adjustment from one frequency to another must be no less than 5 min).
3.9. Admissible variation of output power level of unmodulated oscillation at slow 10% variation of primary power voltage for AC 50Hz, is no more than ±0.5dB.
3.10. 50 Hz AM level of output CW signal is no larger than 1%.
3.11. VSWR of output of the Generator is no more than 1.5:1 at the 1 mW output power.
3.12. Output waveguide and flanges: WR-15 with UG-385/U for 50-75GHz frequency band, WR-10 with UG-387/U-M for 75-110GHz frequency band and WR-6 with UG-387/U-M for 110-170GHz frequency band.

3.13. Internal square-wave modulation frequency, kHz 1.
3.14. External square-wave modulation frequency, kHz 1-100.
3.15. External Power Control Voltage, V 0…+10.
3.16. External Frequency Control Voltage, V – see calibration files.
3.17. Operating modes CW:

Remote frequency and power regulation by an analogue voltage, frequency and power regulation from front panel and GPIB interface.

3.18. Electrical resistance between primary power line and the cabinet is no less than 100 MOhm; at high humidity – no less than 3 MOhm; at high temperature – no less than 5 MOhm.
3.19. All parameters mentioned above are valid after 30-min warming-up period.
3.20. Power consumption is no more than 400 VA.

4. RELIABILITY

4.1. Main time to failure, no less than 2000 h.
4.2. 90% life time, no less than 2 years.

5. CONSTRUCTIVE PARAMETERS

5.1. Dimensions of the generator 495x180x480 mm.
5.2. Dimensions of BWO Module 120x100x130 mm.
5.2. Weight generator with BWO Module, no more than 23 kg.

6. PRINCIPLE OF OPERATION

Generator is made up of the oscillator unit, control unit, modulator unit and power supply unit (Supplement. 3).

BWO Module is made up of BWO and high voltage isolator. BWO intended to generate UHF oscillations. High voltage isolator intended to isolate the BWO's cabinet being kept under high voltage, from grounded output waveguide.

Control unit is based on PC microcomputer. It is used together with digital to analogue converter as triangle wave voltage oscillator, for digital remote control of generator from front panel or by means GPIB bus.

Power supply unit includes the following parts. Controlled high voltage source for accelerating electrode of BWO. Controlled 5…230 V DC voltage intended to feed the modulator and BWO control electrode. DC 1.2 V voltage source intended to feed the BWO heater. DC +16 and –16 V voltage sources intended to feed OA's. DC +5 V voltage source intended to feed computer and relays. BWO current overload protection circuit intended to switch off the high voltage transformer, if load current of decelerator power supply is larger than 50 mA. Control voltage overload protection circuit is intended to switch off the BWO control electrode voltage, if deceleration voltage is lower than 300 V. This circuit allows also the BWO control electrode voltage to be supplied, if only the deceleration voltage higher than 300 V is presented on BWO's deceleration electrode, when the Generator is being turning on. BWO heater current overload protection circuit intended to limit the BWO heater current at the current spikes in the moment of Generator turning on. High voltage indication "READY" (3) circuit intended for signalling if decelerating voltage source is switched on.

Modulator unit intended to modulate amplitude of output signal depending on operating mode.

On the front panel of generator are installed the following controls (see Supplement 1):

Button “Power” (1) to turn on the generator and indicator “Power” to indicate condition of generator.

Liquid Crystal Display for indication of various regimes of Generator (5).

Tuning knob for frequency and power setting (6).

Two buttons for fine setting of frequency or power (7).

Digital Keyboard (8), Functions Keyboard (11-14).

Button “Power Control”(14) switches External or Internal Power Control modes. If LED on the button is glow it means that External Power Control mode is switched on. In External Power Control mode 0…+10VDC control voltage should be applied to the corresponding socket “Input” (No20 on the front panel) for a remote electrical manipulation of output BWO’s power. In Internal Power Control mode the power is controlled by microcomputer using DAC.

Button “Frequency Control” (11) switches External or Internal Frequency Control modes. If LED on the button is glow it means that External Frequency Control mode is switched on. In External Frequency Control mode DC control voltage (according calibration files) should be applied to the corresponding socket “Input” (10) for a remote electrical manipulation of output BWO’s frequency. In Internal Frequency Control mode the frequency is controlled by microcomputer using DAC.

Buttons “Amplitude Modulation” (13) switch on different modes of amplitude modulation: CW (“OFF” button), Internal 1 kHz Amplitude Modulation (“Internal” button), Amplitude Modulation with External Triggering (“External” button). TTL signal from an external pulse generator should be applied to corresponding plug (⎍⎍) (No19 on the front panel) for the triggering of External Amplitude Modulation mode.

Button “Reset” restarts built-in microcomputer (4).

Button “Menu” calls operation menu to LCD (12).

On the rear panel of generator the following controls are installed (see Supplement 2):

“AM INPUT” (19) for triggering of External Amplitude Modulation;

“POWER CONTROL” (20) is intended for a remote electrical manipulation of output BWO’s power in External Power Control Mode;

“Operating Time” counter (21).

“GPIB” for connecting the Generator to GPIB bus (22);

Ground socked (23).

Fuses (24 and 25).

“Power Plug” AC 220V (26).

“High Voltage Monitor” output plug (27) intended for an external checking up the frequency of the oscillation. Dependence of High Voltage Monitor output voltage versus frequency of oscillations is supplied in Supplement 8.

“Strobe AM signal”, output plug (TTL) (28).

“Strobe FM signal”, output plug (TTL) (29).

BWO is a heart of the Generator. Electrical Scheme of BWO is presented in Supplement 9. The Generator is functioning properly, if the following conditions are met:

- When turning on the power, the current spikes must be restricted;
- BWO control electrode voltage should appear if only deceleration voltage is present, and must be switched off in the opposite case;
- BWO control electrode voltage must not be higher than 237V.

BWO is a source of UHF oscillations, which a voltage of the decelerating system (Anode Voltage) controls frequency, and output power is controlled by a voltage applied to the control electrode.

BWO is connected in a grounded-cathode circuit. In this case the output waveguide of the BWO, as well as its cabinet, has a high electric potential relative the Generator cabinet, so the special high voltage isolator is used to isolate the BWO's output waveguide from the Generator's cabinet.

Setting the proper voltage on the BWO decelerating system provides the setting of the Generator's frequency. For this purpose the circuit is used which consists of the next parts:

- commutator;
- control unit;
- controlled high voltage source;
- BWO decelerating system.

Commutator provides a connection between control input of the High voltage power supply and external broadband frequency tune input (10), if "External Frequency Control" (11) is switched on.

Commutator provides a connection between control input of the High voltage power supply and control unit output, if "External Frequency Control" (11) is switched off.

Control unit provides:

- Linear control voltage with different full band Sweep Times (0.01, 0.02, 0.04, 0.08, 0.1, 0.2, 0.4, 0.8, 1, 2, 4, 8, 10, 20, 80, 100 Sec) in sweep frequency mode (see Supplement 6);
- Fixed DC voltage in fixed frequency mode.

There are two possibilities of the Control unit programming:

- Manual control, using front panel controls;
- Remote control, using GPIB bus.

Built-in microcomputer serves an indication of Initial and Final frequencies on the LCD display (5). The computer calculates corresponding frequency from the code of DAC that serves frequency control, using a base file "frequen(1,2 or 3).dat". Please refer to supplement 5. This file contains 4096 lines. Each line presents frequency at maximum output power corresponding digital to analogue converter code from 0 till 4095. At smaller output power the operation frequency is shifted a bit from the position corresponded to the maximum output power. Frequency shift between values at maximal and minimal power is about 1 GHz. Frequency shift is calculated by formula and used by microcomputer for indication of actual frequency. For example, initial and final frequencies of the sweep indicated on LCD are calculated this way.

Operating regime of the Generator is defined by BWO control electrode voltage (grid). In the CW regime this voltage is constant. In the Internal or External Amplitude Modulation regimes, this voltage is also symmetric rectangular pulse sequence with amplitude equal to the constant voltage in CW regime. In the External Power Control regime the voltage is user defined. In all regimes voltage applied to BWO control electrode must not exceed 237V.

The operating regime of the Generator is defined by a joint functioning of the next parts of the device:

- Operating regime switch;
- Modulator;
- 5-237 V controlled voltage source;
- BWO control electrode.

The BWO current overload protection circuit receives the signal proportional to the decelerating system current. When this current is larger than 50 mA, the circuit comes into action and disconnect the high-voltage transformer. In order to switch the high voltage source again, it is necessary to turn off and then turn on the power switch. The high incidence of activation of this circuit testifies that Generator is out of order.

The BWO control voltage overload protection circuit receives the signal proportional to the BWO decelerating system voltage. This circuit is a part of the modulator circuit. When BWO decelerating voltage falls down bellow 300 V, the BWO control electrode voltage is switched off. In particular, this circuit comes into action when high voltage transformer is switched off.

The BWO heater overload protection circuit is a part of heat stabiliser circuit. It provides the limitation of BWO heater current during the transition process at the turning on the Generator.

7. OPERATION MANUAL

ATTENTION! Before turning on the Generator, ensure that device is properly grounded using the corresponding contact "⊥".

When using the Generator connected with other electrical devices, the potentials of Generator and other devices must be equalised before the power is turned on. Mentioned actions are not needed if you sure, that the device is grounded in primary power plug.

It is prohibited to turn on the Generator unless a waveguide with a load is attached to the output waveguide of the Generator!

8. HOW TO TURN ON THE GENERATOR

A. Order taking out of BWO Module.

- Twist off four support screws (see Supplement 12);
- Simultaneously twist off two guideway screws for taking out BWO Module from plug-in BWO section.

B. Order installation of BWO Module.

- Put BWO Module in plug-in section up to connecting guideway screws with case of the generator;
- Push BWO Module to the end by twisting of guideway screws;
- Install four support screws.

All BWO Modules have electronic key, witch allows the generator to detect what BWO is installed. After switching on, the generator recognises type of BWO automatically and uses corresponded base file (frequen(1,2 or 3).dat) for operation.

C. Order switch on of the generator.

- Install BWO Module;
- Ground the Generator;
- Ensure that fuses are present;
- Attach a load to the output of Generator;
- Turn on the power. The "Power ON" indicator (2) must glow and in approximately 40s "READY " indicator (3) must glow as well. On LCD (5) a current time will be indicated and after about 4s the main menu will be activated;
- All settings are stored automatically in flash memory of microcomputer. Generator loads automatically last settings after switch on or restart. Every time the "10%" power level will be installed after the tuning on the Generator to avoid possible

problems with high power output. User should to install the higher power level, if it is needed in the experiment. Warm-up time is approximately 30 min.

9. PURSUANCE OF MEASUREMENTS

A. Frequency sweep mode.

In this mode Generator provides frequency sweep from the initial frequency to final one. User would program both frequencies, power and time of sweep. The sweep is provided by saw-tooth voltage. During Sweep Time Control Unit provides linear increasing of control voltage and then fast voltage decreasing during approximately 1 ms time. Pay attention that the sweep is provided by linear increasing control voltage, but frequency increases according the dependence of frequency versus control voltage that presented in Certification Card (see Supplements 8x).

