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Millimeter-wave source
With digital and analogue control and remote diagnostic
Model VCOM-10/94/200-DP
Serial No A-1009/68

February 2016

Specifications

Operating Frequency Range	93.5…94.5 GHz
Max output power	More then 170 mW over the frequency range (see details in Fig.6)
Frequency Step (max):	250kHz
Power Level Step:	not more 1mW
Spectrum line width at level -10 dBc	200 kHz max
Absolute accuracy of set Frequency:	<0.5MHz within +10ºC to +40ºC
Settling time to major frequency step:	less than or equal to 500 msec (max) into ±0.5MHz window at target value
Frequency settling time:	0.5 sec (max)
Frequency modulation (FM) bandwidth (max) Note: depends on central frequency	200 MHz (typ)
Phase noise:	-57 dBc/Hz @ 100 KHz -68 dBc/Hz @ 1 MHz
Control attenuation of output power	0…40 dB
Control program Version	160218
Long term stability of reference crystal oscillator:	± 1 ppm per month at constant temperature
Output Frequency/Power Control connector through RS-232 interface:	RS-232, DB-9 male
Remote Diagnostic Protocol:	Ethernet/SNMP v1
Ethernet port:	RG-45 Socket
Power supply voltages:	-12VDC ±10% 0.2A, +12VDC ±10% 0.6A, +24VDC ±10% 0.7A, +24VDC ±10% < 0.7A (Heater) +5VDC ±10% 0.8A
Output flange / Waveguide	UG-387/U-M /WR10
Analogue frequency and power control connector	BNC
Analogue frequency and power control voltage	0...+10V
Input impedance of frequency and power control inputs	10 kΩ
Ability to change Frequency via direct DAC settings:	Min step time 100msec per update
Remote diagnostic protocol	Ethernet / SNMP v1
Operating Humidity:	< 70% (non-condensing) at Temp range +10 to +40degC
Size, mm	380x130x85
External power supply	220-230VAC
Operating temperature	+10º C…+40º C

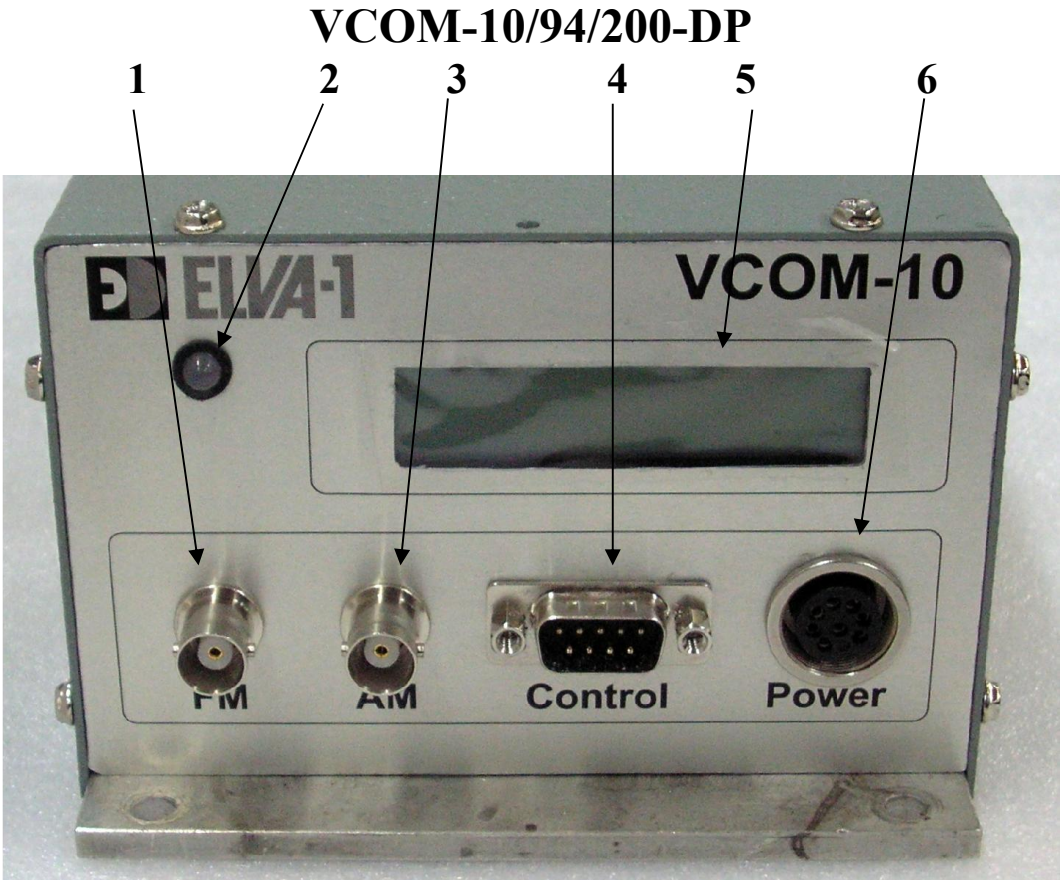
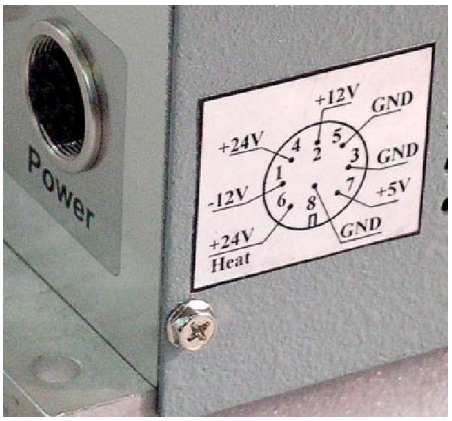


Fig.1 Front panel of VCOM-10/94/200-DP

1 –FM (frequency modulation) input (BNC)
2 – LED indicator
3 – AM (amplitude modulation) input (BNC)
4 – DB-9 connector for output frequency/power level control
5 – LCD Display
6 – Power supply socket “LUMBERG” # 030408-1



Pin #	
1	-12V
2	+12V
3	Ground
4	+24V
5	Ground
6	+24V (heater)
7	+5V
8	Ground

Fig.2 Pinout of the power supply cable connector of the VCOM source.

Power supply cable has connector “LUMBERG” # 033208-1 or compatible.

Fig.3 Millimeter wave output of **VCOM-10/94/200-DP** source

Order of switching the mm-wave source ON/OFF

Switching ON:

1. Put the Source on place
2. Connect output flange to waveguide input

Attention: Make sure that the waveguide flanges are properly connected. Large leakages of mm-wave power from waveguide channel are dangerous for human body.

3. Connect control cable to DB-9 connector. The cable connector must be DB-9 female.

Note: Use MODEM cable for connection of the source to RS-232 port of control computer. Wire pinout of MODEM cable is presented in fig.4. Only 3 wires numbered 2, 3 and 4 at DB-9 are used.

