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SGMW-xxx Millimetre Wave Oscillator

(With external BWO Modules)

Operation manual

(3rd edition, 09.2012)

SGMW-xxx Millimeter Wave Generator.
(With external BWO Modules)

User Manual.

Contains.

1. GENERAL REMARKS

1.1. Microwave generator SGMW-xxx series 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. The SGMW-X series, hereinafter called Generator, is fully packaged sweeper series. The sweeper consists of external module with BWO-X series and power supply. The device contains all the electronic circuitry and power supplies required to provide the operation of BWO. PC compatible microcomputer integrated into the device provides operating control of the system. The sweeper self-tests at turn-on. BWO tube is fully protected against improper voltage connections. High voltage monitor is built-in. There is input for control of frequency by means of an external voltage. Phase locking possibility is provided. One power supply can be used with different BWO.
Frequency range is determined by BWO Modules. Device has a reserve more then 1% at the edges of the range. Specification of BWO modules is presented in Table No.1.

Table No.1

MODEL NUMBER	BWO-Q	BWO-U	BWO-V	BWO-E	BWO-W	BWO-F	BWO-D
Frequency Range, GHz	37-54	40-60	50-75	60-90	75-110	90-140	110-170
Output waveguide size, mm	5.69x2.84 WR22	4.8x2.4 WR19	3.8x1.9 WR15	3.1x1.5 WR12	2.54x1.27 WR10	2.03x1.02 WR8	1.7x0.83 WR6
Wavequide Flange	UG-383/U	UG-383/U-M	UG-385/U	UG-387/U	UG-387/U-M	UG-387/U-M	UG-387/U-M
Minimum CW power, mW	50	100	25	25	25	35	25
Typical peak power, mW	150	200	80	80	90	110	80

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 at the load VSWR no larger than 1.3 within - see Table No1.
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 - see Table No1.
3.13. Internal square-wave modulation frequency, kHz 1…100.
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 – 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 for power supply, no less than 2000 h.
4.2. 90% life time for BWO tube, no less than 500 h.

5. CONSTRUCTIVE PARAMETERS

5.1. Dimensions of the generator 490x240x270 mm.
5.2. Dimensions of BWO Module 190x150x200 mm.
5.3. Weight of power supply, no more than 25 kg.
5.4. Weight of BWO Module, no more than 4 kg.

6. PRINCIPLE OF OPERATION

Generator consists of the power supply and BWO module. BWO module is made up of BWO, witch is placed into protection box with high voltage connector and cooling fans.

The power supply is based on PC microcomputer. It is used together with digital to analogue converter as internal voltage control 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 (-500…-3000V). Controlled 5…230 V DC voltage intended to feed BWO control electrode (greed). DC 1.2 V voltage source intended to feed the BWO heater. Heater and greed voltage sources are connected with accelerating electrode of BWO and keep under high voltage. DC +12 and –12 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" (7) circuit is intended for signalling if decelerating voltage source is switched on.

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" (6) to indicate condition of generator.
- Button "Reset" restarts built-in microcomputer (2).
- Liquid Crystal Display for indication of various regimes of Generator (3).
- Two buttons for fine setting of frequency or power (4).
- Tuning knob for frequency and power setting (5).
- Indication "READY" (7)
- Control indicators (8). "+5V" and "+12V" signal that, DC +5V and +12V are presented. Red indicators provide condition of protection circuits. If one of them is glow, it means this protection circuit comes into action.
- Digital Keyboard (9).
- "AM Strobe output", output plug (TTL) (10), synchronised with Internal AM mode;
- "FM Strobe output", output plug (TTL) (11), synchronised with Internal frequency sweep;
- "HV monitor output", output plug (0…+10V) (12), corresponds to HV deceleration voltage (0…-3000V);
- Button "Frequency Control" (13) 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 positive control voltage (see 91.2.) should be applied to the corresponding socket “Input” (14) for a remote electrical manipulation of output BWO’s frequency. In Internal Frequency Control mode the frequency is controlled by microcomputer using DAC.

- Button “Menu” (15) calls operation menu to LCD (3).
- Button “Power Control”(19) 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 “Power Control” (18) for a remote electrical manipulation of output BWO’s power. In Internal Power Control mode the power is controlled by microcomputer using DAC.
- Buttons “Amplitude Modulation” (16) switch on different modes of amplitude modulation: CW (“OFF” button), Internal 1…100 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 (17) for the triggering of External Amplitude Modulation mode.
- "PLL Input" (20).

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

- "Keyboard", connector for external keyboard (21).
- "SVGA", connector for external PC monitor (22).
- "COM", RS-232 port (23).
- “GPIB” for connecting the Generator to GPIB bus (24).
- Ground socked (25).
- “Power Plug” AC 220V with fuse 3A (26).
- Fan (27).
- HV connector to BWO module (28).

Disposition of controls of BWO module is presented in Supplement 3.

- Power indicator (29).
- RF output (30).
- Time operating counter (31).
- HV connector to power supply (32).
- Cooling fan (33).

BWO is a heart of the Generator. Electrical Scheme of BWO is presented in Supplement 7. 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 (Cathode Voltage) controls frequency, and output power is controlled by a voltage applied to the control electrode.

BWO is connected in a grounded-anode circuit. In this case the output waveguide of the BWO, as well as its cabinet, is grounded.

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 (14), if "External Frequency Control" (13) is switched on.

Commutator provides a connection between control input of the High voltage power supply and control unit output, if "External Frequency Control" (13) is switched off.

Control unit provides:

- Linear control voltage with different full band Sweep Times (from 0.01 to 99.99 sec with step 0.01 sec) in sweep frequency mode (see Supplement 4);
- 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 (3). The computer calculates corresponding frequency from the code of DAC that serves frequency control, using a base files "frequen_x.dat". 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 and glow control indicator on the front panel (8). 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

- Install BWO Module. Connect BWO Module (32) with power supply (28) by supplied special cable;
- Ground the Generator;
- Ensure that fuses are present;
- Attach a load to the output of BWO;
- Turn on the power. The "Power ON" indicator (6) must glow and in approximately 20s "READY " indicator (7) must glow as well. On LCD (3) 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.

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_x.dat) for operation.

9. PURSUANCE OF MEASUREMENTS.

There are two operating menus witch are controlled by “Menu” button (15):
- Main Menu.
- Sweep Menu.

“Main Menu” consists of:
1 Freq_____ GHz
2 Power_____ %
3 Fr Step_____GHz
4 AM _____ kHz
5 GPIB adr _____
6 Save program
7 Load program

“Sweep Menu” consists of:
1 Sfreq _____ GHz
2 Efreq _____ GHz
3 Time _____ s
4 Sweep Start
5 0:Up 1:Rev _____

9.1 Frequency control

There are two modes of frequency control: Internal and External Frequency Control modes.
Turn on the Generator as directed in part 8.

9.1.1 Set Internal Frequency control mode.

One should check LED “External” on the button “Frequency Control” (13). If LED doesn’t glow, it means that the device is installed in Internal Frequency Control mode. If LED glows, one should press button “Frequency Control” to switch off LED on the button (13).

A. Fixed frequency mode.
At this mode the operation frequency is fixed.

- Turn on the Generator as directed in part 8.
- Set Internal Frequency control as described in par. 9.1.1.
- Press button “Menu”(15) to active the “Main Menu”.
- Set frequency step using command "3 Fr Step_____GHz" from Main menu, for that press "3" on digital keyboard (9) enter frequency step for tuning in GHz from keyboard and press "Enter".
- Using buttons “Step” “<-“ or “->” (4) or Rotate Tuning Knob (5) install marker opposite line “1. Freq _____ GHz” of “Main Menu” and press key “Enter” on keyboard (9) for put in the setting regime of frequency. One can press key “1” to active of this line directly.

To enter the desired frequency one has three possibilities:

- Rotate Tuning Knob (5) and then press key “Menu” (13). Output operation frequency changes synchronously with value indicated on the display;

- Press buttons “Step” “<-“ or “->” (4) and then press key “Menu” (15). This way is useful if it is necessary to provide precision tuning. One button realising leads to the change of the frequency on the set frequency step determined by "Fr step" menu. Output operation frequency changes synchronously with value indicated on the display;
- Enter frequency from Digital Keyboard (9). A marker will appear on the display just after the realising of one of the keys (9). One can use buttons “Step” “<-“ or “->” (4) 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. 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.

B. 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 can be provided in two forms (see Supplement 4). During one sweep Control Unit provides linear increasing of output frequency and then fast decreasing during approximately 5 ms time (reg. "0") and over one - linear increasing and the decreasing of output frequency (reg. "1").

- Set the desired sweep time, initial and final frequency.
- Turn on the Generator as directed in part 8. Set Internal Frequency control as described in par. 9.1.1. Press button “Menu”(15) to activate the “Sweep Menu”.
- There are the following commands in this local menu:

"1 SFreq_____ GHz" – set Initial Frequency;
"2 EFreq_____ GHz" – set Final Frequency;
"3 Time_____ s" – set sweep time;
"4 Sweep Start"
"5 0:Up 1:Rev ___" - set sweep type.