There are two modes of frequency sweep: Internal and External Frequency Control modes.

· Turn on the Generator as directed in part 8.

· Set Internal Frequency control mode.
One should check LED “External” on the button “Frequency Control” (11). If LED not glows, it means that the device is installed in Internal Frequency Control mode. If LED glows, one should run command “Control” of menu pressing key “4” on keyboard. Press button “Frequency Control” to switch off LED on the button (11). To abort “Control” presses key “Menu”.

· Set External Frequency control mode.
One should check LED “External” on the button “Frequency Control” (11). If LED glows, it means that the device is installed in External Frequency mode. If LED glows, one should go to position “Control” of menu pressing key “4” on keyboard. Press button “Frequency Control” to switch on LED on the button (11). To abort “Control” presses key “Menu”.

There are two modes of power control: Internal and External Power Control modes.

· Set Internal Power control mode.
One should check LED “External” on the button “Power Control” (14). If LED not glows, it means that the device is installed in Internal Power Control mode. If LED glows, one should go to position “Control” of menu pressing key “4” on keyboard. Press button “Frequency Control” to switch off LED on the button (14). To abort “Control” presses key “Menu”.

· Set External Power control mode.
One should check LED “External” on the button “Power Control” (14). If LED glows, it means that the device is installed in External Power Control mode. If LED not glows, one should go to position “Control” of menu pressing key “4” on keyboard. Press button “Frequency Control” to switch on LED on the button (14). To abort “Control” presses key “Menu”.

· Set the desired sweep time, power level, initial and final frequency.
Press key “1” on Digital Keyboard (8) to activate “Set Up” local menu.
There are four commands in the local menu “Set Up”:

1. “Fr_intl” – set initial frequency;
2. “Fr_fnl” – set final frequency;
3. “Time_swp” – set sweep time;
4. “Power_lv” – set power level.

Press one of four keys from “1” to “4” to enter in local menu commands for example “1” – “Fr_intl”
Wait few seconds, if Generator asks that.
To enter the desired value one has three possibilities:

- Rotate Tuning Knob (6) and then press key “Menu” (12);
- Press buttons “Step” “<-“ or “->” (7) and then press key “Menu” (12). This way is useful if it is necessary to provide precision tuning. One button realising leads to the change of the value on the smallest available step;
- Enter frequency from Digital Keyboard (8). One can use buttons “Step” “<-“ or “->” (7) to change marker position. That allows edit the value on the display. Press key “Enter” to finish editing. Press key “Menu” (12).

One can combine these three cases.
If one enter the value using Digital Keyboard, Generator sets the nearest value from value grid that reflects the fact that output voltage of controlling 12-bits DAC’s can’t be installed with accuracy better then 1/4096.
In the case of Power Level, the grid is defined in percents of voltage applied to Control Electrode of BWO tube. In Supplements 7x dependencies of output power versus frequency for different voltage applied to control electrode (in percents) are presented. Control Unit indicates Output Power also in percents of control voltage applied, not in percents of real output power.
In the case of Sweep Time, only one of the following values could be installed: 0.01, 0.02, 0.04, 0.08, 0.1, 0.2, 0.4, 0.8, 1, 2, 4, 8, 10, 20, 80, 100 Sec. If one try to enter a value that isn’t fitted to the grid exactly, the fitting will be produced automatically.

Press “Menu” button (12) to abort local menu.

· To start sweep press key “2” on Digital Keyboard (8). Generator indicates initial and final frequencies of sweep and starts sweep. At the beginning of each sweep Generator produces TTL strobe pulses. Use Strobe Signal output plug (29) for the triggering of external devices at the moment of the sweep beginning (see Supplement.6).
To stop sweep press key “Menu”.

B. Fixed frequency mode.

At this mode the operation frequency is fixed.
Turn on the Generator as directed in part 8.
Set Internal Frequency and Power control as described in par. **A**.
Set the desired power level as described in par. **A**.
Press key “3” on keyboard to activate the local menu “Manual”.
Wait few seconds, if Generator asks that.
To enter the desired frequency one has three possibilities:

- Rotate Tuning Knob (6) and then press key “Menu” (12). Output operation frequency changes synchronously with value indicated on the display;
- Press buttons “Step” “<-“ or “->” (7) and then press key “Menu” (12). This way is useful if it is necessary to provide precision tuning. One button realising leads to the change of the frequency on the smallest available step. Output operation frequency changes synchronously with value indicated on the display;
- Enter frequency from Digital Keyboard (8). A marker will appear on the display just after the realising of one of the keys (8). One can use buttons “Step” “<-“ or “->” (7) to change the marker position. That allows edit the frequency on the display. Press key “Enter” to finish editing and change the output operation frequency. Press key “Menu” (12). If one will try to enter a wrong frequency, out of operating frequency range, max or min one available will be installed correspondingly.

One can combine these three cases.

If one enter the frequency using Digital Keyboard, Generator sets the nearest frequency from frequency grid that reflects the fact that output voltage of controlling 12-bits DAC’s can’t be installed with accuracy better then 1/4096. If one try to enter a frequency that isn’t fitted to the grid exactly, the fitting will be produced automatically.

Press “Menu” button (12) to abort local menu.

C. Zoom frequency window mode.

In this mode Generator provides frequency sweep in the vicinity of fixed frequency (See par. **B**). User would program zoom window width (0.25, 0.5, 1.0 or 2.0 GHz), power and time of sweep. The sweep is provided by saw-tooth voltage. Control Unit provides linear increasing of control voltage during Sweep Time and then fast voltage decreasing during approximately 1 ms time. Pay attention that the sweep is provided by linear increasing control voltage, sweep frequency range is small and linear approximation of the frequency dependence versus control voltage is taken into account within zoom window.

Turn on the Generator as directed in part 8.

Set Internal Frequency and Power control as described in par. **A**.

Set the desired power level as described in par. **A**.

Set the desired fixed frequency as described in par. **B**.

Press key “5” on Digital Keyboard (8) to activate local menu “Zoom”.

Set the desired zoom window width using the following command from the local menu:

1. 0.25 – set zoom width 0.25 GHz
2. 0.50 – set zoom width 0.5 GHz
3. 1.00 – set zoom width 1.0 GHz
4. 2.00– set zoom width 2.0 GHz

Press one of four keys from “1” to “4”. Generator sets zoom window width and returns automatically to main menu.

To start the sweep one should press key “6” on Digital Keyboard (8). Generator will indicate initial and final frequencies of sweep calculated using linear approximation and start the sweep. At the beginning of each sweep Generator produces TTL strobe pulses. Use Strobe Signal output plug (29) for the triggering of external devices at the moment of the sweep beginning (see Supplement.6). To stop sweep press key “Menu”.

D. Internal Amplitude Modulation mode.

Square wave 100% amplitude modulation with frequency 1 kHz is provided in this mode. Use Strobe Signal output plug (28) for the triggering of external devices.

- Turn on the Generator as directed in par. **A**.
- Set operating frequency and power level as described in par. **A-B**.
- Press key "4" on Digital Keyboard (8) to activate local menu "Control".
  Press button "Internal" in "Amplitude Modulation" group of buttons on Functional Keyboard (13) to switch on 1 kHz Internal Amplitude Modulation mode.
  Press button "Menu" to abort local menu "Control" and return to main menu. After that Generator will provide 1 kHz amplitude modulation.

E. External Amplitude Modulation mode.

Square wave 100% amplitude modulation with frequency of an external triggering source is provided in this mode.

- Turn on the Generator as directed in part 8.
- Set the desired frequency and power level as described in par. **A** – **B**.
- Press key "4" on Digital Keyboard (8) to activate local menu "Control".
- Press button "External" in "Amplitude Modulation" group of buttons on Functional Keyboard (13) to switch on External Amplitude Modulation mode.
- Feed the 5 V (TTL) positive pulses with a frequency in the range 1-100 kHz and duty ratio 2 (square wave) into the External Triggering Plug _⎍_ (16).
  Press button "Menu" (12) to abort local menu "Control" and return to main menu. After that Generator will provide amplitude modulation with frequency of the triggering signal.

F. External Power Control mode.

In this mode an external positive voltage 0…+10 VDC controls output power of Generator.

- Turn on the Generator as directed in part 8.
- Set output frequency as described in par. **A** or **B**.
- Set External Power control mode of Generator.
  One should check LED "External" on the button "Power Control" (14). If LED glows, it means that the device is installed in External Power Control mode. If LED not glows, one should go to position "Control" of menu pressing key "4" on keyboard. Press button "Frequency Control" to switch on LED on the button (14). To abort "Control" presses key "Menu".
- Feed the positive 0…+10 VDC voltage into the plug "Input" (15) "External Power Control". The higher voltage corresponds to the higher output power.

G. External Frequency Control mode.

In this mode an external positive voltage controls output frequency of Generator. *One should be very careful and applies voltage according calibration table (if do not allow this table one can break BWO tube):*

BWO Module	External Control Voltage
50 – 75GHz	+1.2 – +3.6 V
75 – 110GHz	+1.4 – +3.9 V
110 – 170GHz	+2.4 – +7.8 V

- Turn on the Generator as directed in part 8.
- Set output power as described in par. **A**.
- Set External Frequency control mode of Generator.
  One should check LED "External" on the button "Frequency Control" (14). If LED glows, it means that the device is installed in External Frequency Control mode. If LED not glows, one should go to position "Control" of menu pressing key "4" on keyboard. Press button "Frequency Control" to switch on LED on the button (14). To abort "Control" presses key "Menu".
- Feed the positive voltage (according calibration table) into the plug "Input" (10) "External Frequency Control". The higher voltage corresponds to the higher output frequency.

H. Save and load operation set-up.

Generator automatically saves all settings from par. **A**-**G** just after one changes these. Current set-up is stored in memory and loaded after restart. There are 10 user defined operation set-ups stored in flash memory. Each set-up consists of the following settings:

Initial frequency;
Final frequency;
Fixed frequency;
Output power level;
Sweep time;
Zoom width;
External of Internal Frequency control mode;
External of Internal Power control mode;
External, Internal or OFF amplitude modulation mode
GPIB address.

- Save current settings in flash memory.
  Only last settings are stored and then loaded in the device automatically. If one would like to store some special set-up, he should to install desire settings as described in par. **A**-**G**. Then one should enter to main menu. Press the button "Menu" (12), if it is needed.
  Press key "7" on Digital Keyboard (8) to activate command "Save Pr" from main menu. Choose number of program from "0" to "9" pressing the corresponding key on Digital Keyboard (8). The current set-up will be stored.
- Load set-up from flash memory.
  If one would like to load set-up saved in flash memory, he should enter to main menu. Press the button "Menu" (12), if it is needed. Press key "8" on Digital Keyboard (8) to activate command "Load Pr" from main menu. Choose number of set-up from "0" to "9" pressing the corresponding key on Digital Keyboard.