4. Connect power supply (fig.5) with the cable included.
5. Turn power supply on.

- The source starts after all diagnostic tests have been passed. Initial state: there is no producing of mm-wave power, output attenuator is closed. Indicator diode on the front panel blinks **RED.**
- To start producing of mm-wave power one has to send two commands to VCOM-10/94/200-DP source: **@U27!on#** and **@PWR!xx#** (see list of commands below).
- It is possible to switch mm-wave power ON/OFF with turning +24V supply voltage ON/OFF from external power supply block or with command: **@U27!on#** or **@U27!off#**. If the +24 voltage is switched OFF, the source does not produce mm-wave power. Indicator diode on the front panel blinks **RED**
- if one of the voltages is OFF, **ALARM** mode is ON. Indicator diode on the front panel blinks **RED,** the source does not produce mm-wave power
- If indicator diode on the front panel shines **GREEN,** all tests have been passed and the VCOM-10/94/200-DP source is producing mm-wave power.

6. Send commands through RS-232 for frequency and power level control.

Note:

It is possible to send the commands after +5V voltage is switched ON (other voltages can be switched OFF). The settings will be accepted by control board. The command will be performed after all supply voltages appear.

9-Pin D-Sub Connector Pin	9-Pin D-Sub Connector Pin
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9

9-Pin D-Sub Connector Pin	25-Pin D-Sub Connector Pin
1	8
2	3
3	2
4	20
5	7
6	6
7	4
8	5
9	22

Fig.4 Schematic of Modem cable

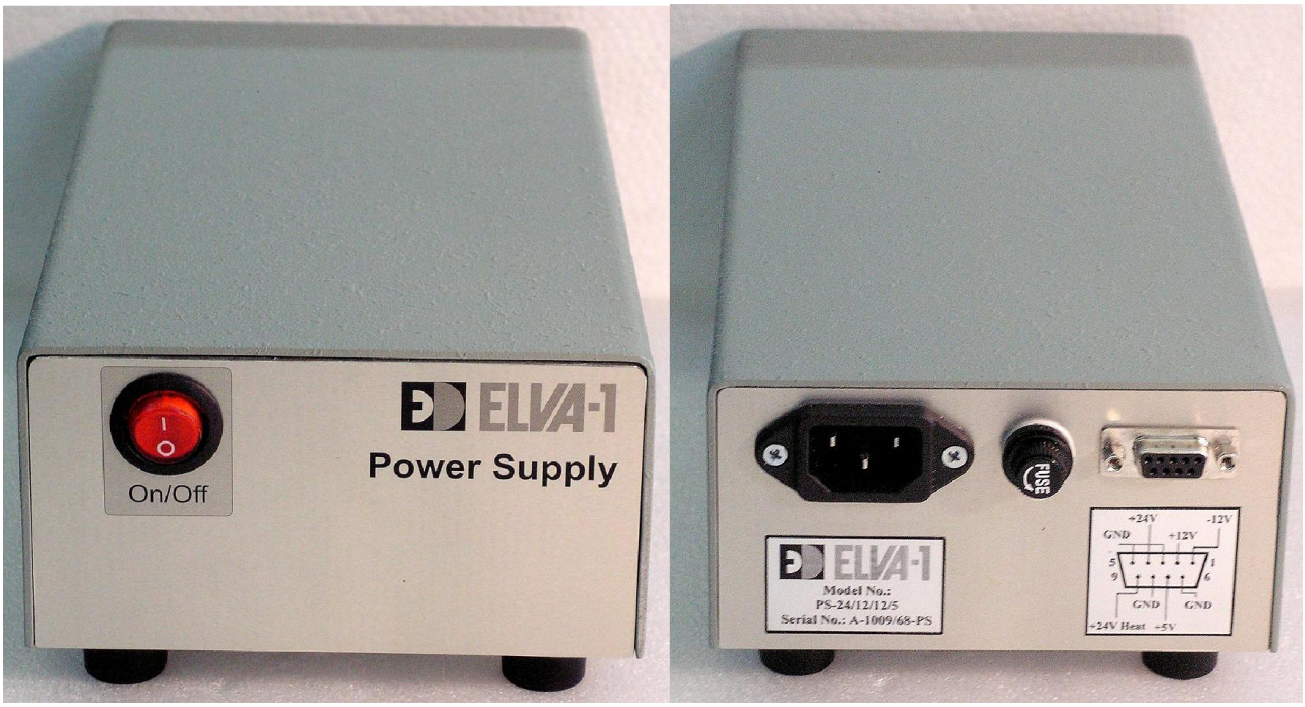


Fig.5 Outward view of external power supply block

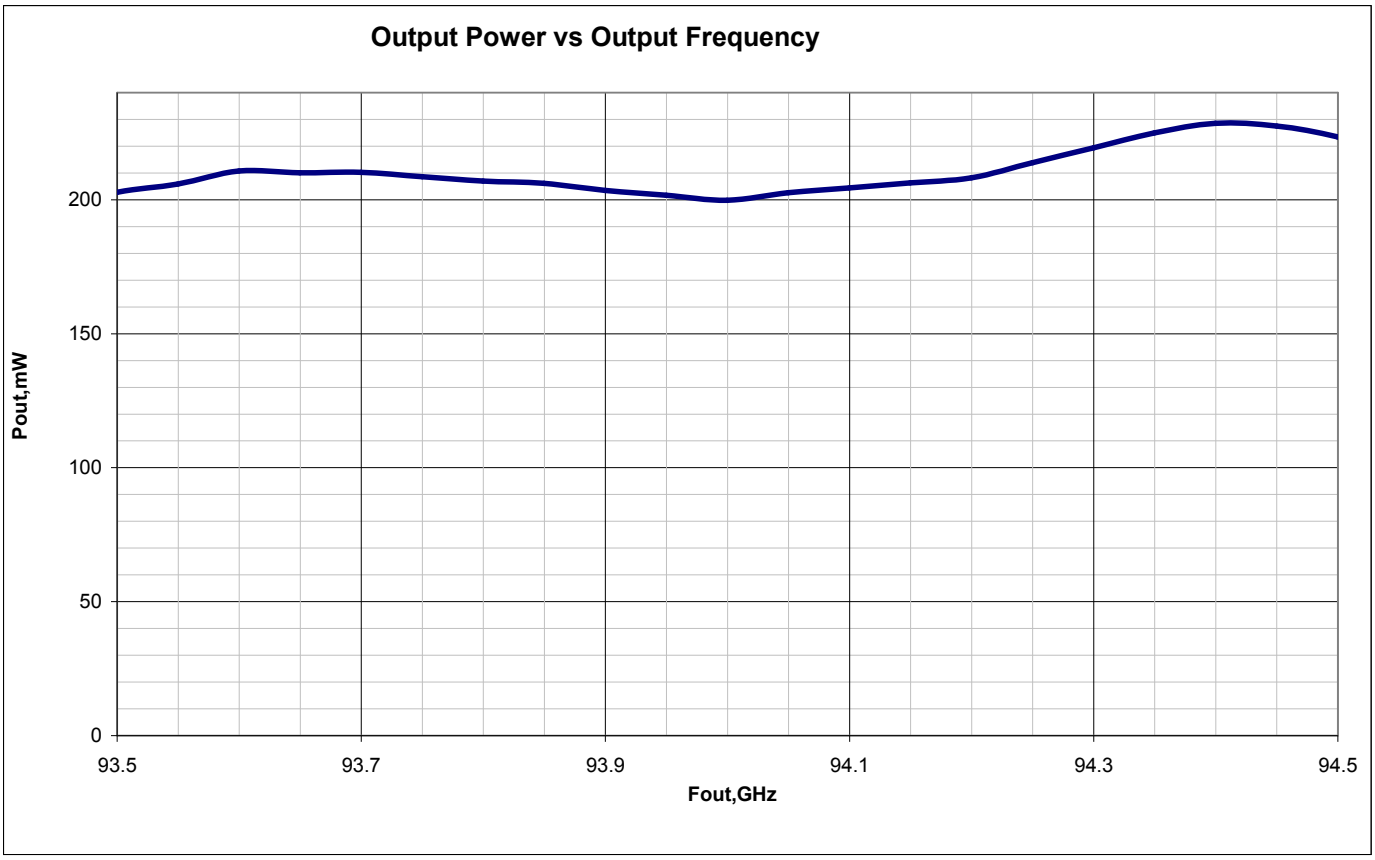


Fig.6 Maximum Output Power of VCOM-10/94/200-DP Serial No A-1009/68 vs. Frequency.