- To enter desired value of sweep time, Initial and Final frequencies to use method described in par. 9.1.1A.
- Sweep Time could be installed from 0.01 to 99.99 sec with step 0.01s using digital keyboard and 1 sec by buttons “Step” “<-“ or “->” (4) or Rotate Tuning Knob (5).
- To start sweep press key “4” on Digital Keyboard (9). Generator indicates initial and final frequencies of sweep and starts sweeping. At the beginning of each sweep Generator produces TTL strobe pulses. Use Strobe Signal output plug (11) for the triggering of external devices at the moment of the sweep beginning (see Supplement 4).
- To stop sweep press key “Menu”.

9.1.2. Set 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
33 - 50 GHz	-
50 – 75 GHz	-
75 – 110 GHz	-
110 – 170 GHz	+1.05 – +7.9 V

One should check LED “External” on the button “Frequency Control” (13). If LED glows, it means that the device is installed in External Frequency mode. If LED doesn’t glow, one press button “Frequency Control” to switch on LED on the button (13).

In this mode an external positive voltage controls output frequency of Generator. Feed the positive (see table) voltage into the plug “Input” (14) “External Frequency Control”. The applied voltage corresponds to output frequency according to calibration table (see Supplement 6).

9.2. Power control.

There are two modes of Power control: Internal and External Power Control modes.
Turn on the Generator as directed in part 8.

9.2.1 Set Internal Power control mode.

One should check LED “External” on the button “Power Control” (18). If LED doesn’t glow, it means that the device is installed in Internal Frequency Control mode. If LED glows, one should press button “Frequency Control” to switch off LED on the button (18).

- To enter desired value of Output Power to press button “Menu”(15) to activate the “Main Menu”. Using buttons “Step” “<-“ or “->” (4) or Rotate Tuning Knob (5) to install marker opposite point “2 Power _____ %” of “Main Menu” and press key “Enter” on keyboard (9) for put in the setting regime of Output Power. One can press key “2” to active of this regime directly.

To enter the desired Output Power one has three possibilities:

- Rotate Tuning Knob (5) and then press key “Menu” (15). Output Power changes synchronously with value indicated on the display;
- Press buttons “Step” “<-“ or “->” (4) and then press key “Menu” (15). 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 Power changes synchronously with value indicated on the display;
- Enter Output Power from Digital Keyboard (9). A marker will appear on the display just after the realising of one of the keys (9). One can use buttons “Step” “<-“ or “->” (4) to change the marker position. That allows edit the power on the display. Press key “Enter” to finish editing and change the

output power. If one will try to enter a wrong power, out of 0-100% range, max or min one available will be installed correspondingly.

- One can combine these three cases.

- In the case setting of Power Level, the grid is defined in percents of voltage applied to Control Electrode of BWO tube. In Supplement 5 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.

9.2.2 Set External Power control mode.

One should check LED “External” on the button “Frequency Control” (19). If LED glows, it means that the device is installed in External Frequency mode. If LED doesn’t glow, one press button “Frequency Control” to switch on LED on the button (19).

In this mode an external positive voltage 0…+10 VDC controls output power of Generator. Feed the positive 0…+10 VDC voltage into the plug “Input” (18) “External Power Control”. The higher voltage corresponds to the higher output power.

9.3 Amplitude Modulation.

There three mode:
- CW (AM OFF);
- Internal;
- External.

One should check LED on “Amplitude Modulation” group of buttons (16). If LED glows, it means that the device is installed in indicated mode.

9.3.1 Set CW mode (Amplitude Modulation is OFF).

Press button “OFF” in “Amplitude Modulation” group of buttons (16).

9.3.2 Set Internal Modulation Mode.

Press button “Internal” in “Amplitude Modulation” group of buttons (16) and square wave 100% amplitude modulation with frequency 1-100 kHz is provided to output. Use Strobe Signal output plug (11) for the triggering of external devices.

- Turn on the Generator as directed in par. 8.
- To enter desired value of frequency modulation to press button “Menu”(15) to activate the “Main Menu”. Using buttons “Step” “<-“ or “->” (4) or Rotate Tuning Knob (5) to install marker opposite point “3. AM _____ kHz” of “Main Menu” and press key “Enter” on keyboard (9) for put in the setting regime of Output Power. One can press key “3” to active of this regime directly.

After activate "Internal AM" mode to enter the desired AM frequency one has three possibilities:

- Rotate Tuning Knob (5) and then press key “Menu” (15). AM frequency changes synchronously with value indicated on the display;

- Press buttons “Step” “<-“ or “->” (4) and then press key “Menu” (15). This way is useful if it is necessary to provide precision tuning. One button realising leads to the change of the AM frequency on the smallest available step. AM frequency changes synchronously with value indicated on the display;
- Enter AM frequency from Digital Keyboard (9). A marker will appear on the display just after the realising of one of the keys (9). One can use buttons “Step” “<-“ or “->” (4) to change the marker position. That allows edit the AM frequency on the display. Press key “Enter” to finish editing and change the AM frequency. If one will try to enter a wrong frequency, out of operating frequency range, max or min one available will be installed correspondingly.
- In the case of AM, only fixed values could be installed. PC main board counter (2MHz/x) provides these values. If one try to enter a value that isn’t fitted to the grid exactly, the fitting will be produced automatically.

9.3.3 Set External Amplitude Modulation.

Press button “External” in “Amplitude Modulation” group of buttons (16) and square wave 100% amplitude modulation with frequency of an external triggering source is provided in this 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 "AM Input" (17). After that Generator will provide amplitude modulation with frequency of the triggering signal.

9.4 Save and load operation set-up.

Generator automatically saves all settings from par. 9.1 - 9.4 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;
Sweep type;
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. 9.1-9.4. Then one should enter to main menu. Press the button “Menu” (15), if it is needed.
Press key “6” on Digital Keyboard (9) to activate command “Save Program” from main menu. Choose number of program from “0” to “9” pressing the corresponding key on Digital Keyboard (9). 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” (15), if it is needed. Press key “7” on Digital

Keyboard (9) to activate command “Load Program” from main menu. Choose number of set-up from “0” to “9” pressing the corresponding key on Digital Keyboard.

9.5 Test parameters of BWO tube.

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

"HV =" – High voltage monitor;
“Ug BWO =” – Control voltage for grid of BWO;
“Iheat =” – Heating Current;
“Ugrid =” – Grid voltage of vacuum tube;
“Ianode =” – HV current;
Pwr control – setting Power control Mode;
Amp Modulat – setting AM Mode;
Frq control – setting Frequency Control Mode.

Press key “.” on Digital Keyboard (9) to active “Additional Menu”.
On LCD screen appears information about operating current and voltage for BWO tube and generator.

10. GPIB INTERFACE

10.1 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 12, assuming that present address is 19. Press button “Menu” to activate “Main menu” of GPIB address setting. Press key “4” and then press keys "1","2" to enter new address 12. After press “Enter” new address will be installed. If one would like to install address 1 he should enter “0” “1” in series.

10.2 GPIB commands.

All commands and settings would be controlled through GPIB interface. Connect the generator to GPIB bus (plug 24 on the rear panel) using special cable.
Turn on the generator as directed in chap. 9 par.
To control of Generator one should send ASCII symbols corresponded to the following table:

Name of Command	Symbols in GPIB port
Fixed Output Frequency	“F3xxx.xxx”
Initial Frequency	“F1xxx.xxx”
Final Frequency	“F2xxx.xxx”
AM Frequency	“F4xx”
Internal Frequency Control	“Fi”
External Frequency Control	“Fe”

Output Power Level	“P_xx”*
Internal Power Control	“Pi”
External Power Control	“Pe”
Amplitude Modulation External	“Ae”
Amplitude Modulation Internal	“Ai”
Amplitude Modulation Off	“Ao”
Sweep Time	“T_xxxx”*
Start Sweep	“G”
Sweep type	“R_0” or "R_1"*
Stop Sweep	“S”