J. Set device address on GPIB bus.

GPIB interface card integrated into Controller is initialised automatically in device (slave) mode. One can set Generator's address on GPIB bus from 01 till 20. Generator saves GPIB address in flash memory and installs it automatically after restart.

- Set new GPIB address for example 14, assuming that present address is 19;

Press key “9” to activate menu of GPIB address setting. On LCD screen appears text “ GPIB address 19 Set new ”;
Press keys "1","4" to enter new address 14;
Address 14 will be installed after the pressing of second digit. Controller will return main menu automatically after two seconds. If one would like to install address 1 he should enter “0” “1” in series.

K. Test parameters of BWO tube.

This mode allows measure actual operating voltages and currents for BWO tube:

i) “Ih” – Heating Current;
ii) “Uh” – Heating Voltage;
iii) “Ia” – Anode Current;
iv) “Ug” – Grid Voltage.

- Press key “.” on Digital Keyboard (8) to active “Additional Menu”.
- Please don’t use Key “2”. This is “Service” mode for the using of technical service staff only.
- Press key “1” to active “Test”.
- On LCD screen appears information about operating current and voltage for BWO tube. For example: “Ih=2.3A Ia= 40mA”, “Uh=1.14A Ug=220V”. “Ia” is variable 3…48mA, “Ug” is variable 3…240V.

10. GPIB INTERFACE

All commands and settings would be controlled through GPIB interface. Connect the generator to GPIB bus (plug 22 on the rear panel) using special cable.

- Turn on the generator as directed in chap. **9** par. **A**.
- To control of Generator one should send ASCII symbols corresponded to keys on keyboard or buttons on front panel according to the following table:

Keys or Buttons of Generator	Symbol in GPIB port
From 0 to 9	From 0 to 9
.	.
Enter	e
External Power Control Ext.	A
Amplitude Modulation Ext.	B
Amplitude Modulation Int.	C
Amplitude Modulation Off	D
Menu	q
External Frequency Control	F
Step <-	l
Step ->	r

The current the Generator settings may be read via GPIB bus in form of "Status String"=“Name_Condition_Finit_Ffin_Time_ScreenCopy”. It consists of 6 information words separated with blanks. The "Status String" dimension is variable and depends on the current status of the Generator.

- The "Name" string occupies first six bytes, from 1st to 6th. For the Generator this string is fixed: "Name"="G4-143".
- The "Condition" hexadecimal word occupies bytes from 8th to 11th. Correspondence between values of each "Condition" bit and the Generator settings are shown in the next table:

Regime	Bit	Value
Amplitude modulation “External”	0	0
Amplitude modulation “Internal”	1	0
Amplitude modulation “OFF”	2	0
Power “External Control”	3	0
Frequency “External Control”	4	0

- «Finit» describes the Initial Frequency in GHz.
- «Ffin» describes the Final Frequency in GHz.
- «Time» describes the sweep period in seconds.
- “CopyScreen” contains 41 symbols displayed on LCD at the moment of the request. 20 first of them correspond to the first string of LCD, then <CR> symbol follows, the next 20symbols correspond to the second string of LCD. <CR> bytes are standard.

The main principle of Generator control using GPIB interface is to repeat the same sequence of commands as used in manual control mode.

11. EXAMPLE OF OPERATION USING GPIB INTERFACE

This part repeats par.’s **A**. –**H**. of par. **9**, but only without comments.

A. Frequency sweep mode through GPIB bus.

For example one could set the follows. Internal Frequency and Power Control mode, Initial Frequency 125.456 GHz, Final Frequency 136.987 GHz, Power Level 50%, Sweep Time 0.04 S.

- Set Internal Frequency control mode.
  Read “Status String”. If bit 7 of 7th byte is clear, it means that the device is installed in Internal Frequency Control mode.
  “4” – activate local menu “Control”, if bit 7 is set.
  “F” – set Internal Frequency Control.
  “q” – abort local menu “Control” and return to main menu.
  Read “Status String”. Once more one should check bit 7 of 7th byte “Frequency Control” in “Status String”.

- Set Internal Power Control mode.
  Read “Status String”. If bit 6 of 7th byte is clear, it means that the device is installed in Internal Power Control mode.
  “4” – activate local menu “Control”, If bit 6 is set.

"A" – set Internal Power Control.
"q" – abort local menu "Control".
Read "Status String".
Once more one should check bit 7 of 7th byte "Frequency Control" in "Status String".

- Set initial frequency.
  "1" – activate "Set Up" local menu;
  "1" – enter in local menu" Fr_intl";
  "1" "2" "5" "." "4" "5" "6" – print frequency value on LCD;
  "e" – enter;
  "q" – return to local menu.

- Set final frequency.
  "2" – to enter in local menu" Fr_fnl";
  "1" "3" "6" "." "9" "8" "7" – print frequency value on LCD;
  "e" – enter;
  "q" – return to local menu.

- Set Sweep Time.
  "3" – enter to local menu "Time_Swp";
  "0" "0" "." "0" "4" – print frequency value on LCD;
  "e" – enter;
  "q" – return to local menu.

- Set Power Level.
  "4" – enter to local menu "Power_lvl";
  "5" "0" "." "0" "0" – print power level on LCD;
  "e" – enter;
  "q" – return to local menu;
  "q" – return to main menu.

- Start sweep
  "2" – to start sweep.
  "q" – to stop sweep and return to main menu.

B. Set Fixed Frequency through GPIB bus.

For example, to set the initial frequency 105.121 GHz and fine adjust it one should to send symbols sequence:

- Set Internal Frequency control mode. See par. **11-A** above.

- Set Internal Power control mode. See par. **11-A** above.

- Set Fixed Frequency.
  "3" – activate "Manual" local menu;
  "1" "0" "5" "." "1" "2" "1" – print frequency value on LCD;
  "e" – enter.

- Fine adjustment of Fixed Frequency.
  "l" – to decrease fixed frequency on one smallest available step (left).
  "r" – to increase fixed frequency on one smallest available step (right).
- Abort setting of Fixed Frequency. "q" – return to main menu.

C. Set Zoom Frequency Window mode through GPIB bus.

For example, to set the zoom window width 1.0 GHz and start sweep one should send symbols sequence:

- Set Internal Frequency and Power control as described in par. **11-A**;
- Set Power Level as described in par. **11-A**;
- Set Fixed Frequency as described in par. **11-B**;
- Set Zoom Frequency Window width;
  "5"- activate local menu "Zoom"
  "3"– set zoom width 1.0 GHz
- Start the sweep;
  "6"- start sweep
- Stop the sweep;
  "q"- stop sweep.

D. Set Internal Amplitude Modulation mode through GPIB bus.

Square wave 100% amplitude modulation with frequency 1 kHz is provided in this mode.

- Set fixed frequency and power level as described in par. **11-A**, **11-B**;
- Set Internal Amplitude Modulation mode;
  Read "Status String" to check the current operation mode. If 4^{th} bit of 7^{th} byte is set, it means that the device is installed in Internal Amplitude Modulation mode;
  "4" – activate local menu "Control", if 4^{th} bit of 7^{th} byte is clear;
  "C" – switch on Internal Amplitude Modulation mode;
  Read "Status String". Once more one should check 4^{th} bit of 7^{th} byte: "Internal Amplitude Modulation" in "Status String";
  "q" – return in main menu.

E. Set external positive pulse modulation mode through GPIB bus.

Square wave 100% amplitude modulation with frequency of an external triggering source is provided in this mode.

- Set the frequency and power level as described in par. **11-A, 11-B**.
- Set External Amplitude Modulation mode;
  Read "Status String" to check operation mode. If bit 6 of 7^{th} byte is set, it means that the device is installed in External Amplitude Modulation mode;
  "4" - activate local menu "Control", if bit 6 of 7^{th} byte is clear;
  "B" – switch on External Amplitude Modulation mode;
  Read "Status String". Once more one should check 6^{th} bit of 7^{th} byte: "External Amplitude Modulation" in "Status String";
  "q" – return to main menu;
- Feed the 5 V (TTL) positive pulses with a frequency in the range 1-100 kHz and duty ratio 2 (square wave) into the External Triggering
  Plug "_⎍_ "(19).

F. Set External Power Control mode through GPIB bus.

In this mode an external positive voltage 0…+10 VDC controls the output power of Generator.

- Set External Power Control mode.
  Read “Status String ”, if bit 5 of 7th byte is set. It means that the device is installed in External Power Control mode;
  "4" – activate local menu "Control", if 5th bit is clear;
  “A” – set External Power Control mode;
  “q” – abort local menu "Control";
  Read“ Status String ”. Once more one should check 3rd bit of 7th byte: "Frequency Control” in “Status String ”;
- Set the fixed frequency as described in par. **11-B**;
- Feed the positive 0...+10 VDC voltage into the plug “Input” (20) “External Power Control”. The higher voltage corresponds to the higher output power.

G. Set External Frequency Control mode through GPIB bus.

In this mode an external positive voltage controls output frequency of Generator (See calibration table - **9-G**).

- .Set External Frequency Control mode;
  Read “Status String”. If 7th bit of 7th byte is set, it means that the device is installed in External Frequency Control mode;
  "4" – activate local menu "Control", if 7th bit is clear;
  “F” – set External Frequency Control mode;
  “q” – abort local menu "Control";
  Read “Status String”. Once more one should check 7th bit of 7th byte "Frequency Control” in “Status String ”;
- Set output power as described in par. **11-A**;
- Feed the positive voltage (according calibration table - **9-G**) into the plug “Input” (10) “External Frequency Control”. The higher voltage corresponds to the higher output frequency.

H. Save and/or load were saving currently settings through GPIB bus.

Save current settings in program No. 5 and load settings from program No. 8.

- Save current settings in flash memory;
  “q” – activate main menu, if it is needed;
  "7" - activate command "Save Pr" from main menu;
  "5" – save settings to program No. 5;
- Load settings from flash memory;
  “q” – activate main menu, if it is needed;
  "8" - activate command "Load Pr" from main menu;
  "8" – load settings from program No. 8.