Frequency Modulation (FM)

The VCOM-10/94/200-DP source s/n A-1009/68 has an additional option of slow (<10 kHz) frequency modulation around central frequency. Max frequency modulation span (bandwidth) is 100MHz…180MHz which depends on central frequency within **93.6GHz…94.3**GHz range.

The frequency modulation is provided with external control voltage 0…+10V to BNC connector FM on front panel (pos1 in fig.1). Max speed of the frequency modulation is 10 kHz.

There are two possibilities of usage the frequency modulation:

1. **Frequency stabilization mode is enabled**.
   Direct frequency control is disabled: @DAF:off# (default mode). Read commands/queries list in pages 16, 17. Frequency modulation span (bandwidth) depends on amplitude of FM voltage Uc (from range 0…+10V). Central frequency is measured with built-in frequency counter and indicated on display on front panel. Frequency stabilization mode is ON. It tries to keep central frequency near to XXX.XX value which was set in last command @FRQ!XXX.XX# (read commands list in page 17). If no command @FRQ!XXX.XX# was applied after switching the source on, the central frequency is 94.00GHz.
   Note: The lowest frequency modulation speed should not be less 500 Hz.
   Differently central frequency can not be measured correctly and will oscillate.

2. **Frequency stabilization mode is disabled.**
   Direct frequency control is enabled: Command @DAF!on# was applied. State is @DAF:YYYY:on#. Read commands/queries list in pages 17, 18. The lowest output frequency (at Uc=0) corresponds to YYYY code. Frequency modulation span (bandwidth) depends on amplitude of FM voltage Uc (from range 0…+10V). The frequency modulation speed can be 0…10 kHz. Central frequency is measured with built-in frequency counter and is indicated on display on front panel. The central frequency value can slowly drift in time because frequency stabilization mode is disabled. The central frequency value can also oscillate if modulation speed is less 500 Hz.

Output frequency dependence of FM input is presented at fig.7-9.
Typical spectrum of frequency modulated output signal is presented in fig.10.

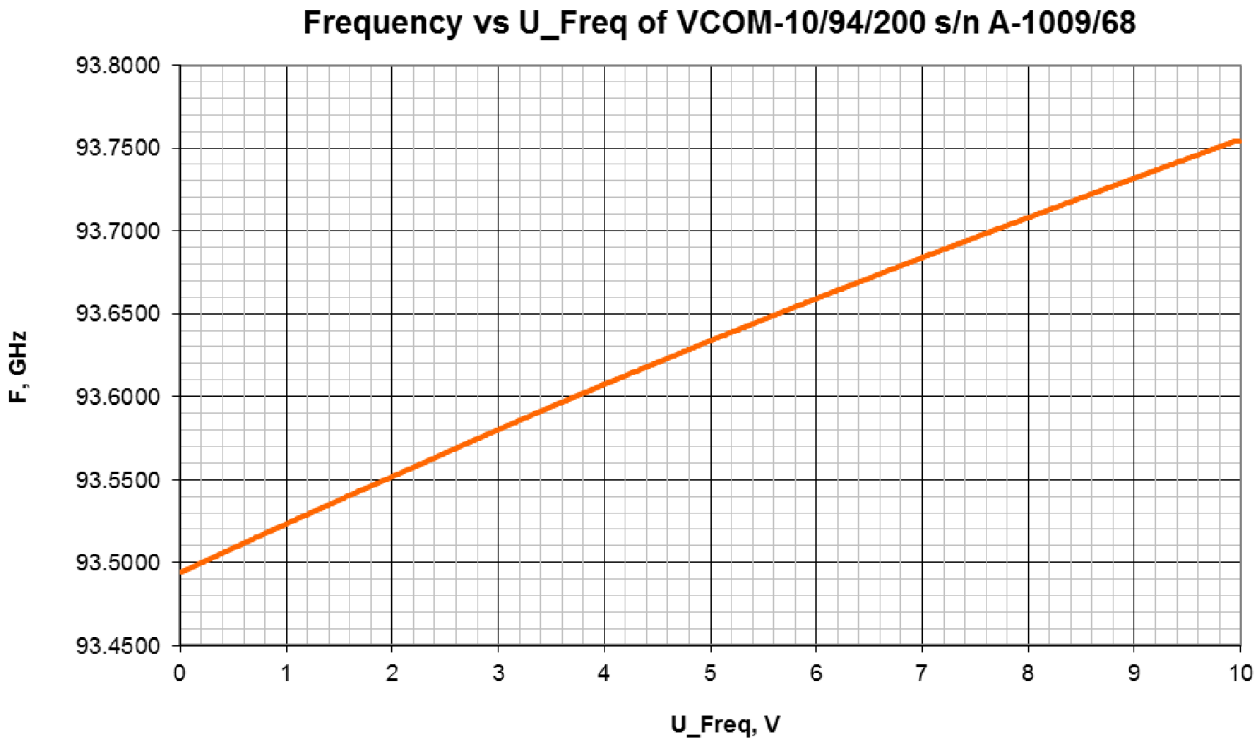


Fig.7. Output frequency of VCOM-10/94/200-DP s/n A-1009/68 vs control voltage (DC) of FM control input. Frequency stabilization mode is disabled. Initial frequency is 93.5 GHz.