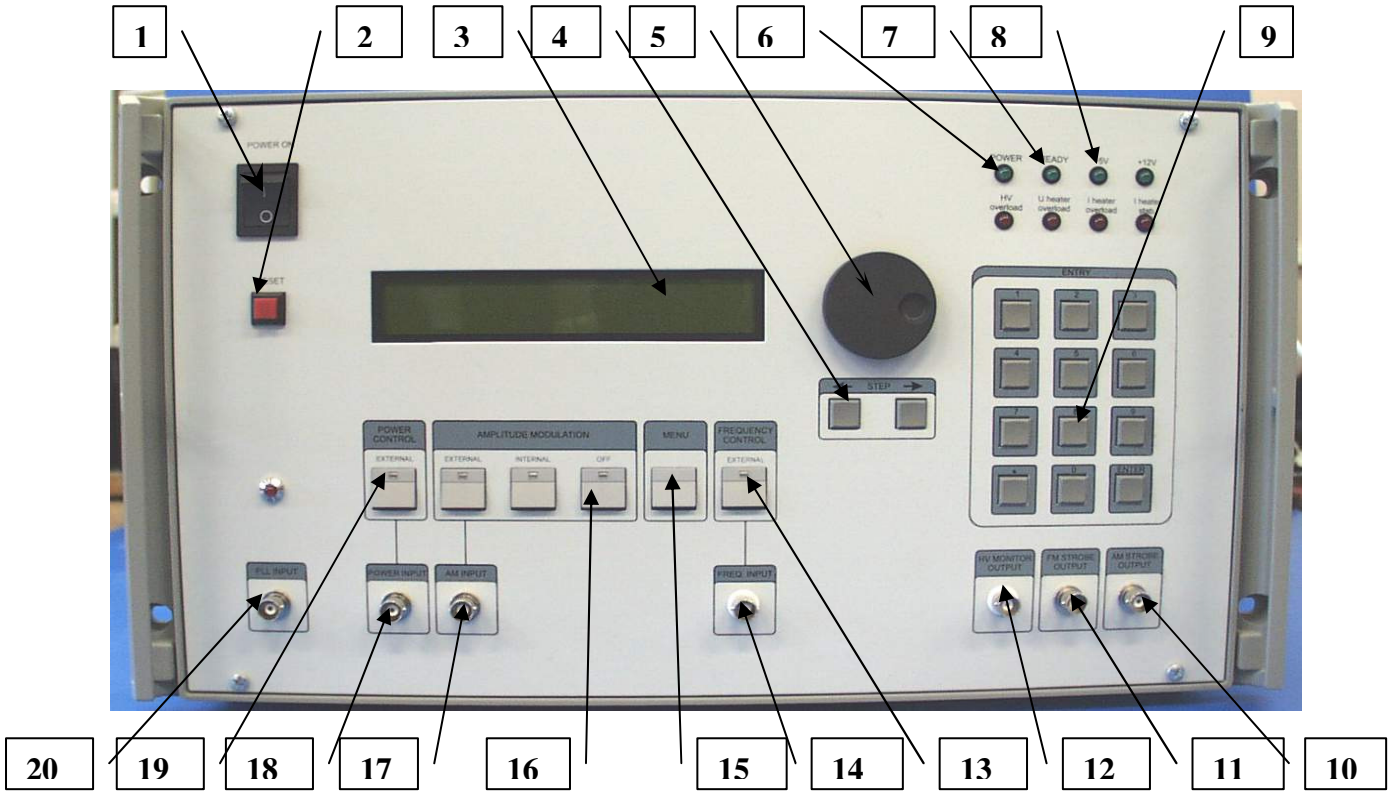
“_” - symbol is blank.

The current the Generator settings may be read via GPIB bus in form of "Status String"=“Name_F3_F2_F1_F4_PowerLevel_SweepTime_Sweeptype_HVmonitor _Iheat_Ianode_Ug__Ugrid_Condition”. 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 4th. For the Generator this string is fixed: "Name"="SGMW".
The "Condition" occupies 4 bytes. Correspondence between values of each "Condition" bit and the Generator settings are shown in the next table:

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

SUPPLEMENT 1

Front panel of the Generator

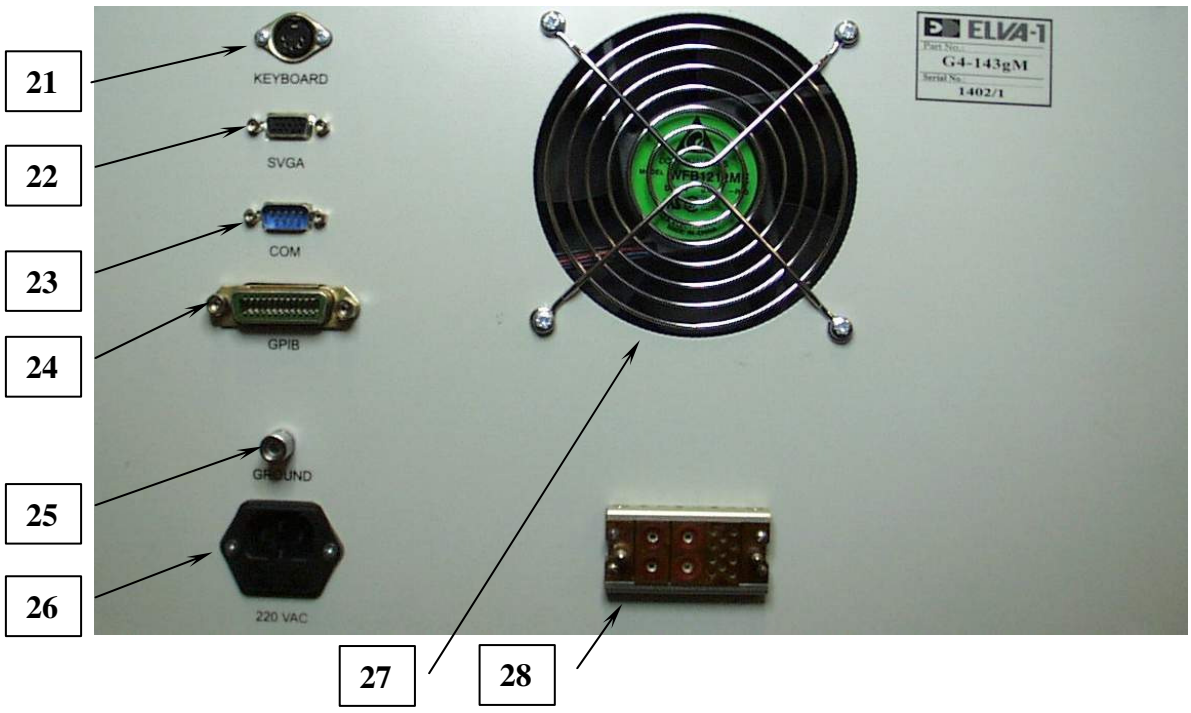


Disposition of the plugs and knobs on the front panel of the power supply.

1. “Power” switch.
2. “Reset” button
3. Liquid Crystal Display.
4. “Step” knobs.
5. Tuning knob.
6. “Power” indicator.
7. “Ready” indicator.
8. Control Indicators.
9. Digital keyboard.
10. "AM Strobe output”, output plug (TTL) (BNC connector).
11. “FM Strobe output”, output plug (TTL) (BNC connector).
12. “HV monitor output”, output plug (0…+10V) (BNC connector).
13. “Frequency Control”, external frequency control switch.
14. "Freq input", external frequency control input (BNC connector).
15. “Menu” button.
16. Amplitude modulation mode switches.
17. "AM Input", input plug (TTL) (BNC connector).
18. "Power input", input plug (0…+10V) (BNC connector).
19. "Power control", external power control switch.
20. Input for PLL system (BNC connector).

SUPPLEMENT 2

Front panel of the Generator Rear .

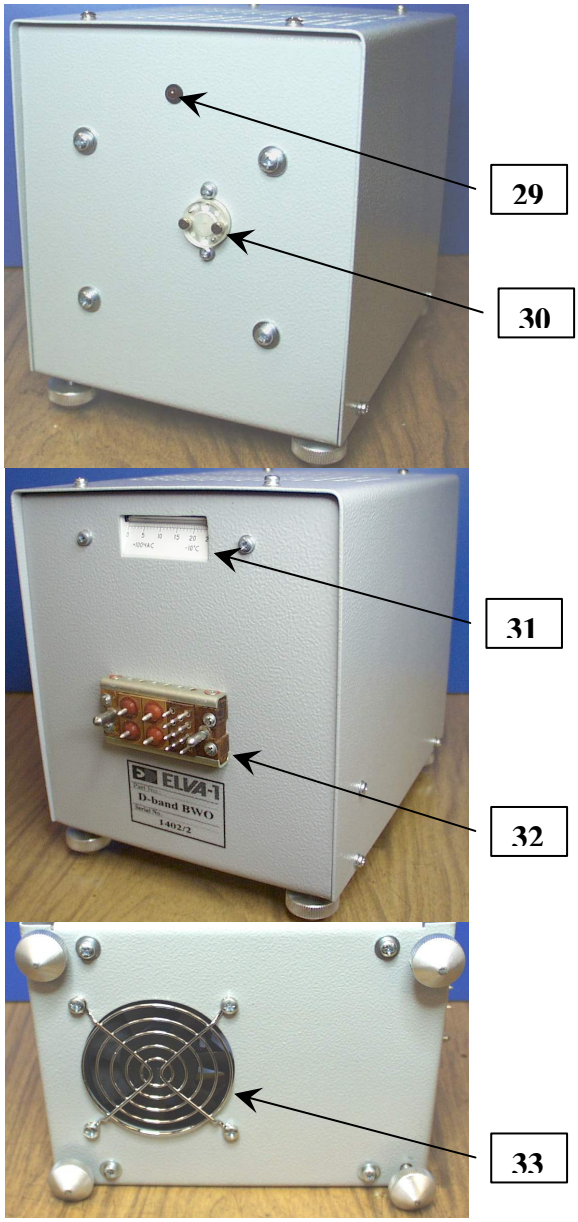


Disposition of the plugs on the rear panel of the Power Supply.

29. “Keyboard”, connector for external keyboard.
30. "SVGA", connector for external PC monitor.
31. "COM", RS-232 port.
32. "GPIB" interface plug.
33. "GROUND" connector.
34. "Power Plug" AC 220V input with fuse 3A.
35. Fan
36. HV connector to BWO module.