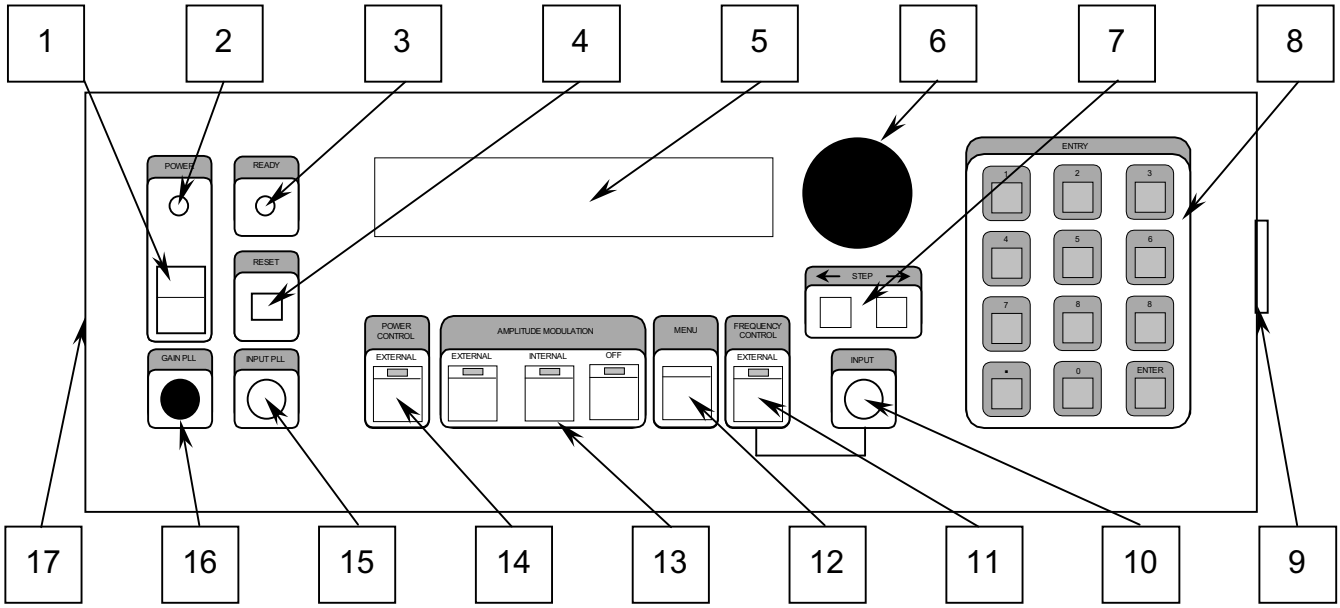
J. Set device address on GPIB bus.

GPIB interface card integrated into Controller is initialised automatically in device (slave) mode. One can set Generator's address on GPIB bus from 01 till 20. Generator saves GPIB address in flash memory and installs it automatically after restart.

- Set new GPIB address for example 5, assuming that present address is 14;
  "9" - activate menu of GPIB address setting;
  "0","5" set new address 5;
  Address 5 will be installed after the sending of "5" within few seconds. After that one have to communicate with device using the new address.

SUPPLEMENT 1

Front panel of the Generator

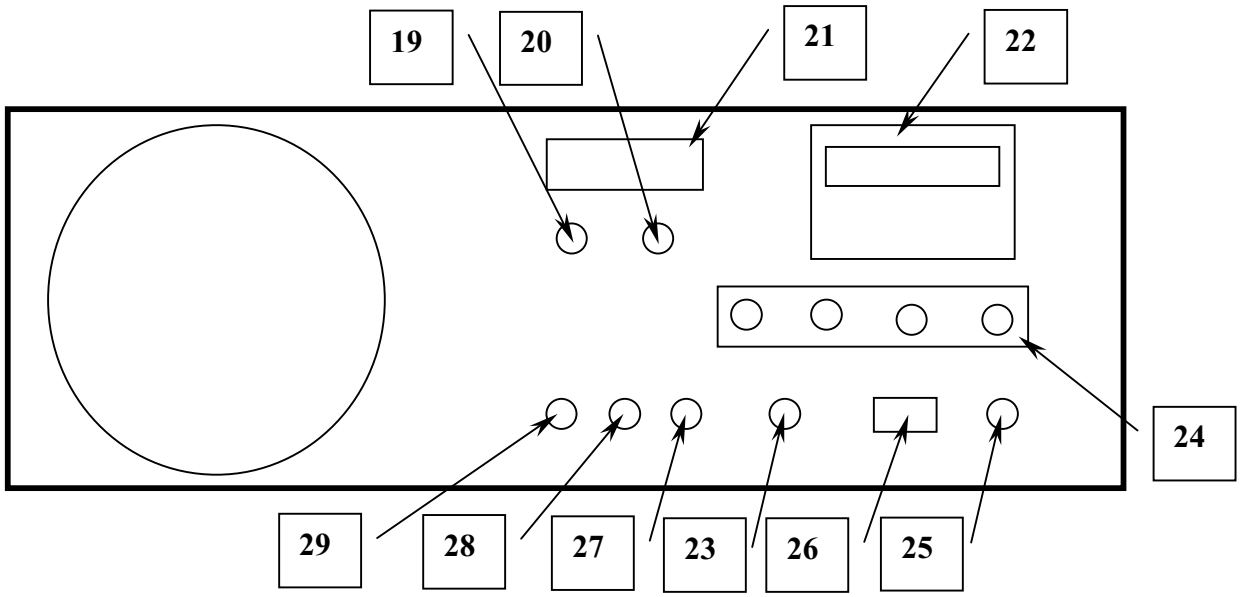


Disposition of the plugs and knobs on the front panel of the Generator.

1. “Power” switch.
2. “Power” indicator.
3. “Ready” indicator.
4. “Reset” button.
5. Liquid Crystal Display.
6. Tuning knob.
7. “Step” knobs.
8. Digital keyboard.
9. Microwave output.
10. External broadband frequency input (BNC connector).
11. External frequency control switch.
12. “Menu” button.
13. Amplitude modulation mode switches.
14. External power control switch.
15. Input for PLL system (BNC connector).
16. “Gain PLL” knob. Setting sensitivity to PLL system.
17. External VGA monitor and keyboard (under cover of left panel).

SUPPLEMENT 2

Rear panel of the Generator

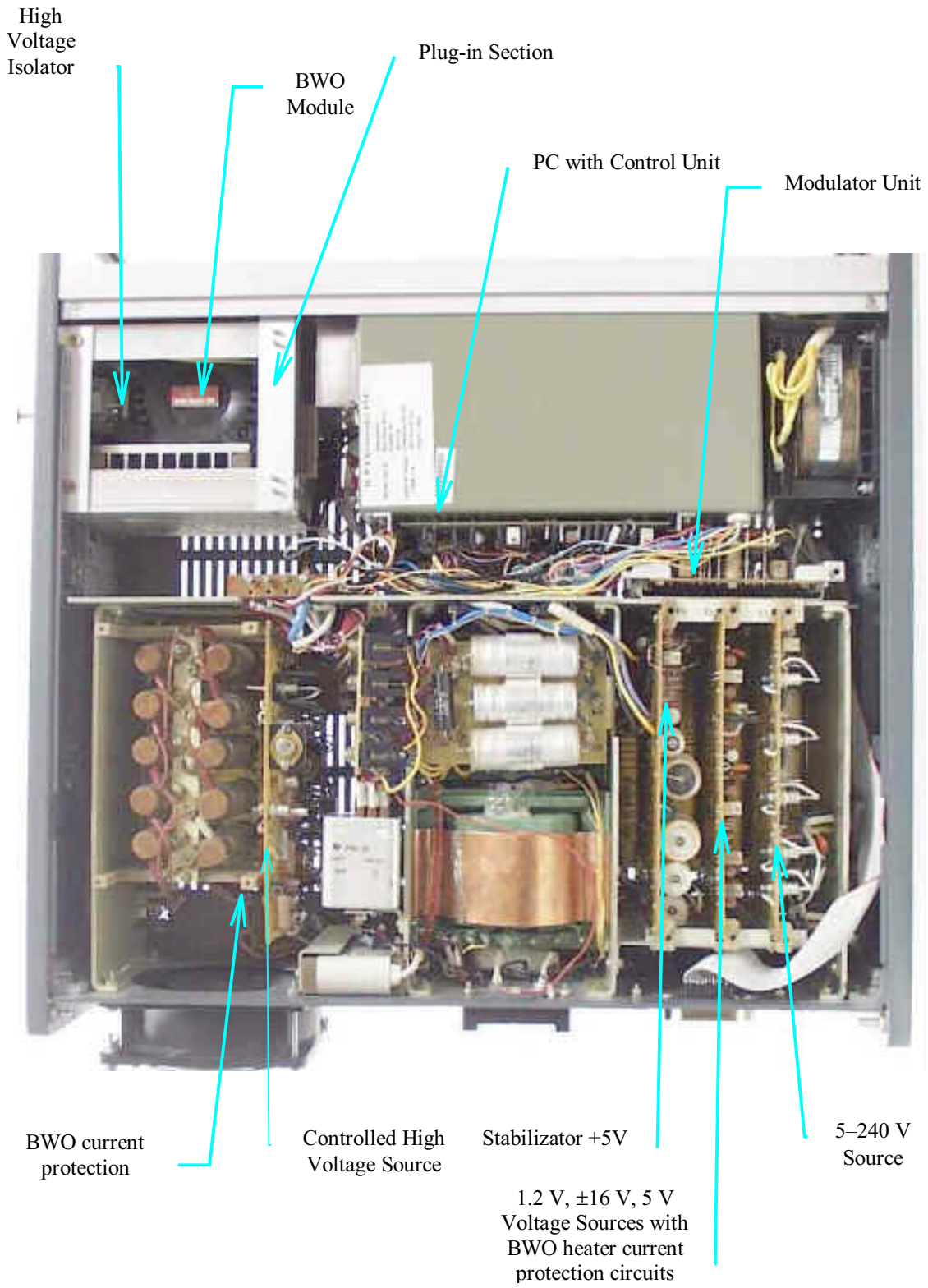


Disposition of the plugs and knobs on the rear panel of the Generator.

21. “AM INPUT”, input for amplitude modulation (BNC connector)
22. “POWER CONTROL”, input for control voltage of output power (BNC connector)
23. «Operating Time» counter.
24. «GPIB» interface plug.
25. Ground
26. Fuses.
27. Fuse 5A (protection +5V).
28. «Power Plug» AC 220V.
29. «High Voltage Monitor» output plug.
30. «Strobe AM signal», output plug (TTL).
31. «Strobe FM signal», output plug (TTL).