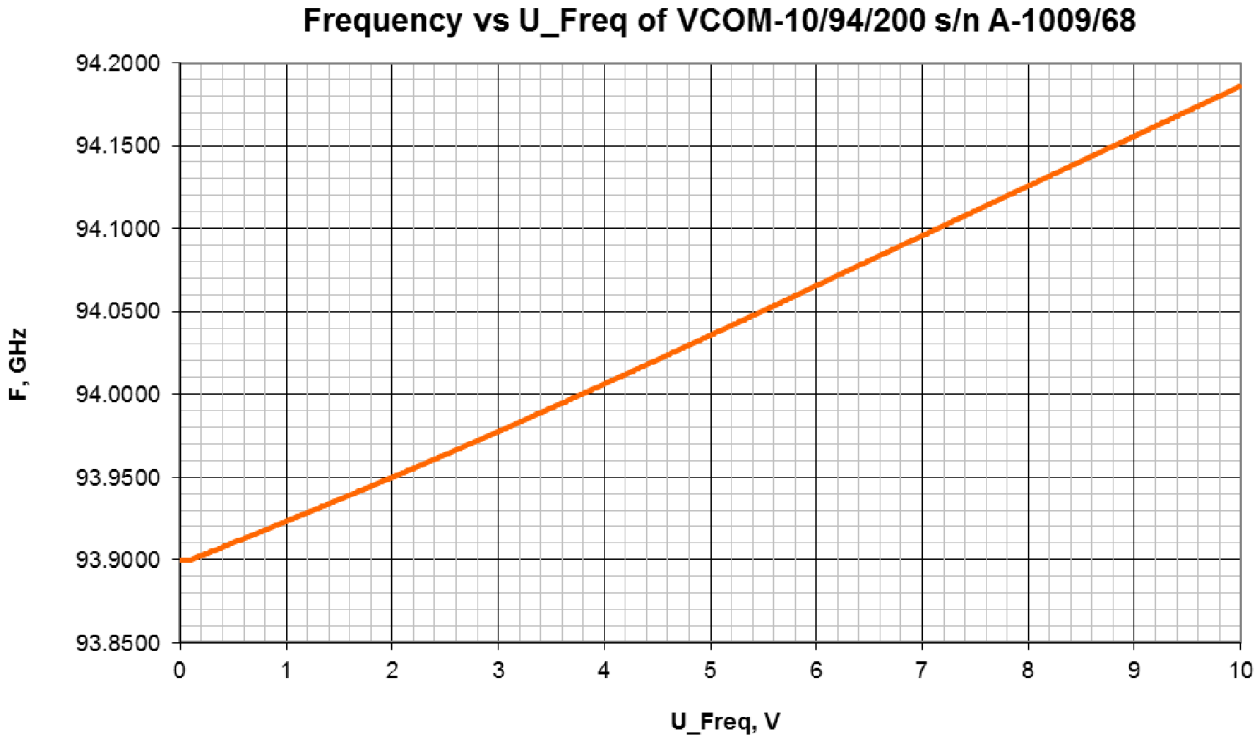


Fig.8. Output frequency of VCOM-10/94/200-DP s/n A-1009/68 vs control voltage (DC) of FM control input. Frequency stabilization mode is disabled. Initial frequency is 93.9 GHz.

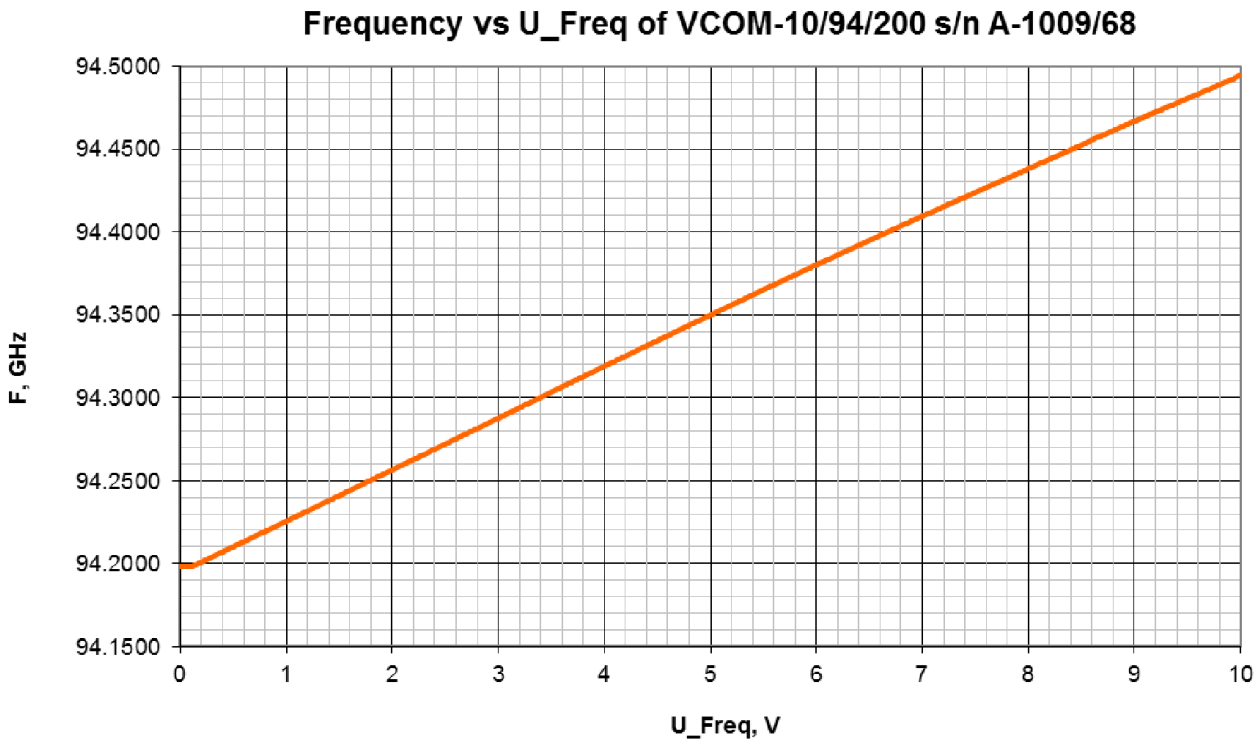


Fig.9. Output frequency of VCOM-10/94/200-DP s/n A-1009/68 vs control voltage (DC) of FM control input. Frequency stabilization mode is disabled. Initial frequency is 94.2 GHz.

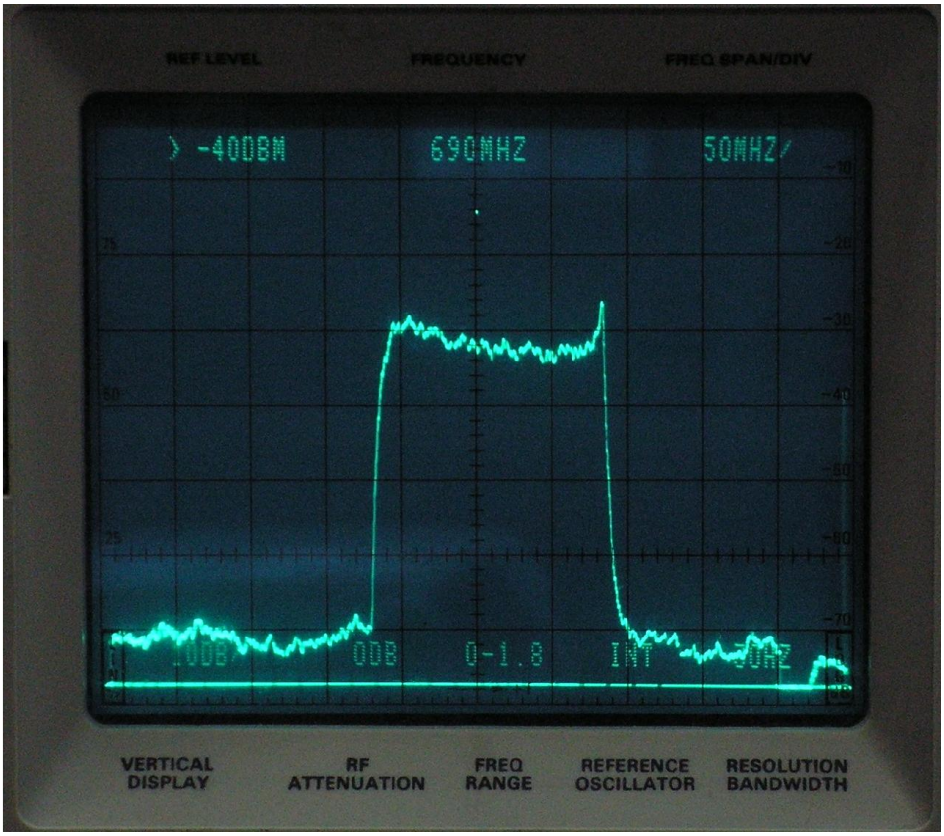


Fig.10. Spectrum of frequency modulated output signal of VCOM-10/94/200-DP source. Central frequency is 94GHz (down-converted to 690MHz), modulation voltage is saw tooth shape, amplitude (peak to peak) is 4V and frequency is 4 KHz.