SUPPLEMENT 3

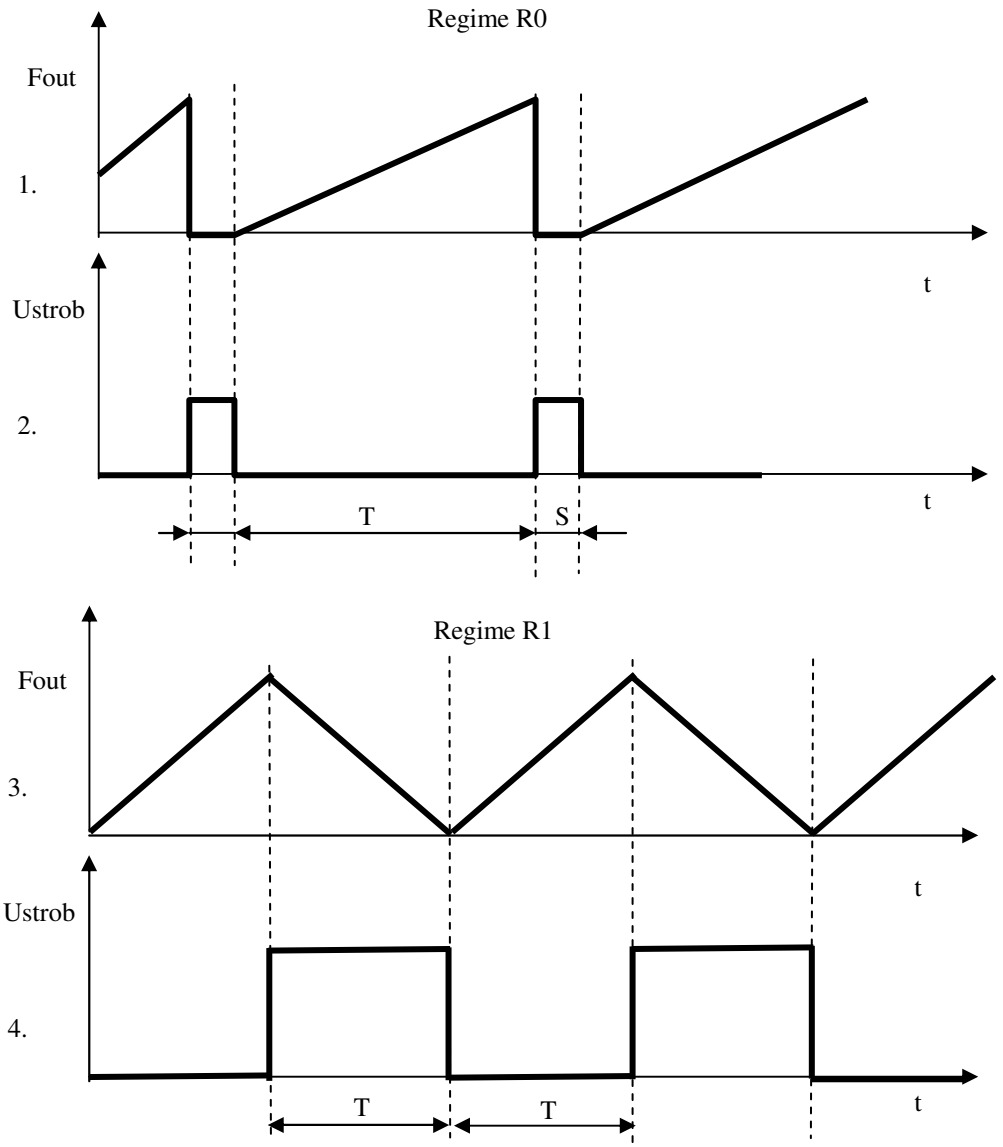
Disposition of controls of BWO module.



29. Power indicator
30. RF output.
31. Time operating counter.
32. HV connector to power supply
33. Cooling fan.

SUPPLEMENT 4

The diagram of the Control Voltage and strobes.

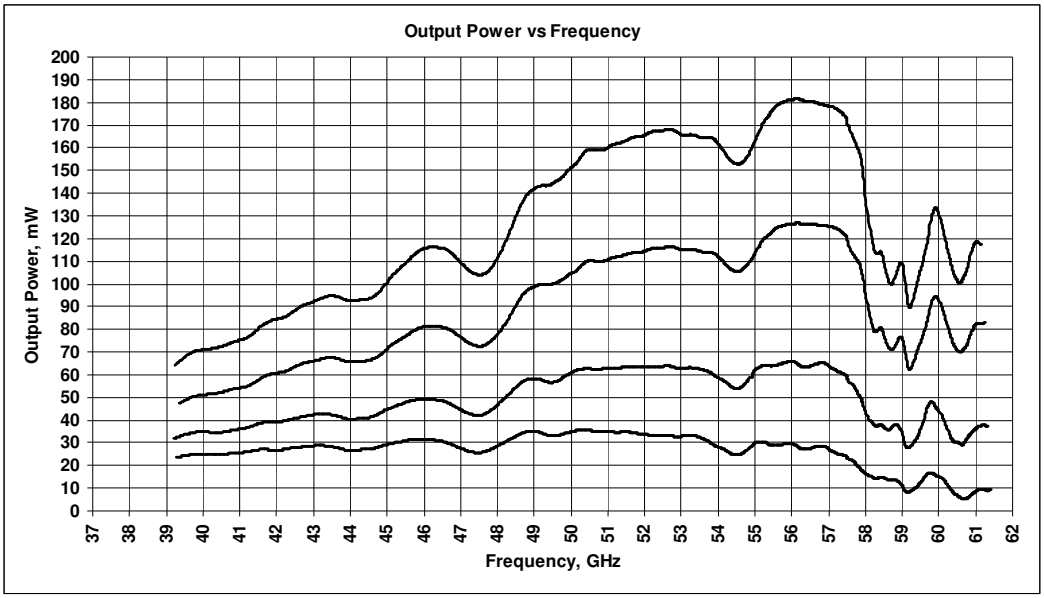


1,3 - The diagram of the internal triangle wave control voltage on plug (12).
2,4 - The diagram of TTL output strobe signal on plug (11).
T – sweep time, set by Digital Keyboard (8) or by GPIB bus command.
S – strobe time, duration about 0.005 sec.

4. Block diagram of the control unit

SUPPLEMENT 5

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



The structure of the calibration data.

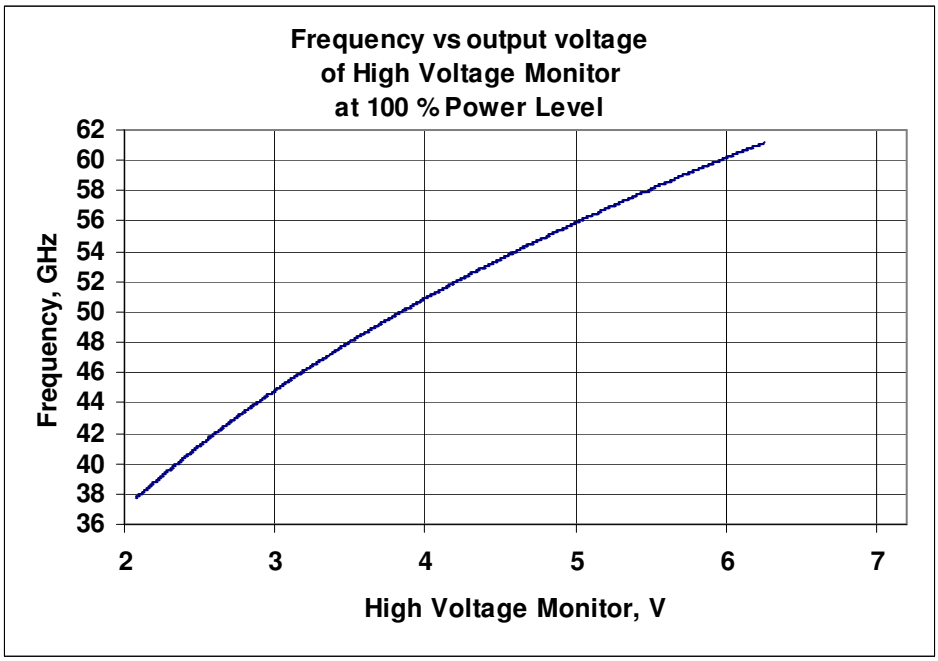
The data in the calibration files are placed in ten columns divided by the tabs:

Uinp	HVm	P35	F35	P50	F50	P75	F75	P100	F100
2.6	1.88	22.2	38.096	28.3	38.008	40.8	37.863	53.2	37.724
2.605	1.885	22.2	38.1	28.3	38.017	40.8	37.873	53.2	37.739