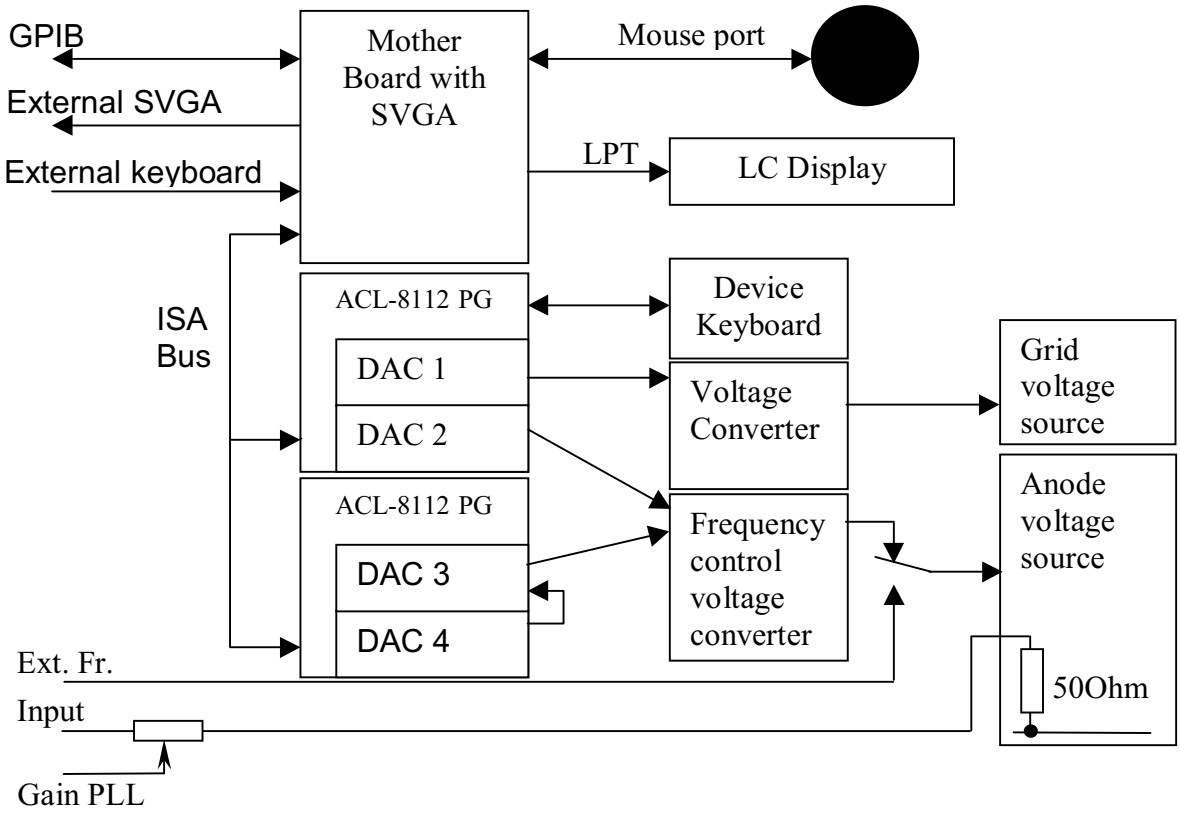
SUPPLEMENT 3

Disposition of the units in the Generator



SUPPLEMENT 4

Block diagram of the control unit.



A simplified block diagram of the Computer Unit is shown on the plot. It includes:

- Mothers board Juky-730 Industrial Standard PC compatible microcomputer.
- There are four digital to analog converters in two data acquisition cards ACL-8112.

DAC1 sets the amplitude of power control voltage;
DAC2 sets the amplitude of frequency control voltage. It is used for full band sweep;
DAC3 sets the amplitude of frequency control voltage in Zoom Sweep Window mode;
DAC4 sets the reference voltage for DAC3. It allows change width of "frequency window" in zoom sweep mode.

The device operates as follows. Built-in microcomputer and data acquisition cards provide voltage for power and frequency control.

DAC1 is used for the regulation of voltage applied to control electrode (grid) of BWO and so for the control of the output microwave power.

DAC2 is used for the regulation of voltage applied to anode of BWO and so for the control of the output frequency. Control voltage is constant in Fixed Frequency mode or triangle linear rise voltage in Sweep Frequency mode.

DAC3 is used in Zoom Sweep Window mode. A constant voltage from DAC2 is added to triangle linear rise voltage produced by DAC3. Output voltage of DAC3 is divided on coefficient 1:20.

DAC4 controls amplitude of Zoom Sweep.

Circuit switches between various modes are provided by relays.

Parallel port (LPT1) is used for control of liquid crystal display (LCD).

RS-232 serial port (COM3) is "mouse" port. It serves the operation of tuning knob.

SUPPLEMENT 5

The structure of the base files.

The structure of the file.

We calibrate the output frequency of Generator through DAC2 (See. Supplement 4). We change DAC2 code from $0000 till $0FFF and measure output frequency *at 100% Power Level*. Maximum Power Level 100% corresponds to code $0FFF in DAC1. Measured results for different BWO are presented in files **frequen1.dat, frequen2.dat and frequen3.dat.** These files are stored in flash memory of Control Unit.

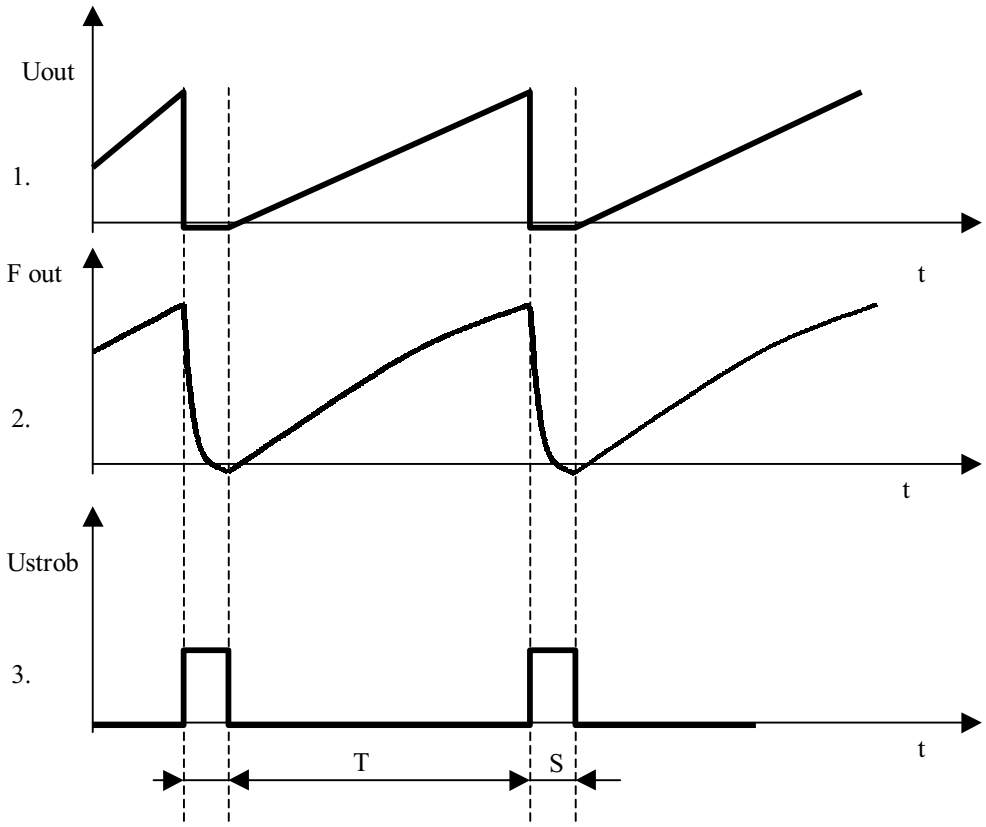
Example for BWO 75-110GHz.

There are about 4096 strings in the file. Each string presents the frequency in GHz. Data presented at the first string corresponds to initial DAC2 code. The code is increasing on 1 with increasing of string number. For example, DAC2 code $0006 corresponds to output frequency 73.197GHz.

73.010
73.048
73.085
73.122
73.160
73.197
…

SUPPLEMENT 6

The diagram of the Control Voltage and strobes.

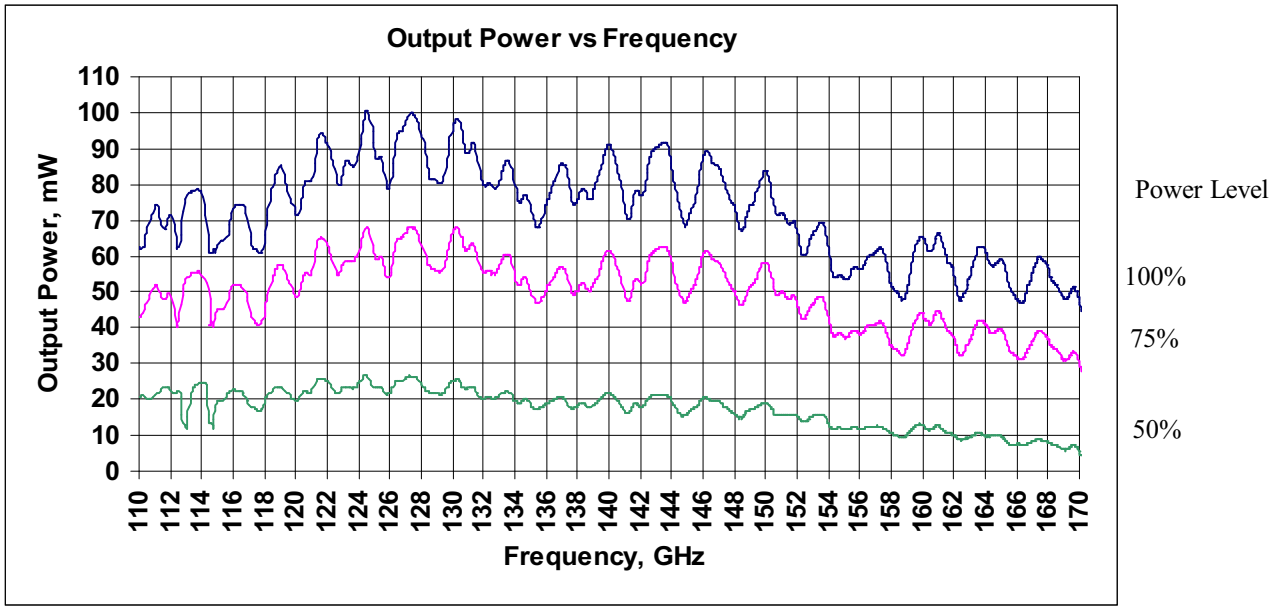


1. The diagram of the internal triangle wave control voltage on plug (27).
2. The diagram of the output frequency.
3. The diagram of TTL output strobe signal on plug (29).

T – sweep time, set by Digital Keyboard (8) or by GPIB bus command.
S – strobe time, duration about 0.001 sec.

SUPPLEMENT 7D

Plot 1. Dependence of Output Power versus frequency by various Power Levels for D band BWO.



The structure of the calibration data.