Analogue control of output power (output attenuator)

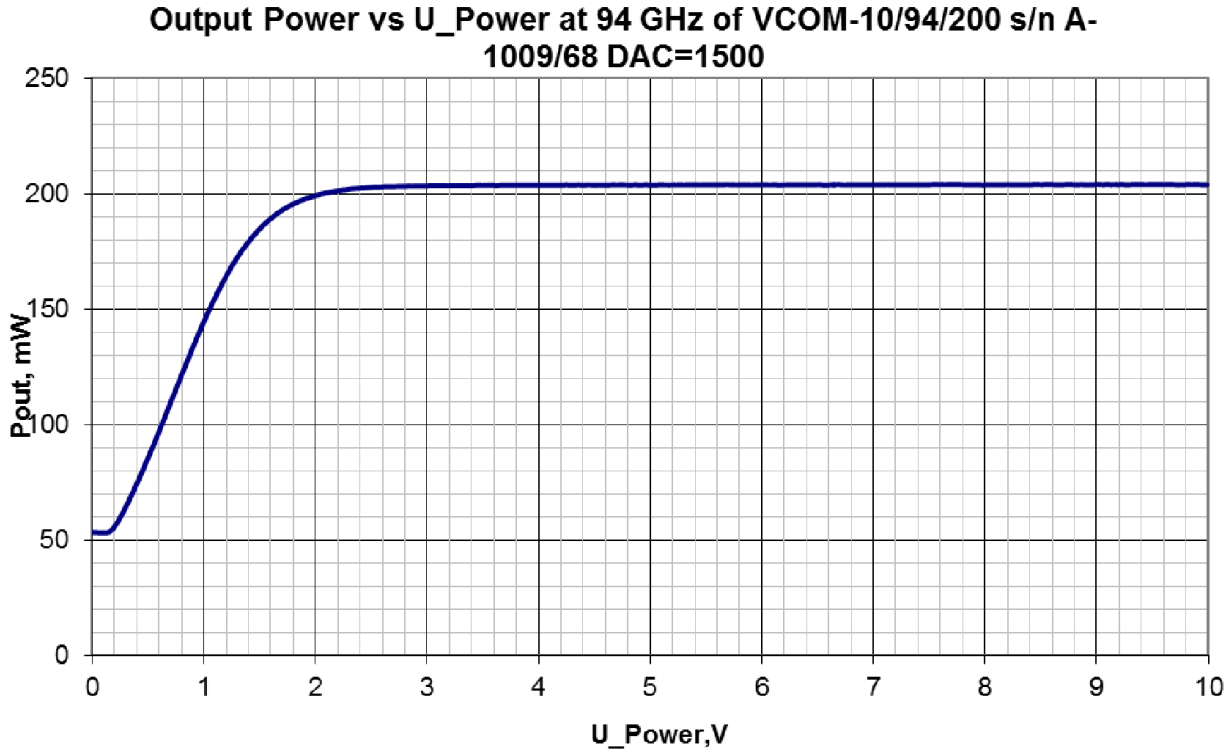
This option should be used if fast output power modulation (up to 5 kHz) is needful. Sequence of operations is the following:

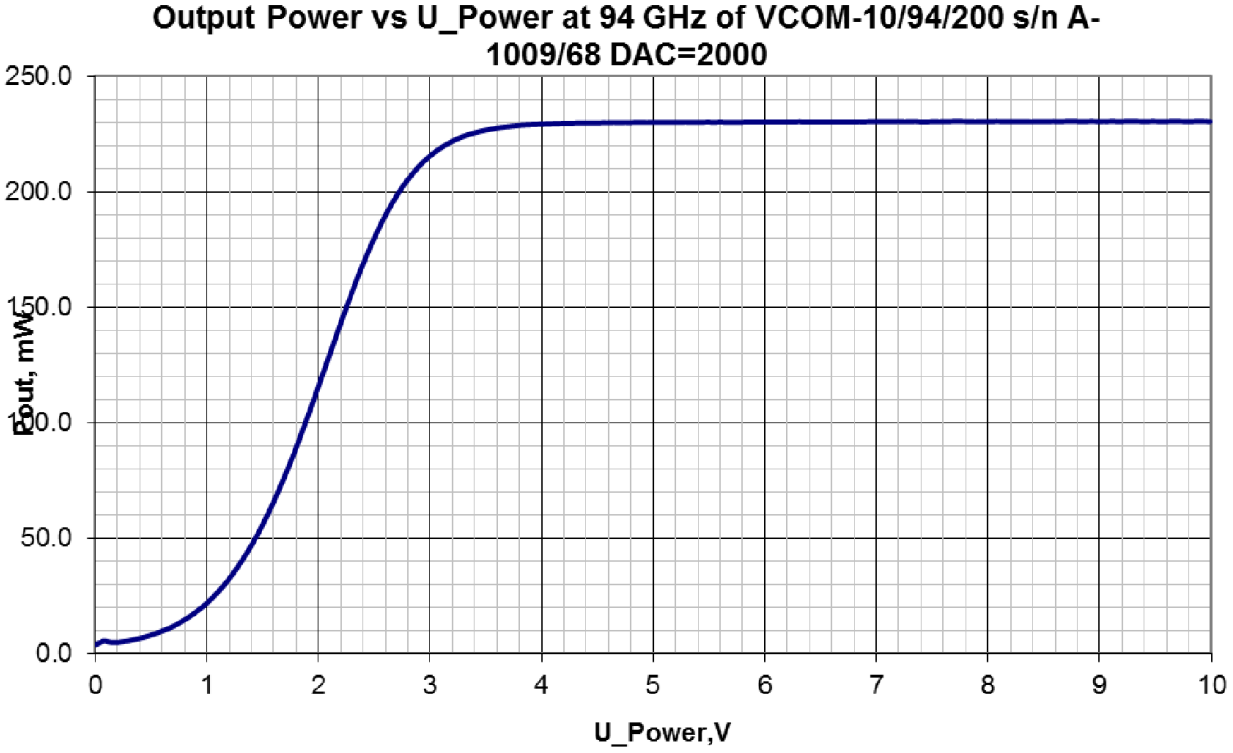
1. Turn the VCOM source ON
2. Send command string **@U27!on#**
3. Turn output attenuator to direct digital code mode with command string **@DAC!on#.** Current power level corresponds to the value XXX from the last command **@PWR!XXX#** or it is 0.0 mW if the source was just switched ON, i.e. command string like **@PWR!XXX#** has not been used after switching the source ON.
4. Set digital code for attenuator control **3000** with command string **@DAC:3000#.** CW output power is less than 1 mW.
5. To open output attenuator feed analogue input with pulses 0…+7V. Attenuator is open at +7 V pulse amplitude, output power is max (see upper graph in Fig.11).