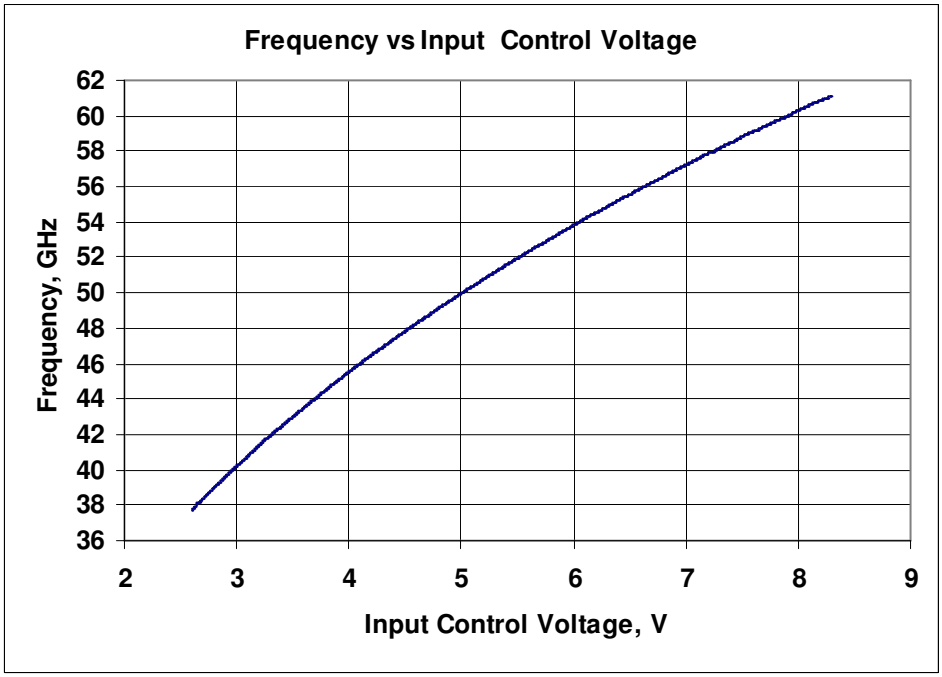
- The first column (Uinp) is a control voltage in V, applying to the external broadband frequency input (10), see supplement 1;
- The second column (HVm) is a voltage in V, measured on the HV Monitor output plug (27), see supplement 2, corresponding to the data placed in the first column.
- The third column (P35) is measured output power of Generator in mW at 35 % power level, corresponding to the data placed in the first column;
- The forth column (F35) is a Generator frequency in GHz at 35 % 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 6

Plot 2. Dependence of voltage on the HV monitor output versus frequency at maximum level of output power.

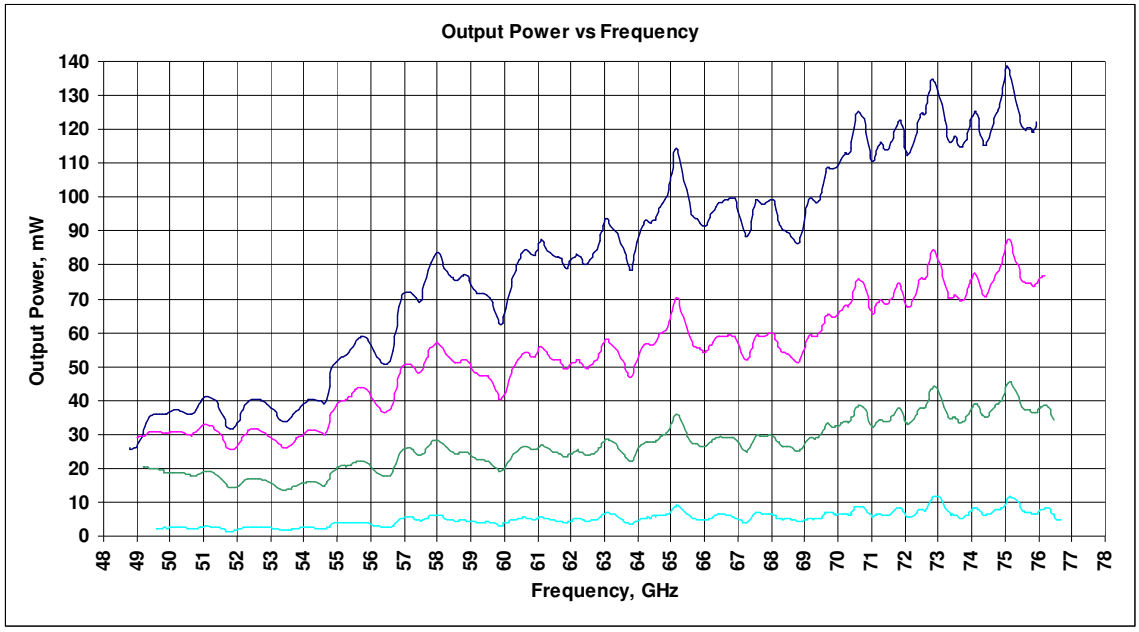


Plot 3. Dependence of frequency versus control voltage applied to the external broadband frequency tune input (10) at maximum level of output power.



SUPPLEMENT 7

Plot 4. Dependence of Output Power versus frequency by various Power Levels for V band BWO.



The structure of the calibration data.

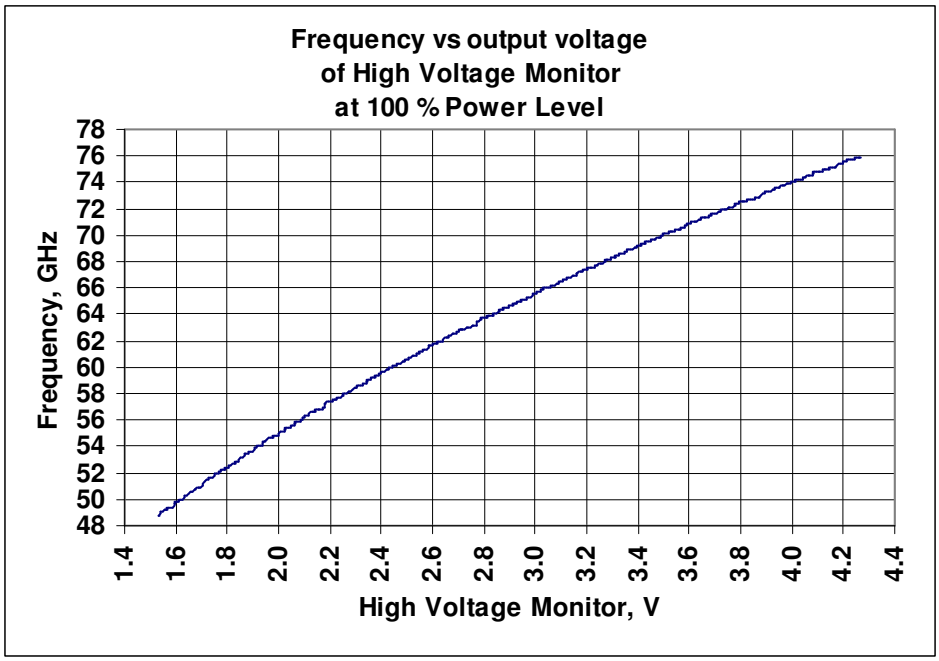
The data in the calibration files are placed in ten columns divided by the tabs:

Uinp	HVm	P40	F40	P50	F50	P75	F75	P100	F100
1.3	1.53	2.2	49.596	20.3	49.199	29.1	48.993	25.9	48.793
1.304	1.533	2.2	49.597	20.3	49.202	29.1	48.997	25.6	48.8

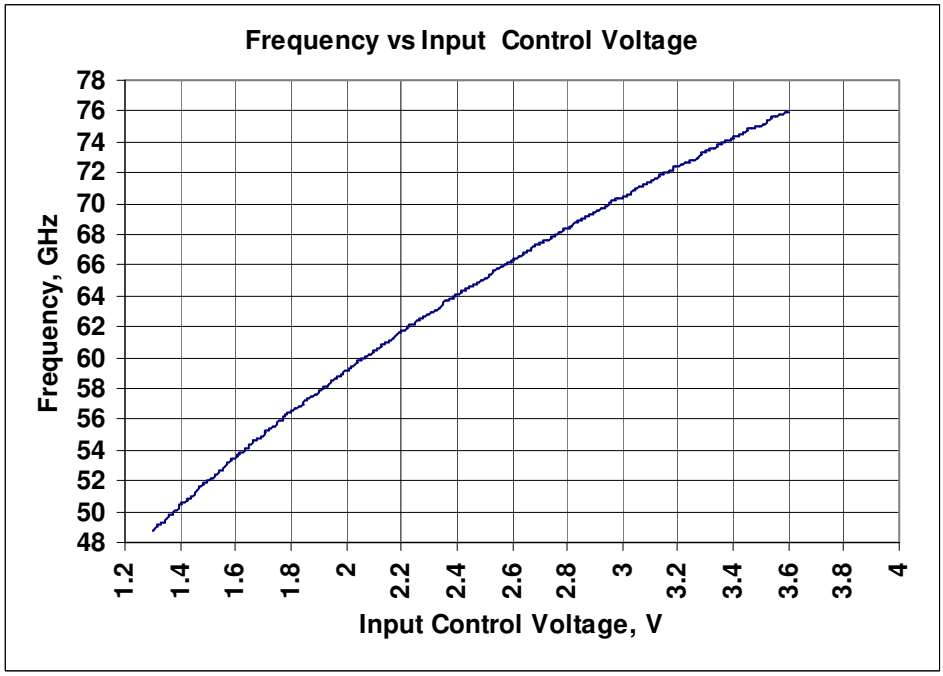
- The first column (Uinp) is a control voltage in V, applying to the external broadband frequency input (10), see supplement 1;
- The second column (HVm) is a voltage in V, measured on the HV Monitor output plug (27), see supplement 2, corresponding to the data placed in the first column.
- The third column (P25) is measured output power of Generator in mW at 25 % power level, corresponding to the data placed in the first column;
- The forth column (F25) is a Generator frequency in GHz at 25 % 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 8

Plot 5. Dependence of voltage on the HV monitor output versus frequency at maximum level of output power for V band BWO.