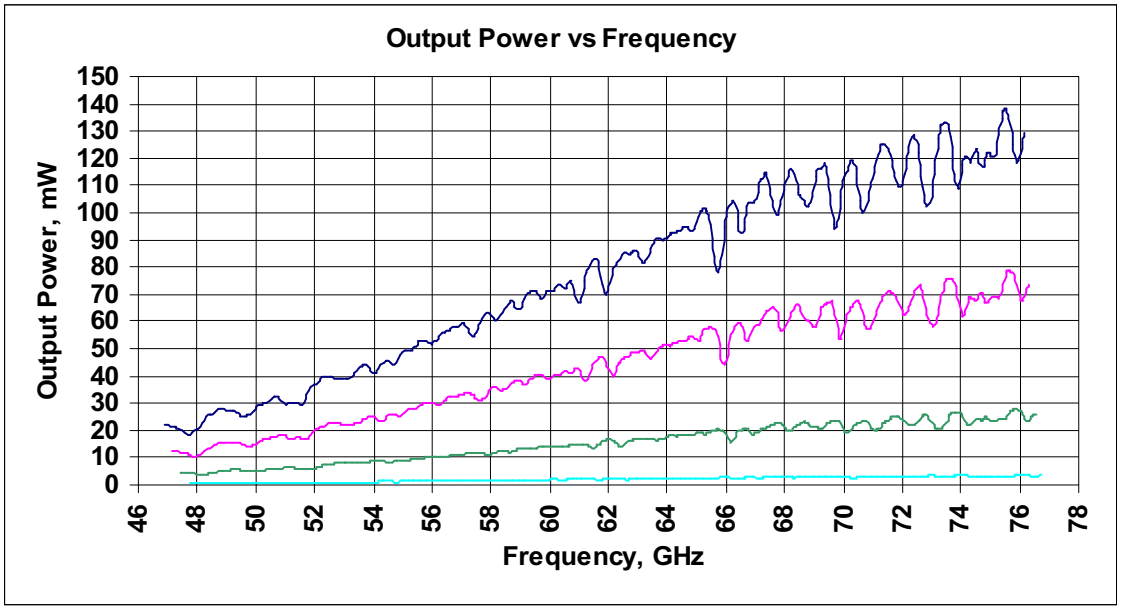
The data in the calibration files are placed in ten columns divided by the tabs:

Uinp	HVm	P50	F50	P75	F75	P100	F100
2.4	2.681	20.3	109.740	5.9	109.231	65.4	109.274
2.405	2.687	20.3	109.866	6.1	109.285	65.2	109.345

- The first column (Uinp) is a control voltage in V, applying to the external broadband frequency input (10), see supplement 1;
- The second column (HVm) is a voltage in V, measured on the HV Monitor output plug (27), see supplement 2, corresponding to the data placed in the first column.
- The third column (P40) is measured output power of Generator in mW at 40 % power level, corresponding to the data placed in the first column;
- The forth column (F40) is a Generator frequency in GHz at 40 % power level, corresponding to the data placed in the first columns;
- The fifth column (P50) is measured output power of Generator in mW at 50 % power level, corresponding to the data placed in the first column;
- The sixth column (F50) is a Generator frequency in GHz at 50 % power level, corresponding to the data placed in the first columns;
- The seventh and eighth columns (P75 and F75) correspond output power and frequency at 75% power level, corresponding to the data placed in the first columns;
- The ninth and tenth columns (P100 and F100) correspond output power and frequency at 100% power level, corresponding to the data placed in the first columns;

SUPPLEMENT 7V

Plot 1. Dependence of Output Power versus frequency by various Power Levels for V band BWO.



The structure of the calibration data.

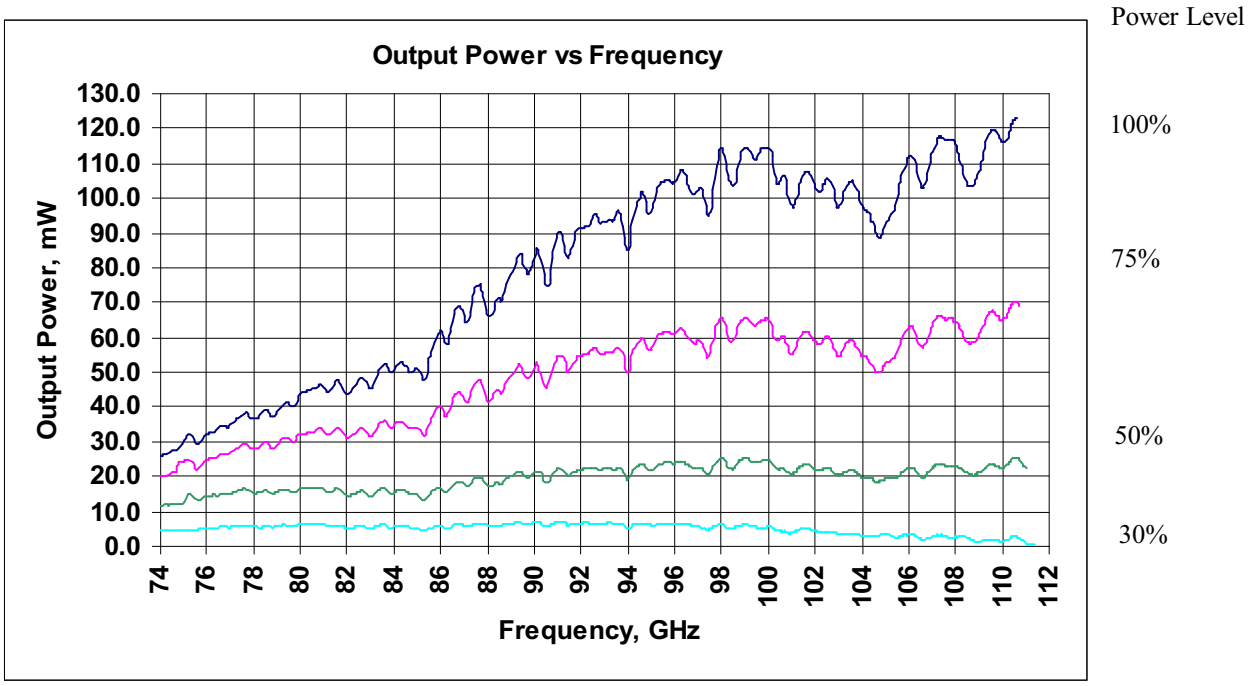
The data in the calibration files are placed in ten columns divided by the tabs:

Uinp	HVm	P40	F40	P50	F50	P75	F75	P100	F100
1.201	1.494	0.6	47.737	4.4	47.396	12.54	47.128	22	46.903
1.206	1.499	0.6	47.796	4.4	47.463	12.54	47.188	22	46.966

- The first column (Uinp) is a control voltage in V, applying to the external broadband frequency input (10), see supplement 1;
- The second column (HVm) is a voltage in V, measured on the HV Monitor output plug (27), see supplement 2, corresponding to the data placed in the first column.
- The third column (P40) is measured output power of Generator in mW at 40 % power level, corresponding to the data placed in the first column;
- The forth column (F40) is a Generator frequency in GHz at 40 % power level, corresponding to the data placed in the first columns;
- The fifth column (P50) is measured output power of Generator in mW at 50 % power level, corresponding to the data placed in the first column;
- The sixth column (F50) is a Generator frequency in GHz at 50 % power level, corresponding to the data placed in the first columns;
- The seventh and eighth columns (P75 and F75) correspond output power and frequency at 75% power level, corresponding to the data placed in the first columns;
- The ninth and tenth columns (P100 and F100) correspond output power and frequency at 100% power level, corresponding to the data placed in the first columns;

SUPPLEMENT 7W

Plot 1. Dependence of Output Power versus frequency by various Power Levels for W band BWO.



The structure of the calibration data.

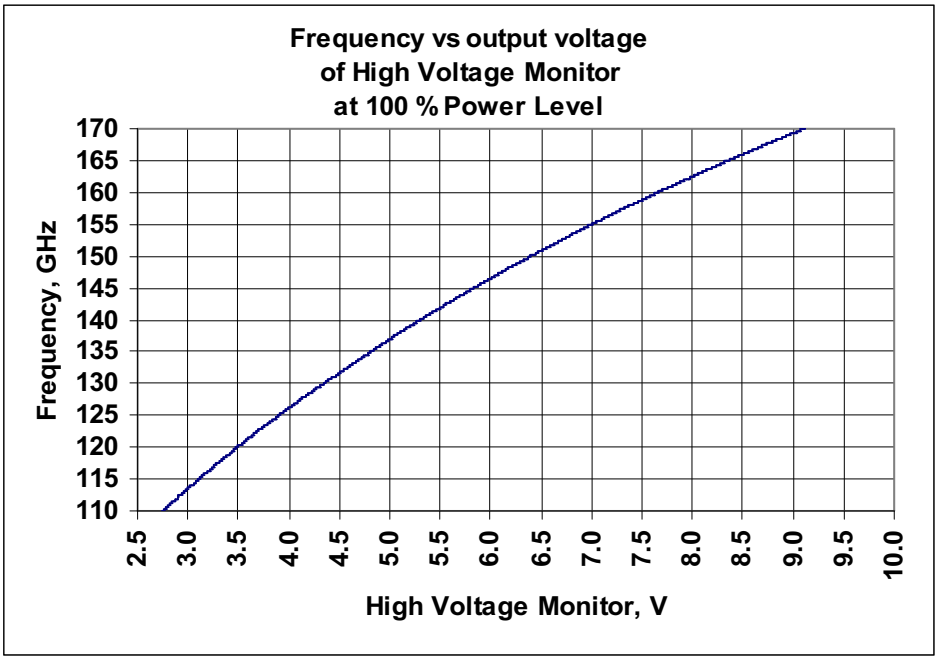
The data in the calibration files are placed in ten columns divided by the tabs:

Uinp	HVm	P40	F40	P50	F50	P75	F75	P100	F100
1.4	1.424	3.8	73.4	12.1	73.06	19.1	72.7	22.2	72.49
1.405	1.429	3.8	73.505	12.1	73.165	19.1	72.805	22.2	72.60

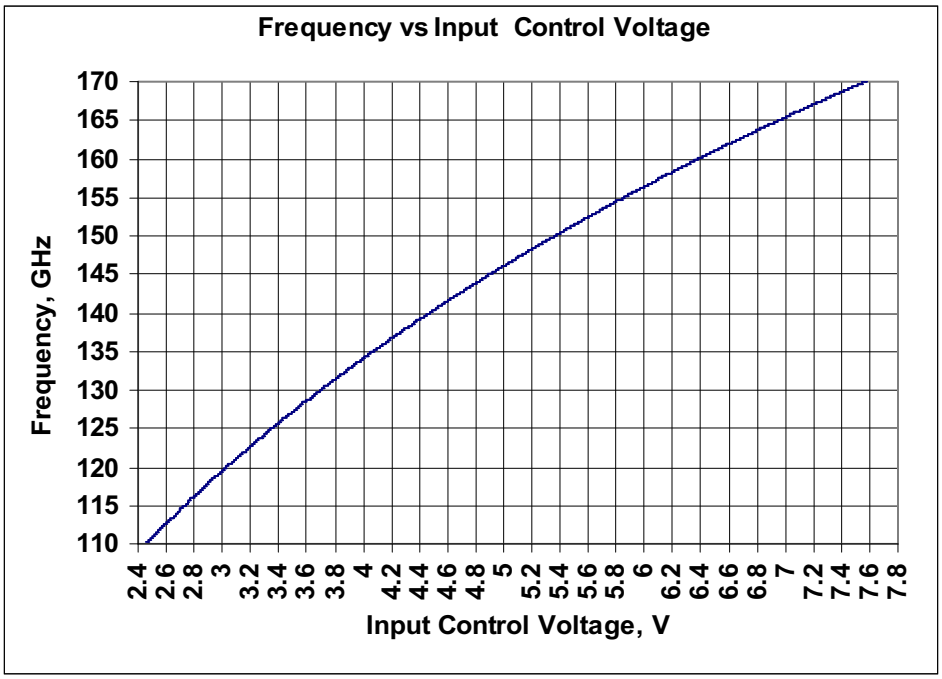
- The first column (Uinp) is a control voltage in V, applying to the external broadband frequency input (10), see supplement 1;
- The second column (HVm) is a voltage in V, measured on the HV Monitor output plug (27), see supplement 2, corresponding to the data placed in the first column.
- The third column (P40) is measured output power of Generator in mW at 40 % power level, corresponding to the data placed in the first column;
- The forth column (F40) is a Generator frequency in GHz at 40 % power level, corresponding to the data placed in the first columns;
- The fifth column (P50) is measured output power of Generator in mW at 50 % power level, corresponding to the data placed in the first column;
- The sixth column (F50) is a Generator frequency in GHz at 50 % power level, corresponding to the data placed in the first columns;
- The seventh and eighth columns (P75 and F75) correspond output power and frequency at 75% power level, corresponding to the data placed in the first columns;
- The ninth and tenth columns (P100 and F100) correspond output power and frequency at 100% power level, corresponding to the data placed in the first columns;

SUPPLEMENT 8D

Plot 1. Dependence of voltage on the HV monitor output versus frequency at maximum level of output power for D band BWO.