Note: If command string **@DAC:4095#** is used, CW output power is minimal (less 20 μW) (read item 4 above). Pulses with amplitude +10 V must be used in this case to get max pulse power at output (see lower graph in Fig.11).

6. To turn output power OFF at any mode send command **@U27!off#**

To turn OFF direct digital code control mode of output attenuator, send command string **@DAC!off#**. After this command power level will be equal to last command **@PWR!XXX#** or it is 0.0 mW if the source was just switched ON, i.e. command string like **@PWR!XXX#** has not been used after switching the source ON.
Analog input voltage must be equal 0V.


Output Power vs U_Power at 94 GHz of VCOM-10/94/200 s/n A-1009/68 DAC=1500
Pout, mW
250
200
150
100
50
0
0
1
2
3
4
5
6
7
8
9
10
U_Power,V


Output Power vs U_Power at 94 GHz of VCOM-10/94/200 s/n A-1009/68 DAC=2000
Pout, mW
250.0
200.0
150.0
100.0
50.0
0.0
0
1
2
3
4
5
6
7
8
9
10
U_Power,V

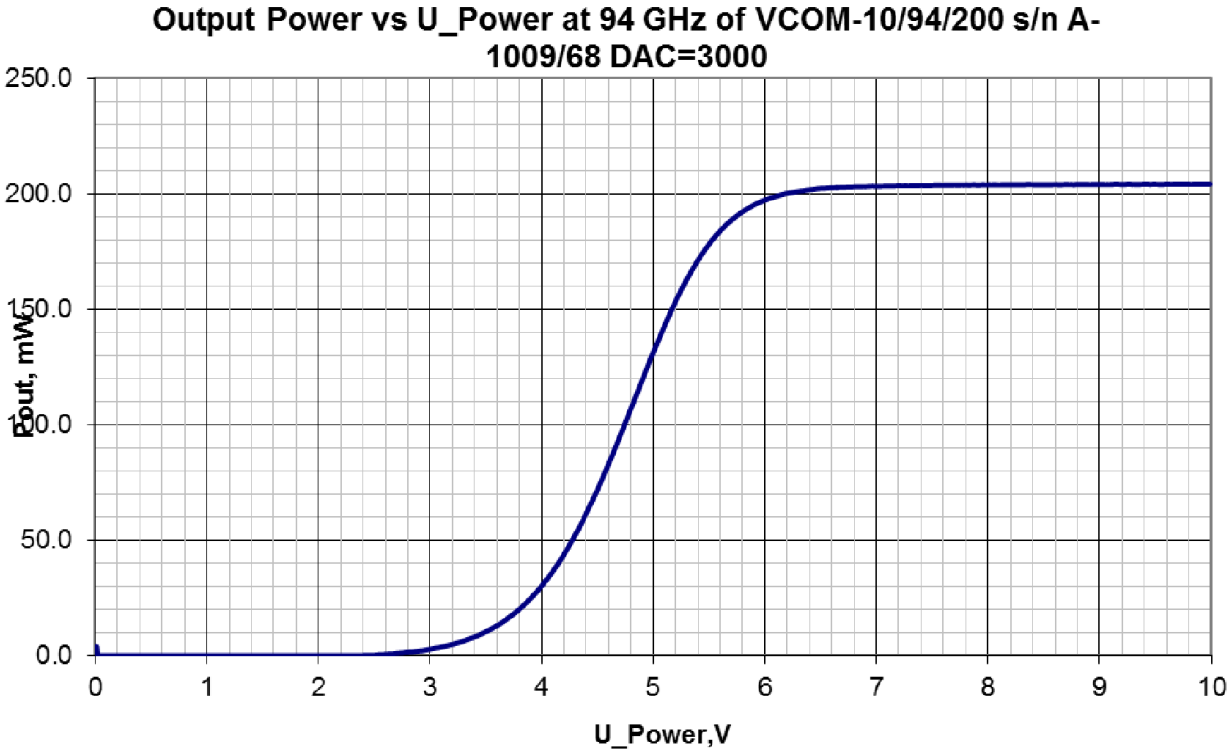
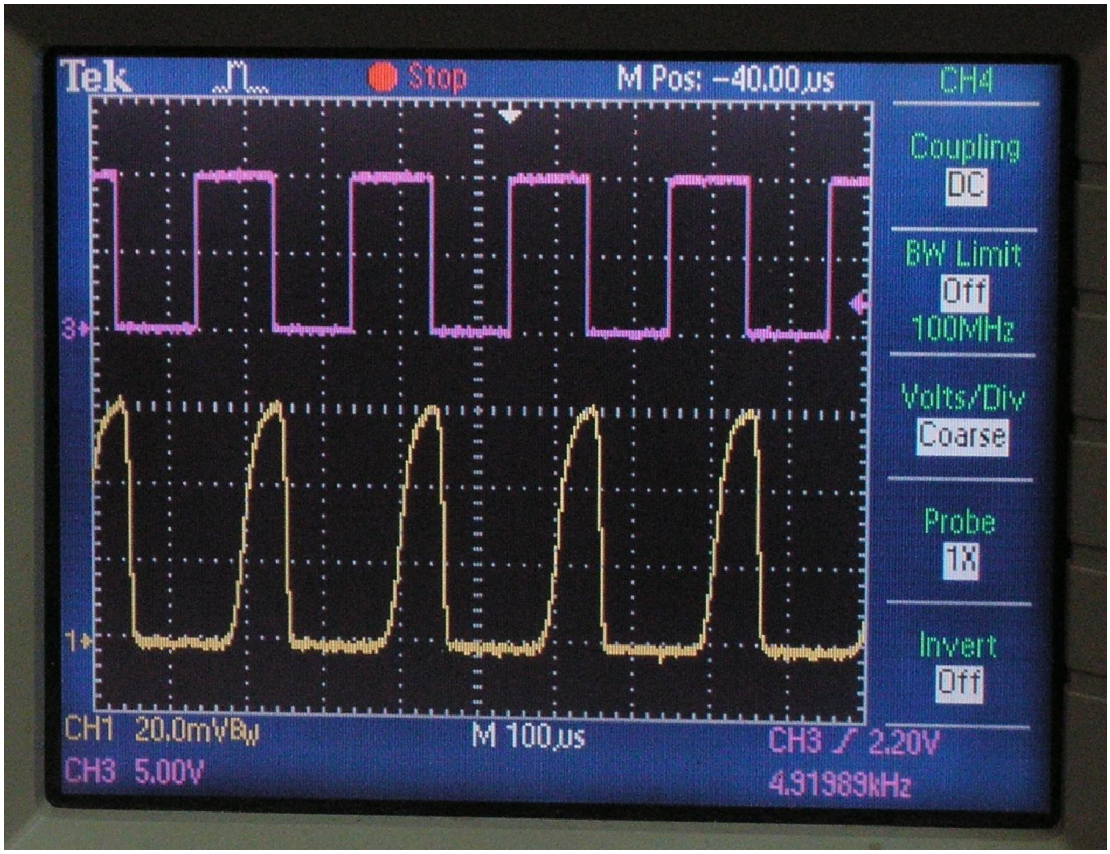


Fig.11 Output Power of VCOM-10/94/200-DP Serial No A-1009/68 vs. Analogue Control Voltage at Frequency of 94GHz.