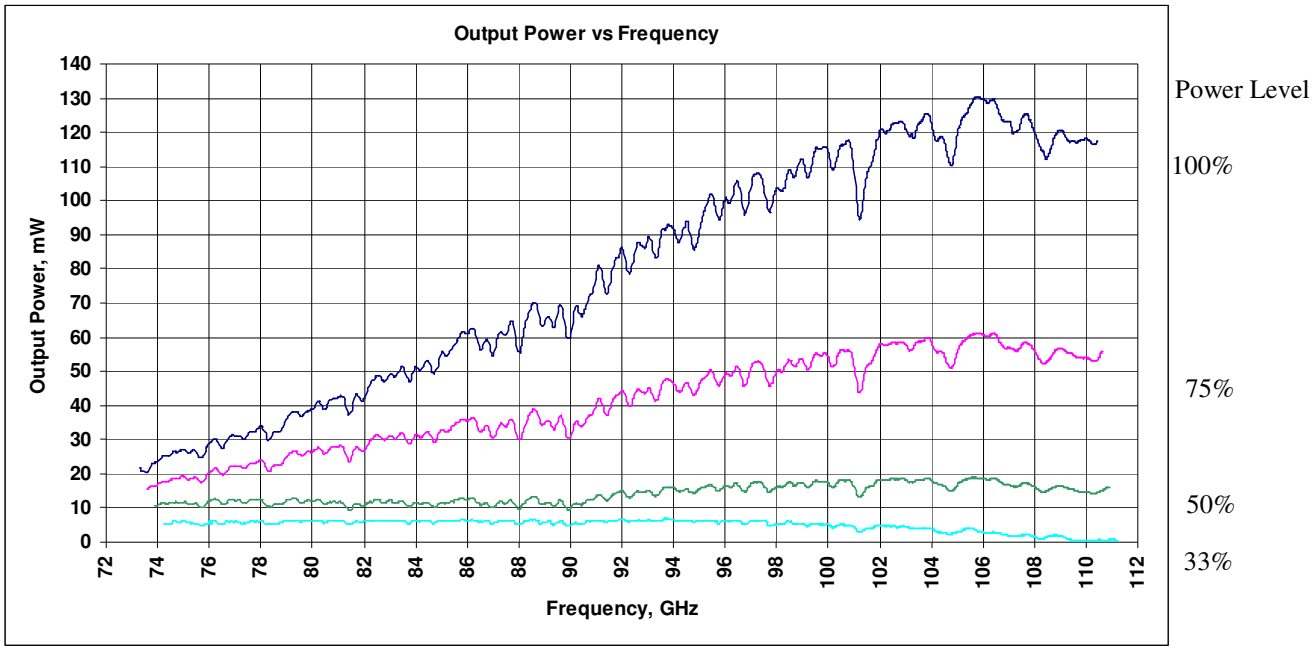


Plot 6. Dependence of frequency versus control voltage applied to the external broadband frequency tune input (10) at maximum level of output power.



SUPPLEMENT 9

Plot 7. Dependence of Output Power versus frequency by various Power Levels. for W band BWO



The structure of the calibration data

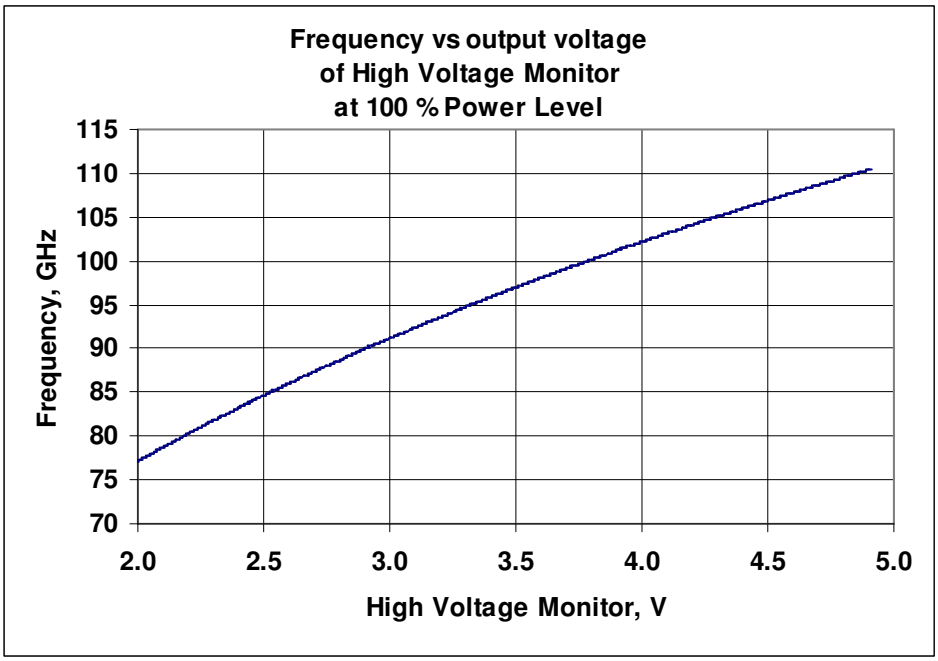
The data in the calibration files are placed in ten columns divided by the tabs:

Uinp	HVm	P33	F33	P50	F50	P75	F75	P100	F100
3.101	1.772	5.2	74.255	10.5	73.884	15.6	73.582	21.5	73.272
3.105	1.777	5.2	74.306	10.5	73.932	15.6	73.633	21.5	73.324

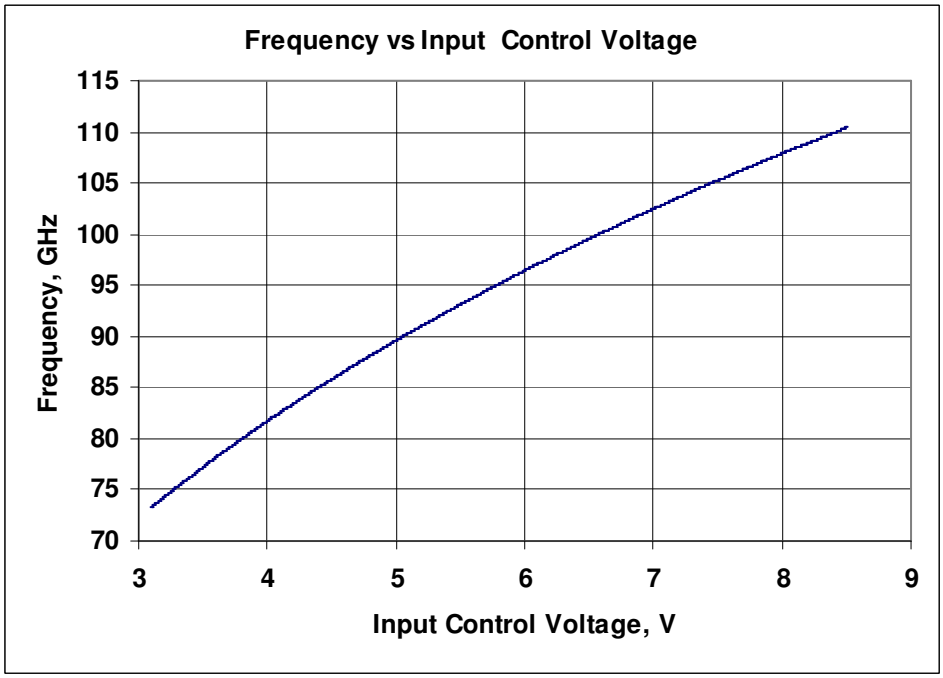
- The first column (Uinp) is a control voltage in V, applying to the external broadband frequency input (10), see supplement 1;
- The second column (HVm) is a voltage in V, measured on the HV Monitor output plug (27), see supplement 2, corresponding to the data placed in the first column.
- The third column (P33) is measured output power of Generator in mW at 33 % power level, corresponding to the data placed in the first column;
- The forth column (F33) is a Generator frequency in GHz at 33 % 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 10

Plot 8. Dependence of voltage on the HV monitor output versus frequency at maximum level of output power.