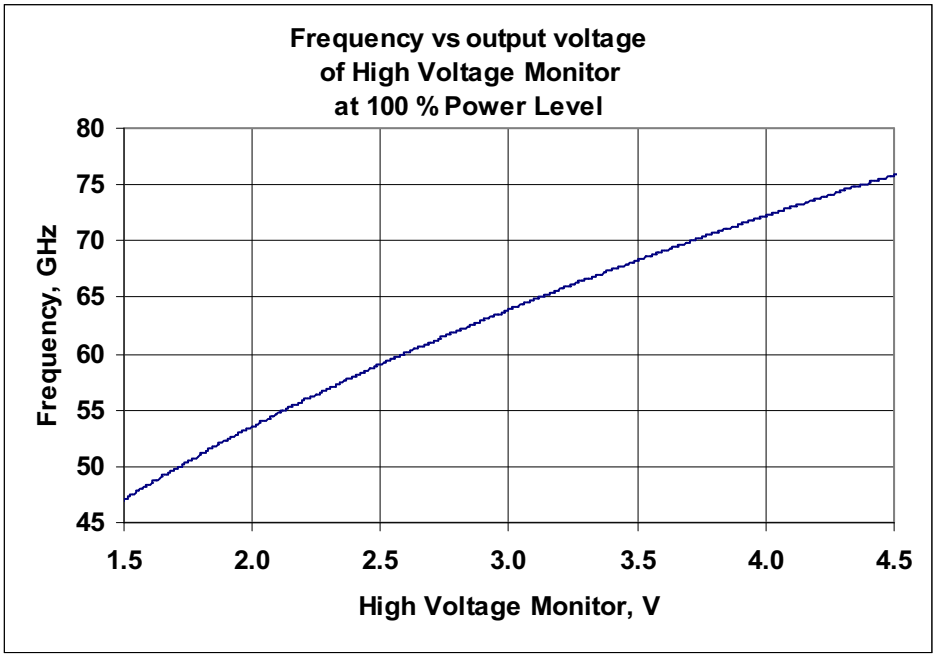


Plot 2. Dependence of frequency versus control voltage applied to the external broadband frequency tune input (10) at maximum level of output power.

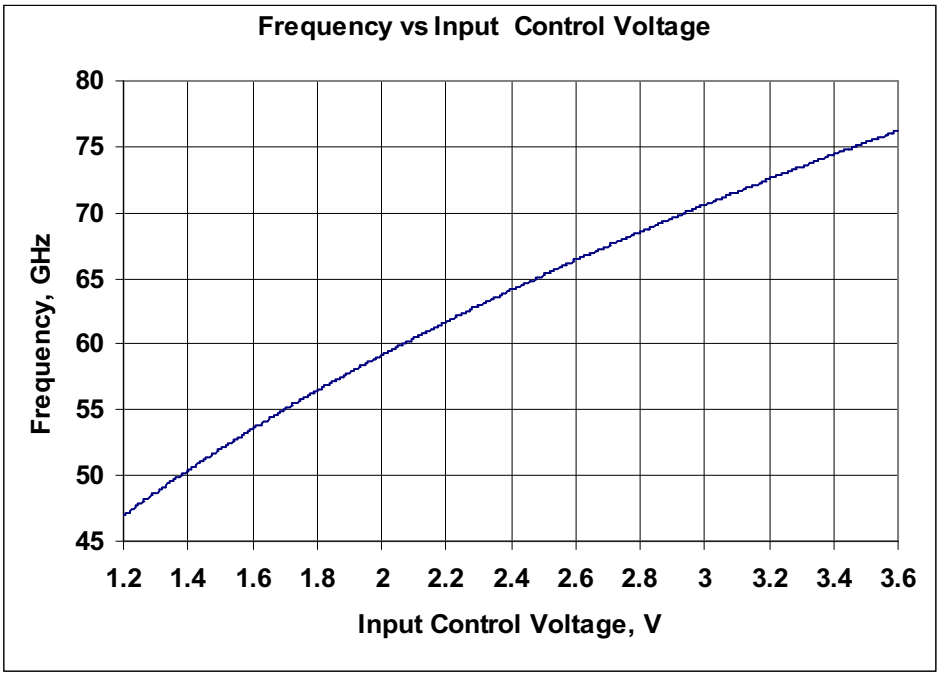


SUPPLEMENT 8V

Plot 1. Dependence of voltage on the HV monitor output versus frequency at maximum level of output power for V band BWO.

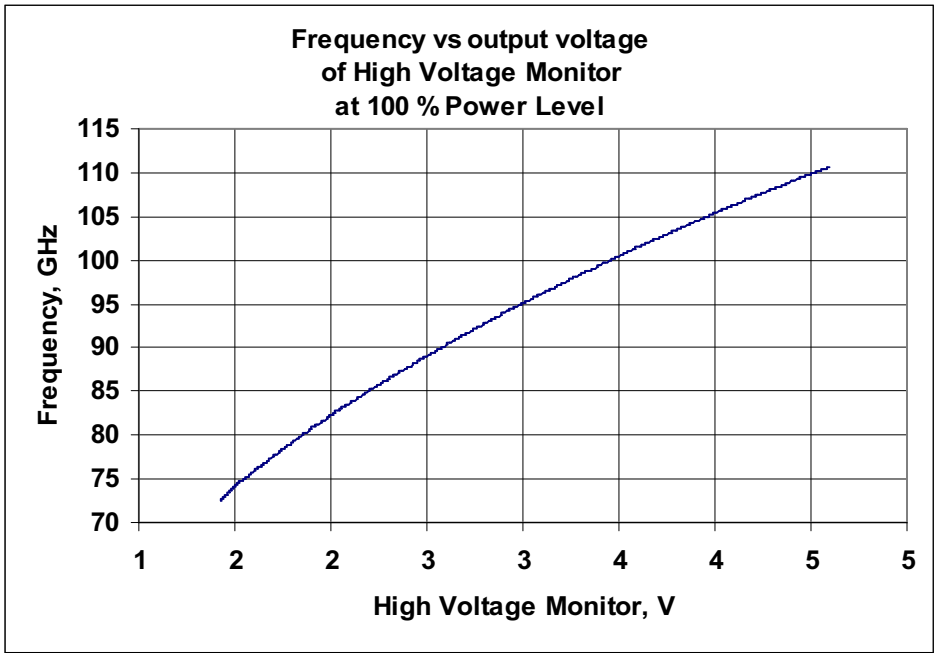


Plot 2. Dependence of frequency versus control voltage applied to the external broadband frequency tune input (10) at maximum level of output power.

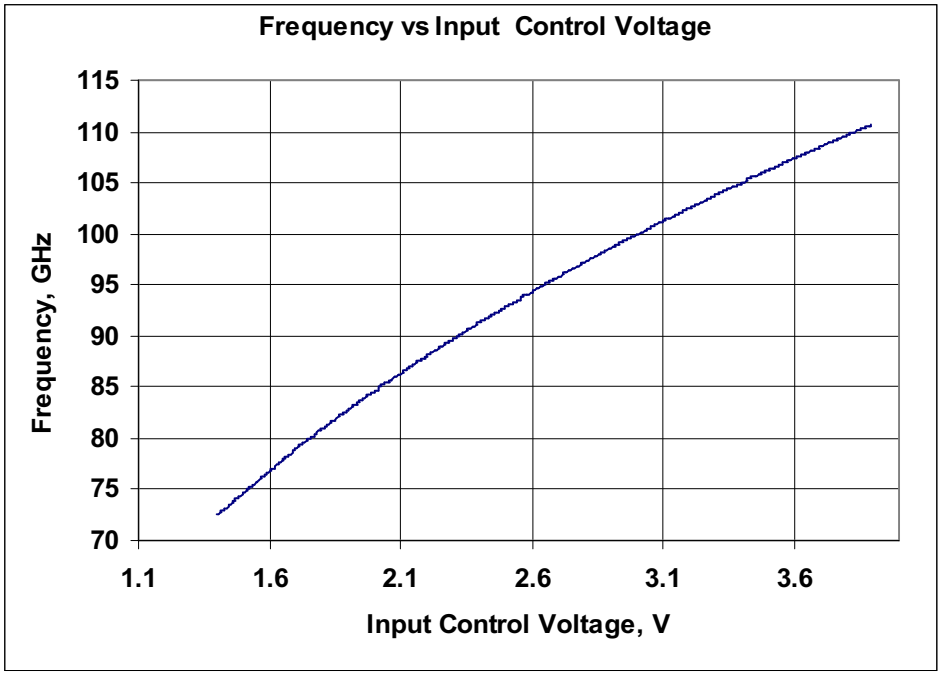


SUPPLEMENT 8W

Plot 1. Dependence of voltage on the HV monitor output versus frequency at maximum level of output power for W band BWO.

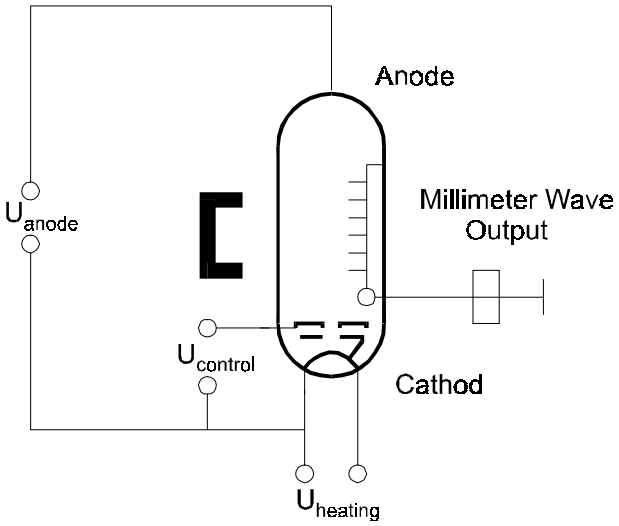


Plot 2. Dependence of frequency versus control voltage applied to the external broadband frequency tune input (10) at maximum level of output power.