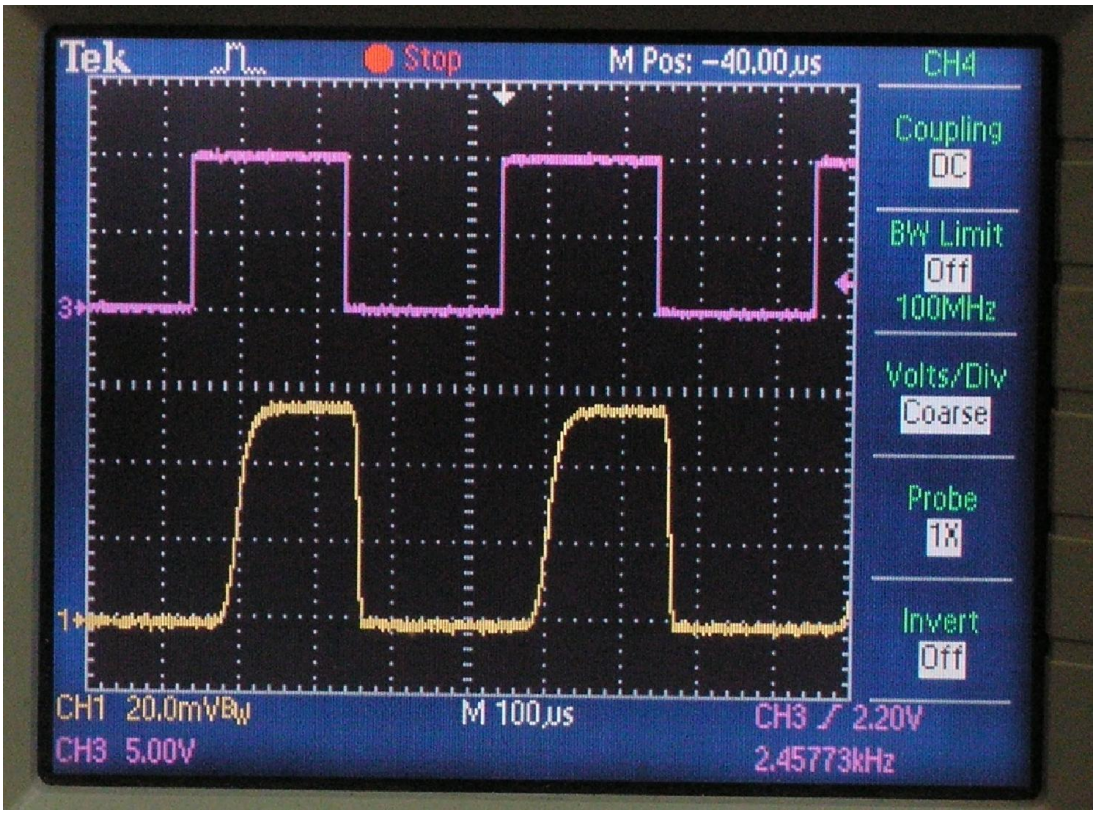


Fig.12 Pulses of output power of VCOM-10/94/200-DP Serial No A-1009/68 – bottom curve and analogue control voltage – upper curve. DAC = 4095.

Additional information

1. Measurement of current frequency is doing approx 1 times per second.
2. Setting of new value of operating frequency is doing with a math algorithm. Frequency correction has been doing with sequence of frequency steps. One step takes approx 0.05 seconds. Max frequency settling time is 0.5 sec.

   Note:

   Frequency stabilization option can be switched off. Direct frequency control can be provided using DAC codes (read list of commands below)
3. The crystal oscillator used in frequency counter is not sensitive to magnet field. Exact value of measured current frequency does not depend on presence of magnet field with level < 0.01 T.
4. Long-time influence of strong magnet field on operation of the VCOM source has not been investigated.

Control Interface Definition

This document defines the messages that are to be used to control the millimetre wave source over an RS-232 link.

RS-232 Options:

Baud Rate	115200
Data bits	8
Parity	none
Stop bits	1

9-pin female Modem cable for connecting PC with VCOM-10/94/200-DP

Table of Contents

1 Introduction

Software version is 160218

The interface is primarily designed to be machine (not human) friendly, so messages should use short mnemonics, obvious delimiters and avoid any unnecessary wordy descriptive text.
All messages use the same prefix ('@') and suffix ('#') character. These characters should not be used within the body of a message. The general format for all messages to be:

@[header][control][optional parameters]#

[header]	The header identifies the message and can be used for both queries and commands and the associated responses.
[control]	The control character is one of: **!** a command **?** a query; or **:** a response (also used to separate multiple parameters).
[optional parameters]	Any optional parameters are defined in section 2.

2 Interface Definition

2.1 Commands

The following table defines all of the commands in the interface, identified by the '!' control character.

Command	Example	Response	Notes
@FRQ!xxxxx.xx#	@FRQ!94100.00#	@FRQ:94100.00# @FRQ:naq#	Value in MHz "ack" indicates success; "naq" indicates invalid value.
@PWR!xxx#	@PWR!045# @PWR!**500**#	@PWR:45# @PWR:naq#	Value in mW "ack" indicates success; "naq" indicates invalid value.
@U27![text]#	@U27!on# @U27!off#	@U27:on# @U27:off#	Enable / disable the output stage to turn milliwaves on/off.
@HEA![text]#	@HEA!on# @HEA!off#	@HEA:on# @HEA:off#	Enable / disable the heater on the main oscillator.
@DAF![text]#	@DAF!on# @DAF!off#	@DAF:on# @DAF:off#	Enable / disable *Direct Frequency Control* mode.
@DAF![code]#	@DAF!37# @DAF!4077# @DAF!5012#	@DAF:37# @DAF:off# @DAF:naq#	Specifies the control code to be used, in the range {0..4095}. Response is "off" if disabled, "naq" for out-of-range.
@DAC![text]#	@DAC!on# @DAC!off#	@DAC:on# @DAC:off#	Enable / disable *Direct Power Control* mode.

Command	Example	Response	Notes
@DAC![code]#	@DAC!37# @DAC!4077# @DAC!5012#	@DAC:37# @DAC:off# @DAC:naq#	Specifies the control code to be used, in the range {0..4095}. Response is “off” if disabled, “naq” for out-of-range.
@[CMD][text]#	@**U25**!on#	@**U25!**:???#	(#1) Response to any unknown message with correct prefix/suffix. 4 first symbols from CMD

2.2 Queries

The following table defines the queries in the interface, identified by the ‘?’ control character.