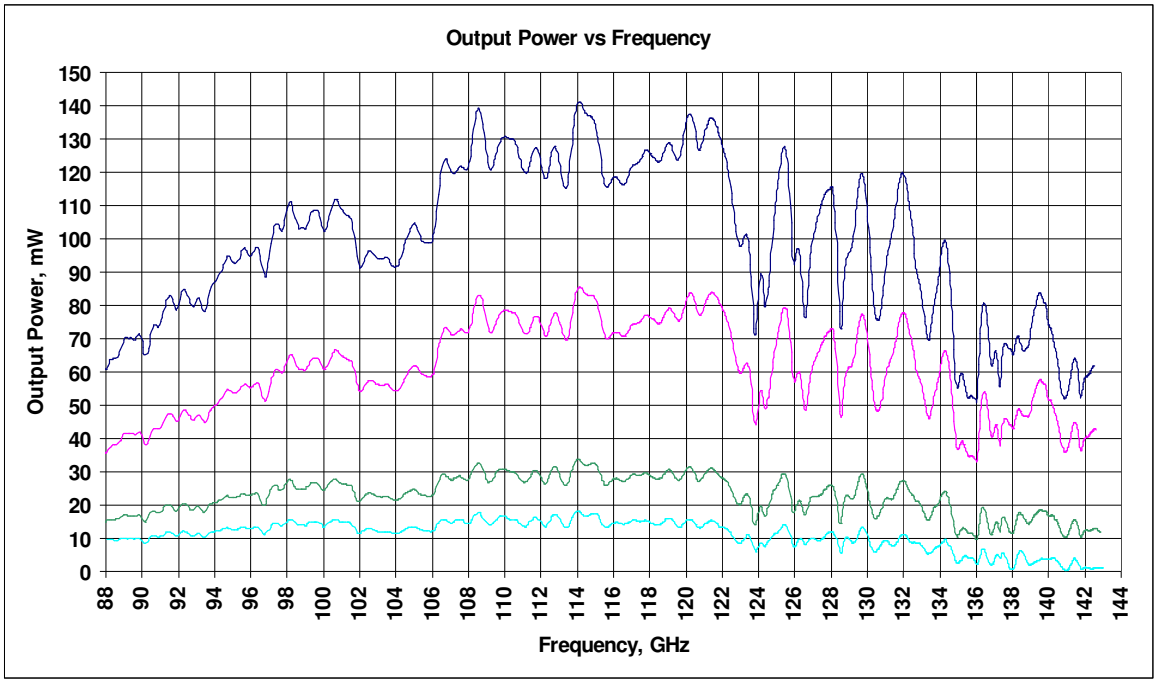


Plot 9. Dependence of frequency versus control voltage applied to the external broadband frequency tune input (10) at maximum level of output power.



SUPPLEMENT 11

Plot 10. Dependence of Output Power versus frequency by various Power levels. for F band BWO



The structure of the calibration data.

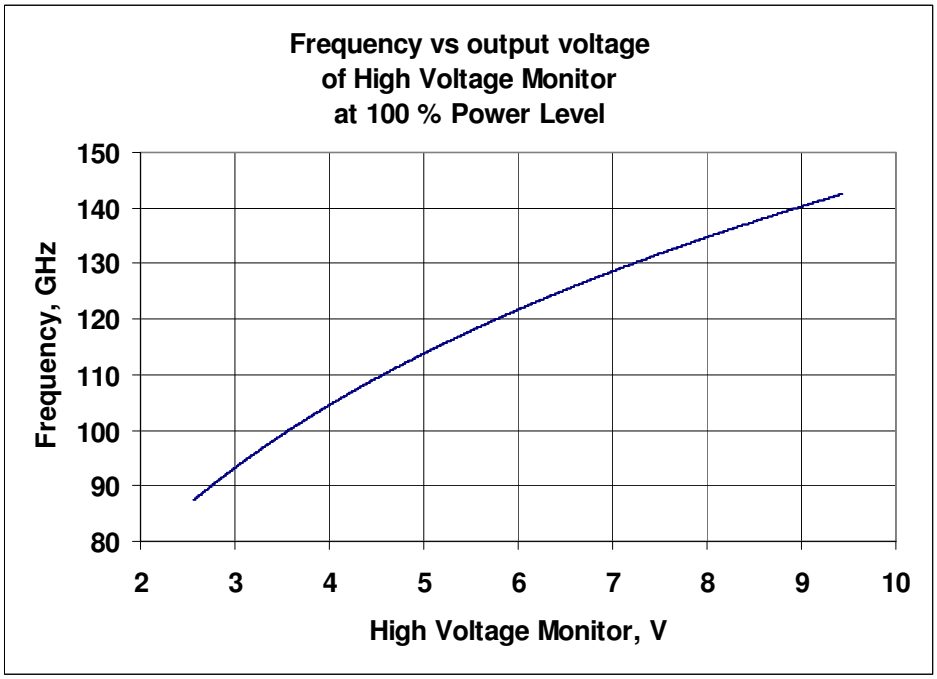
The data in the calibration files are placed in ten columns divided by the tabs:

Uinp	HVm	P40	F40	P50	F50	P75	F75	P100	F100
2.3	2.560	9.8	88.095	14.9	87.935	38.1	87.522	66.4	87.384
2.305	2.565	9.8	88.142	15	87.973	38	87.58	66.4	87.419

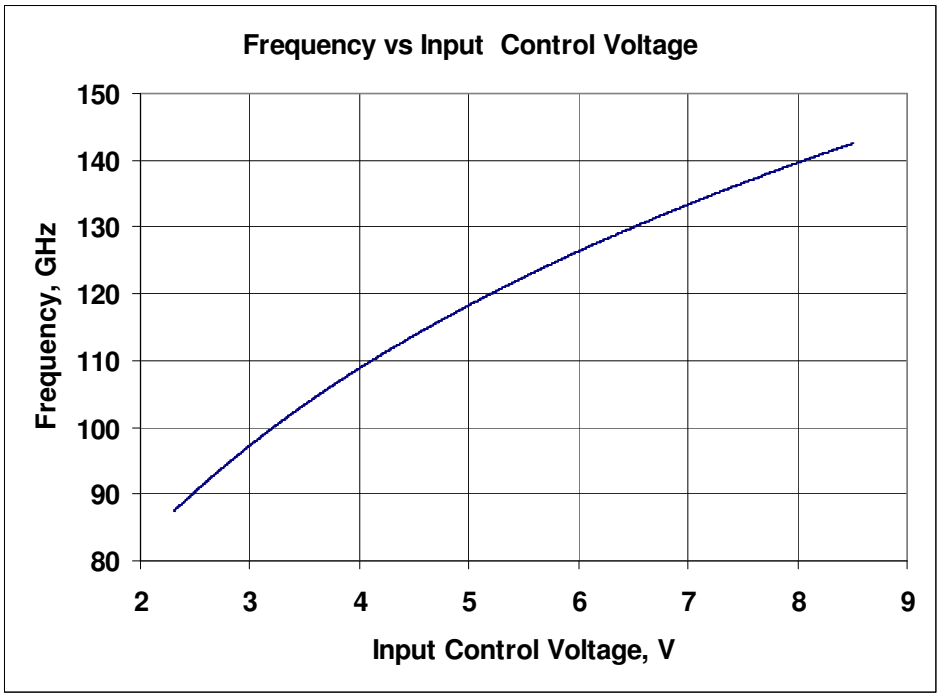
- The first column (Uinp) is a control voltage in V, applying to the external broadband frequency input (10), see supplement 1;
- The second column (HVm) is a voltage in V, measured on the HV Monitor output plug (27), see supplement 2, corresponding to the data placed in the first column.
- The third 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 12

Plot 11. Dependence of voltage on the HV monitor output versus frequency at maximum level of output power.

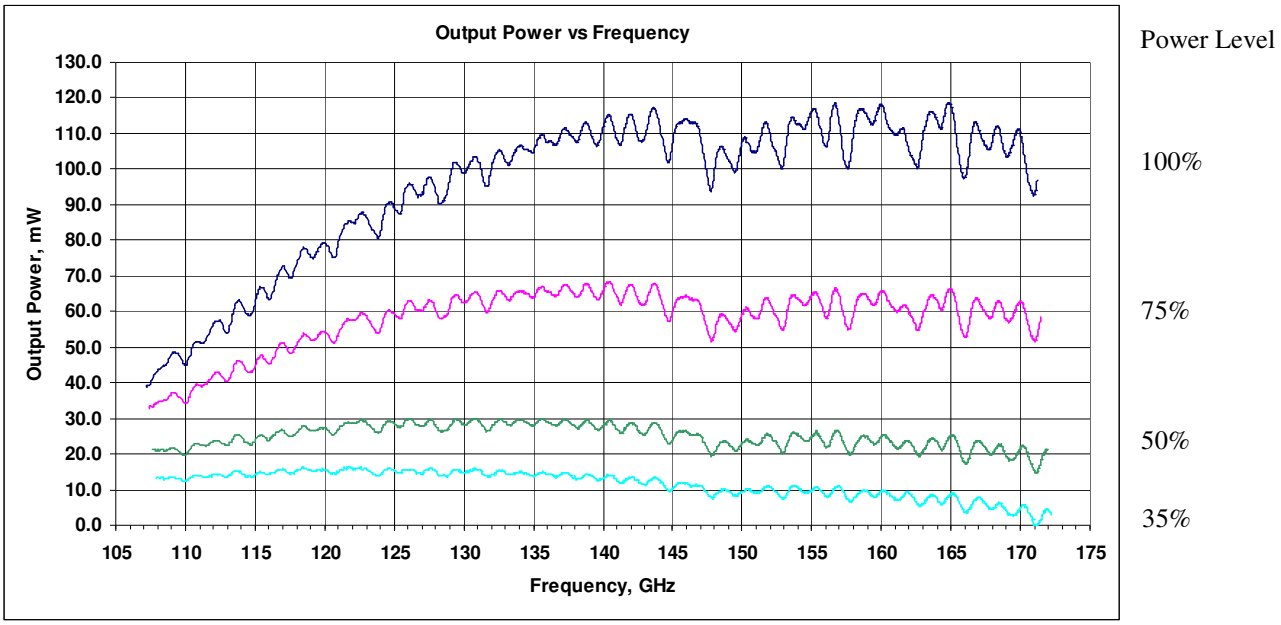


Plot 12. Dependence of frequency versus control voltage applied to the external broadband frequency tune input (10) at maximum level of output power.