SUPPLEMENT 9

Electrical Scheme of BWO Tube



Uanode = +500VDC…+2500VDC,
Ucontrol=+5…+230VDC,
Uheating=+1.0…+1.2VDC.

SUPPLEMENT 10

Example of programming

```
{This program is placed on flexible diskette and contains a example of
programming on Pascal language}

program sample_pas;
uses dos,crt;                    { include standart units }
{$L   ITF488TP.OBJ}             { load interface function      }
{$I   ITF488TP.INC}             { include function declaration }

var
dev, i          : integer;
buff,str        : string[100];
ch              : char;

const
port = $2E1;                     { GPIB card address }
myadr = 1;
bufflen = char(100);
{ }
procedure SendCharToGPIB(Ch:char);
begin
buff:=ch;
writeln(ibwrt(dev,buff));
Delay(10);
end;
{ }
procedure SendStringToGPIB(InputString:string);
var l:word;
begin
for l:=1 to byte(InputString[0]) do SendCharToGPIB(InputString[l]);
end;
{ }
begin
writeln('GPIB device address:');
readln(dev);                     { read device address}
buff[0]:=bufflen;                { clear buff}
i:=ibinit(port,myadr,0);         { initialisation }
i:=ibtout(1000);                 { set timeout }
i:=ibifc;                        { clear inteface}
repeat

       writeln('Enter next regim: 1 - Initial Frequency.');
       writeln('                  2 - Final   Frequency.');
       writeln('                  3 - Sweep Time.');
       writeln('                  4 - Power Level.');
       writeln('                  5 - Switch Ext/Int Frequency Control');
       writeln('                  6 - Switch Ext/Int Power Control');
       writeln('                  7 - Start Sweep');
       writeln('                  8 - Stop  Sweep');
       writeln('                  9 - Read " Status String');
       writeln('                  0 - Exit.');

       Ch:= Readkey;

       case Ch of
       '1':   begin                      { case of 1 }
              SendCharToGPIB('1');       { to local menu }
              SendCharToGPIB('1');       { to initial frequency set-up }
              delay(3000);               { Please wait }
              SendStringToGPIB('55.00');{ initial frequency 55.00 GHz }
```

```
              SendCharToGPIB('e');       { Enter }
              SendCharToGPIB('q');       { to local menu }
              SendCharToGPIB('q');       { to main menu }
              end;                       { case 1 }

       '2':   begin                      { case of 2 }
              SendCharToGPIB('1');       { to local menu }
              SendCharToGPIB('2');       { to final frequency set-up }
              delay(3000);               { Please wait }
              SendStringToGPIB('56.00'); { final frequency 56.00 GHz }
              SendCharToGPIB('e');       { Enter }
              SendCharToGPIB('q');       { to local menu }
              SendCharToGPIB('q');       { to main menu }
              end;                       { case 2 }

       '3':   begin                      { case of 3 }
              SendCharToGPIB('1');       { to local menu }
              SendCharToGPIB('3');       { to sweep time set-up }
              delay(3000);               { Please wait }
              SendStringToGPIB('000.01');{ sweep time 0.01 s }
              SendCharToGPIB('e');       { Enter }
              SendCharToGPIB('q');       { to local menu }
              SendCharToGPIB('q');       { to main menu }
              end;                       { case 3 }

       '4':   begin                      { case of 4 }
              SendCharToGPIB('1');       { to local menu }
              SendCharToGPIB('4');       { to power level set-up }
              delay(3000);               { Please wait }
              SendStringToGPIB('071.00');{ power level 71% }
              SendCharToGPIB('e');       { Enter }
              SendCharToGPIB('q');       { to local menu }
              SendCharToGPIB('q');       { to main menu }
              end;                       { case 4 }

       '5':   begin                      { case of 5 }
              SendCharToGPIB('4');       { to control menu }
              SendCharToGPIB('F');       { switch ext/int frequency control }
              SendCharToGPIB('q');       { to main menu }
              end;                       { case 5 }

       '6':   begin                      { case of 6 }
              SendCharToGPIB('4');       { to control menu }
              SendCharToGPIB('A');       { switch ext/int power control }
              SendCharToGPIB('q');       { to main menu }
              end;                       { case 6 }

       '7':   SendCharToGPIB('2');

       '8':   SendCharToGPIB('q');

       '9':   begin              { case of receiver data}
              buff[0]:=bufflen;
              i:=ibrd(dev,buff);
              writeln('Exit code = ',i);
              for i:=1 to 100 do if buff[i] = #13 then buff[i]:=#32;
              writeln('Receive string:');
              writeln(buff);
              end;
     end; {}
     until Ch = '0';
end.
```

SUPPLEMENT 11

Step by step instruction:
Setting Power Level and Fixed Frequency Mode without Amplitude Modulation

This supplement describes how to set Power Level and Fixed Frequency mode without Amplitude Modulation using device keyboard steps 1…5 and trough GPIB interface steps 6…10 .

- **Step 1: Set Internal Frequency control mode.**

One should check LED “External” on the button “Frequency Control” (11). If LED not glows, it means that the device is installed in Internal Frequency Control mode and you should go to step 2. If LED glows, one should run command “Control” of menu pressing key “4” on keyboard. Press button “Frequency Control” to switch off LED on the button (11). To abort “Control” menu presses key “Menu”.

- **Step 2: Set Internal Power control mode.**

One should check LED “External” on the button “Power Control” (14). If LED not glows, it means that the device is installed in Internal Power Control mode and you should go to step 3. If LED glows, one should go to position “Control” of menu pressing key “4” on keyboard. Press button “Frequency Control” to switch off LED on the button (14). To abort “Control” presses key “Menu”.

- **Step 3: Set Amplitude Modulation OFF.**

One should check LED “OFF” on the field “Amplitude Modulation” (13). If LED glows, it means that the Amplitude Modulation switch off and you should go to step 4.

If LED not glows, press key “4” on Digital Keyboard (8) to activate local menu “Control”.

Press button “Off ” in “Amplitude Modulation” group of buttons on Functional Keyboard (13) to switch off Internal Amplitude Modulation. LED “OFF” should glow.

Press button “Menu” to abort local menu “Control” and return to main menu.

- **Step 4: Set a Fixed Frequency.**

Press key “3” on keyboard to activate the local menu “Manual”.

Wait few seconds, if Generator asks that.

To enter the desired frequency one has three possibilities:

i. Rotate Tuning Knob (6) and then press key “Menu” (12). Output operation frequency changes synchronously with value indicated on the display;
ii. Press buttons “Step” “<-“ or “->” (7) and then press key “Menu” (12). This way is useful if it is necessary to provide precision tuning. One button realizing leads to the change of the frequency on the smallest available step. Output operation frequency changes synchronously with value indicated on the display;
iii. Enter frequency from Digital Keyboard (8). A marker will appear on the display just after the realizing of one of the key (8). One can use buttons “Step” “<-“ or “->” (7) to change the marker position. That allows edit the frequency on the display. Press key “Enter” to finish editing and change the output operation frequency. Press key “Menu” (12). If one will try to enter a

wrong frequency, out of operating frequency range, max or min one available will be installed correspondingly.

- **Step 5: Set a desired Power Level.**

Press key "1" on Digital Keyboard (8) to activate "Set Up" local menu.
There are four commands in the local menu "Set Up":

1. "Fr_intl" – set initial frequency;
2. "Fr_fnl" – set final frequency;
3. "Time_swp" – set sweep time;
4. "Power_lv" – set power level.

Press key "4" to enter in local menu commands "Power_lv".
Wait few seconds, if Generator asks that.
To enter the desired value (for example 100%) one has two possibilities:

i. Rotate Tuning Knob (6) in clock direction and then press key "Menu" (12); Output power changes synchronously with value indicated on the display
ii. Enter Power Level from Digital Keyboard (8). Press keys "1","0","0",".","0". One can use buttons "Step" "<-" or "->" (7) to change marker position. That allows edit the value on the display. Press key "Enter" to finish editing. Output power changes after pressing key "Enter".

Press key "Menu" (12) to go to main Menu.

Setting Power Level and Fixed Frequency Mode without Amplitude Modulation through GPIB

- **Step 6: Set Internal Frequency Control mode.**

Read "Status String". If bit 7 of 7th byte is clear, it means that the device is installed in Internal Frequency Control mode and you should go to step 7.
"**4**" – activate local menu "Control", if bit 7 is set.
"**F**" – set Internal Frequency Control. Please pay attention that each of sending symbol "F" leads to switching between External/Internal Frequency control mode.
"**q**" – abort local menu "Control" and return to main menu.
Read "Status String". Once more one should check bit 7 of 7th byte "Frequency Control" in "Status String".

- **Step 7: Set Internal Power Control mode.**

Read "Status String". If bit 6 of 7th byte is clear, it means that the device is installed in Internal Power Control mode and you should go to step 8.
"**4**" – activate local menu "Control", If bit 6 is set.
"**A**" – set Internal Power Control. Please pay attention that each of sending symbol "A" leads to switching between External/Internal Power control mode.
"**q**" – abort local menu "Control" and return to main menu.
Read "Status String". Once more one should check bit 6 of 7th byte "Frequency Control" in "Status String".

- **Step 8: Set Internal Amplitude Modulation OFF.**

Read "Status String" to check the current operation mode. If 3rd bit of 7th byte is set, it means that the device is installed in Internal Amplitude Modulation mode and you should go to step 9.
"**4**" – activate local menu "Control", if 3rd bit of 7th byte is clear;
"**D**" – switch on Internal Amplitude Modulation OFF mode. Symbols "D" and "B","C" define Amplitude Modulation Mode one-valued.

Read “Status String”. Once more one should check 3rd bit of 7th byte: “Internal Amplitude Modulation” in “Status String”;
“**q**” – abort local menu “Control” and return in main menu.

- **Step 9: Set Fixed Output Frequency**

For example, to set the fixed frequency 115.121 GHz
“**3**” – activate “Manual” local menu;
Wait few seconds;
“**1**” “**1**” ”**5**” ”**.**” ”**1**” ”**2**” ”**1**” – print frequency value on LCD;
“**e**” – enter.
Fixed frequency should changed.
Abort setting of Fixed Frequency.
“**q**” – return to main menu.

- **Step 10: Set Power Level.**

For example, to set the Power Level 100.00%.
“**1**” – enter to local menu ”Set Up”;
“**4**” – enter to local menu ”Power_lvl”;
Wait few seconds;
“**1**” “**0**” ”**0**” ”**.**” ”**0**” ”**0**” – print power level on LCD;
“**e**” – enter;
Output power should changed.
“**q**” – return to local menu;
“**q**” – return to main menu.

SUPPLEMENT 12

Support BWO Module in plug-in BWO section