SUPPLEMENT 13

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



The structure of the calibration data.

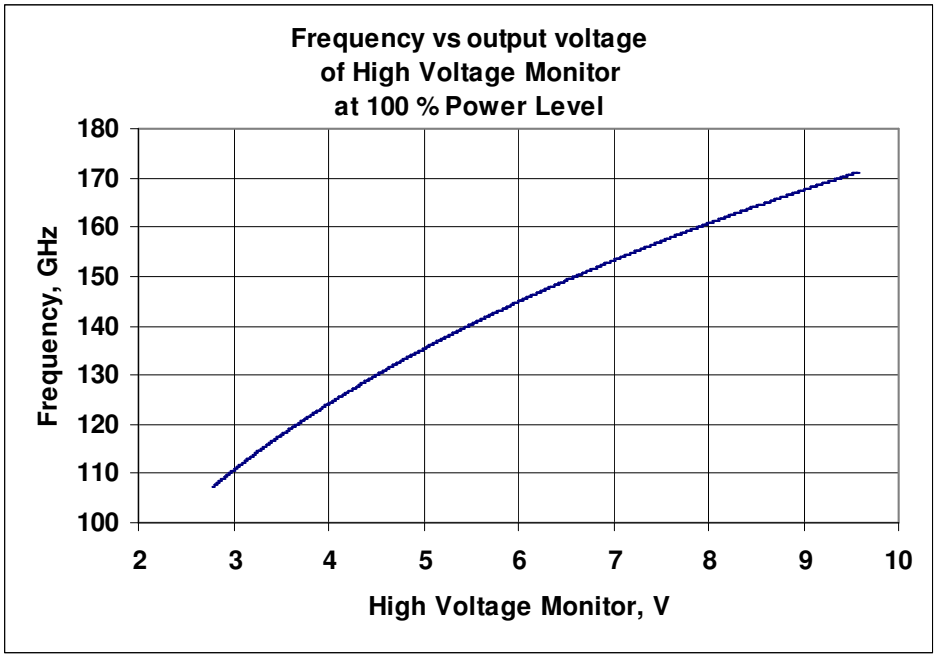
The data in the calibration files are placed in ten columns divided by the tabs:

Uinp	HVm	P35	F35	P50	F50	P75	F75	P100	F100
1.050	2.773	13.2	107.894	21.2	107.604	32.8	107.367	38.8	107.165
1.055	2.778	13.3	107.951	21.2	107.772	33.1	107.388	38.8	107.174

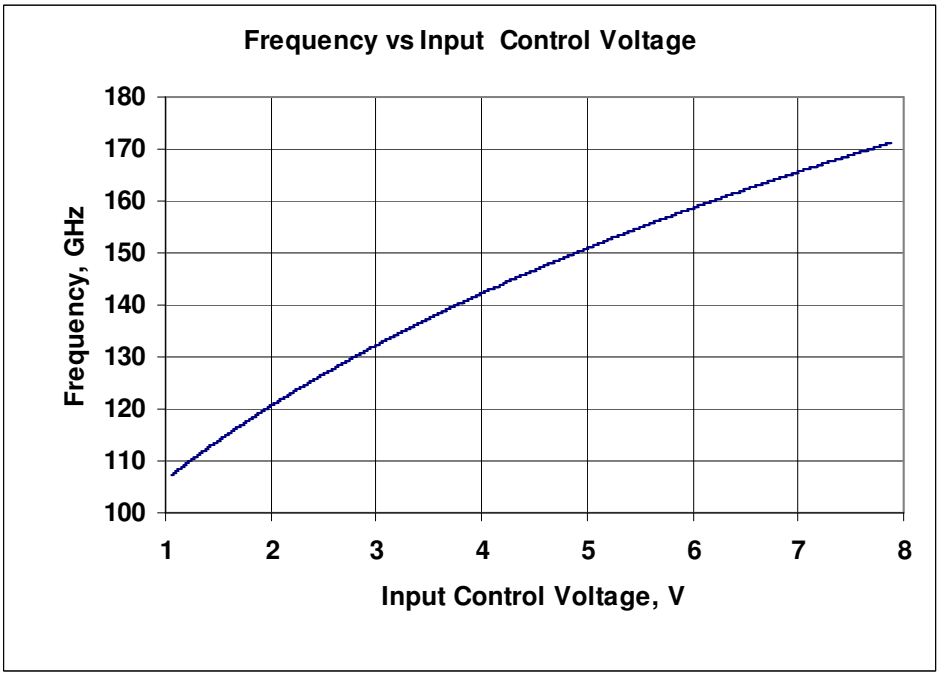
- The first column (Uinp) is a control voltage in V, applying to the external broadband frequency input (14), see supplement 1;
- The second column (HVm) is a voltage in V, measured on the HV Monitor output plug (12), see supplement 1, corresponding to the data placed in the first column.
- The third column (P35) is measured output power of Generator in mW at 35 % power level, corresponding to the data placed in the first column;
- The forth column (F35) is a Generator frequency in GHz at 35 % 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 14

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

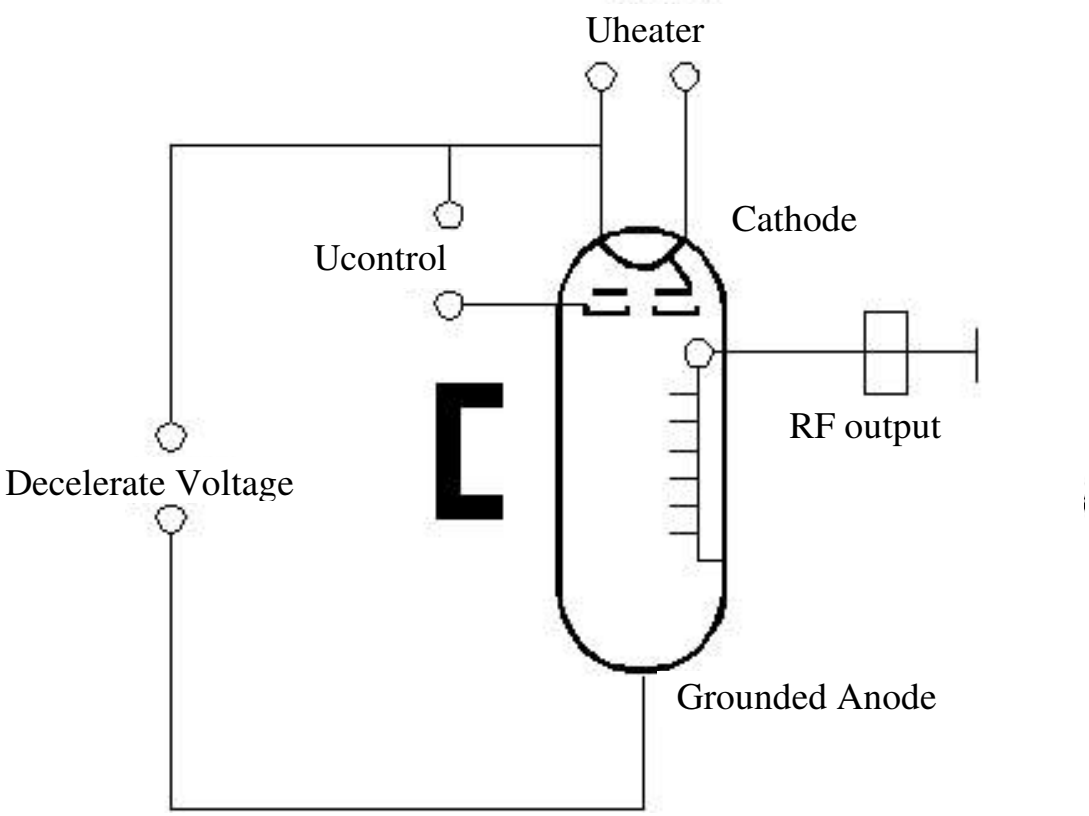


Plot 2. Dependence of frequency versus control voltage applied to the external broadband frequency tune input (10) at maximum level of output power.



SUPPLEMENT 15

Electrical Scheme of BWO Tube



Ucathode = -500…-3000VDC (Decelerate Voltage).
Ucontrol =+5…+230VDC (from cathode level).
Uheating =+1.0…+1.2VDC (from cathode level).