Query	Response	Example	Notes
@FRQ?#	@FRQ:xxxxx.xx#	@FRQ:94000.00#	Value in MHz. requested frequency
@FRC?#	@FRC:xxxxx.xx#	@FRC:93999.87#	Value in MHz. Current Frequency
@PWR?#	@PWR:xxx.x#	@PWR:57.6#	(#1) Value in mW, Requested power not measured
@PMA?#	@PMA:xxx.x#	@PMA:185.0#	Maximum power *at any frequency* Value in mW (spec: ≥ 180.0 mW)
@PMC?#	@PMC:xxx.x#	@PMC:197.0#	Maximum power (in mW) *at the current frequency*.
@HEA?#	@HEA:[text]#	@HEA:on# @HEA:off#	Status of the heater on the main oscillator.
@U27?#	@U27:[code]:[text]#	@U24:26949:on# @U24:27012:off#	Query the current voltage (in mV) and on/off state.
@DAF?#	@DAF:[code]:[text]#	@DAF:3724:on# @DAF:241:off#	Query the control code for the current frequency.
@DAC?#	@DAC:[code]:[text]#	@DAC:129:on# @DAC:3742:off#	Query the control code for the current power.
@VER?#	@VER:xxxxxx#	@VER:160218#	Version number
@S/N?#	@S/N:[text]#	@S/N:A-1009/68#	Serial number of the unit.

2.3 Alarms

The current alarm status can be queried using the following query. More detailed alarm status information is available using reserved commands (see section 2.5).

Query	Response	Examples	Notes
@ALA?#	@ALA:[state]#	@ALA:ok# @ALA:+27:temp#	See the next table for state strings.

Notes:

1. The response may contain more than one string, each identifying an alarm. Each string is separated by a `':'` control character.

The following table defines all the valid alarm strings:

[state]	Description	Remedy
Ok	All tests passed. Everything is OK	
+5	The +5v supply voltage is wrong.	Check the power supplies (turn them on).
-12	The -12v supply voltage is wrong.	Check the power supplies (turn them on).
+12	The +12v supply voltage is wrong.	Check the power supplies (turn them on).
+27	The +27v supply voltage is wrong.	Check the power supplies (turn them on).
Temp	At least one test point is over-temperature.	Try to cool the source.
Afc	Frequency control does not work	Reset the source
Fail	The source can not work properly.	Detailed diagnostics is required or if @U27:off#.
Off	@U27:off#	send @U27!on#

2.4 Supplemental

The following table defines supplementary queries in the interface that are not generally used by customer.

Query	Response	Example	Notes
@IMM?#	@IMM:[value]#	@IMM:11798#	Value in mV
@IMF?#	@IMF:[value]#	@IMF:16183#	Value in mV
@IMS?#	@IMS:[value]#	@IMS:14930#	Value in mV
@VCO?#	@VCO:[value]#	@VCO:9208#	Value in mV
@TS1?#	@TS1:[value]#	@TS1:24#	Value in degrees Celsius.
@TS2?#	@TS2:[value]#	@TS2:24#	Value in degrees Celsius.
@H27?#	@H27:[value]#	@H27:28096#	Value in mV
@U12?#	@U12:[value]#	@U12:11368#	Value in mV
@N12?#	@N12:[value]#	@N12:12263#	Value in mV
@U5S?#	@U5S:[value]#	@U5S:4947#	Value in mV

2.5 Reserved Messages

2.5.1 Queries

The following queries provide more detailed alarm status information.

Query	Response	Example	Notes
@ALM?#	@ALM:[A1][A2]#	@ALM:FE#	Current alarm status (hex)
@ALD?#	@ALD:[A1][A2]#	@ALD:175046#	Current alarm status (decimal)

2.5.2 Alarm flags

The following tables define the meaning of the two sets of flags `[A1]` and `[A2]` returned by the @ALM?# and @ALD?# queries. Each binary digit, shown as 'X', indicates the status of one parameter with the values 0 (OK) or 1 (failure).

Alarms: A1

7	6	5	4	3	2	1	0	Name	Description ('0' indicates OK)
							X	F	Frequency outside operating range
						X		TS1	Temperature of sensor 1 is outside limits
					X			TS2	Temperature of sensor 2 is outside limits
				X				TS3	Temperature of sensor 3 is outside limits
			X					+5v	+5v supply failed
		X						Imp M	Supply voltage at test point 1 is OK/ failed
	X							Imp F	Supply voltage at test point 2 is OK/ failed
X								Imp S	Supply voltage at test point 3 is OK/ failed

Alarms: A2

7	6	5	4	3	2	1	0	Value(Name)	Description ('0' indicates OK)
							X	-12v (N12)	Failure of -12V supply.
						X		+12v (U12)	Failure of +12V supply.
					X			+27 (U27)	Failure of +24V supply.
				X				+27H (H27)	Failure of heater +24V supply.
			X					I -12v (C12)	current in -12V circuit is wrong
		X						I +12 (I12)	current in +12V circuit is wrong
	X							I +27 (I27)	current in +24V circuit is wrong
X								I +27H (C27)	current in heater +24V circuit is wrong or Heater is OFF

Example:
Everything is OK but +24V heater is OFF following **@HEA!off#** command. The +24V heater power supply is good but there is no current consumption in the heater circuits.
Alarm response is **@ALD:000128#.**

Segment	Decimal	Flags	Description
A1	000	00000000	No flags set.
A2	128	10000000	Current in heater +24V circuit is wrong or Heater is OFF.

3 Source Initialisation

This section defines requirements on the source during and just after power-on.

3.1 Requirements

The following table defines an initial sequence that allows the software to confirm the presence of a new-style source without applying the +27v power.

Command	U27!	FRQ!	FRC?	PWR!	PWR?	HEA!	Comments
Supply voltages +5/+12/-12 V off	n/a	n/a	n/a	n/a	n/a	n/a	No response from unit expected (!)
Supply voltages +5/+12/-12 V on	OFF	94.0	Lowest	0.0	0.0	OFF	Responds to all valid queries/commands.
Supply voltage +24V on	OFF	94.0	94.0	0.0	0.0	OFF	Responds to all valid queries/commands.
From now on, FRQ, PWR & HEA should maintain values set via commands, shown as (^)							
@FRQ!nnnnn.nn#	OFF	nn.n	nn.n	0.0	0.0	OFF	*These commands are not required and can come in any order.*
@PWR!nnn#	OFF	(^)	(^)	n.n	0.0	OFF	
@HEA!on#	OFF	(^)	(^)	(^)	0.0	on	
@U27!on#	ON	(^)	(^)	(^)	n.n	(^)	Enables final stage output.
@U27!off#	OFF	(^)	(^)	(^)	0.0	(^)	Disables final stage output.
@U27!on#	ON	(^)	(^)	(^)	(^)	(^)	Enables final stage output.
…other commands…							
Supply voltage +24V off	OFF	(^)	Lowest	(^)	0.0	(^)	Preserve FRQ, PWR & HEA
Supply voltage +24V on	OFF	(^)	(^)	(^)	0.0	(^)	Preserve FRQ, PWR & HEA
@U27!on#	ON	(^)	(^)	(^)	(^)	(^)	Enables final stage output

In summary:

- start with U27 state OFF, power at zero and heater off
- accept & respond to queries/commands with supply voltage +24V OFF
- do not reset FRQ, PWR or HEA once set via command
- do reset U27:OFF state if supply voltage +24V goes OFF.

IF supply voltage +24V off, @FRQ?# shows target frequency sent with the last @FRQ!XXXXX.XX# command. Default value is @FRQ:94000.00#

- IF supply voltage +24V off, @FRC?# shows current frequency which is below the lowest specified operating frequency 93.5 GHz

There is possibility to make diagnostic through RS-232 port and Ethernet/SNMP v1 protocol.
Note: Normally the diagnostics is doing at preventive testing or repair by staff of producer.
In case of failure or for test one can send a request for ALARM status of the source.

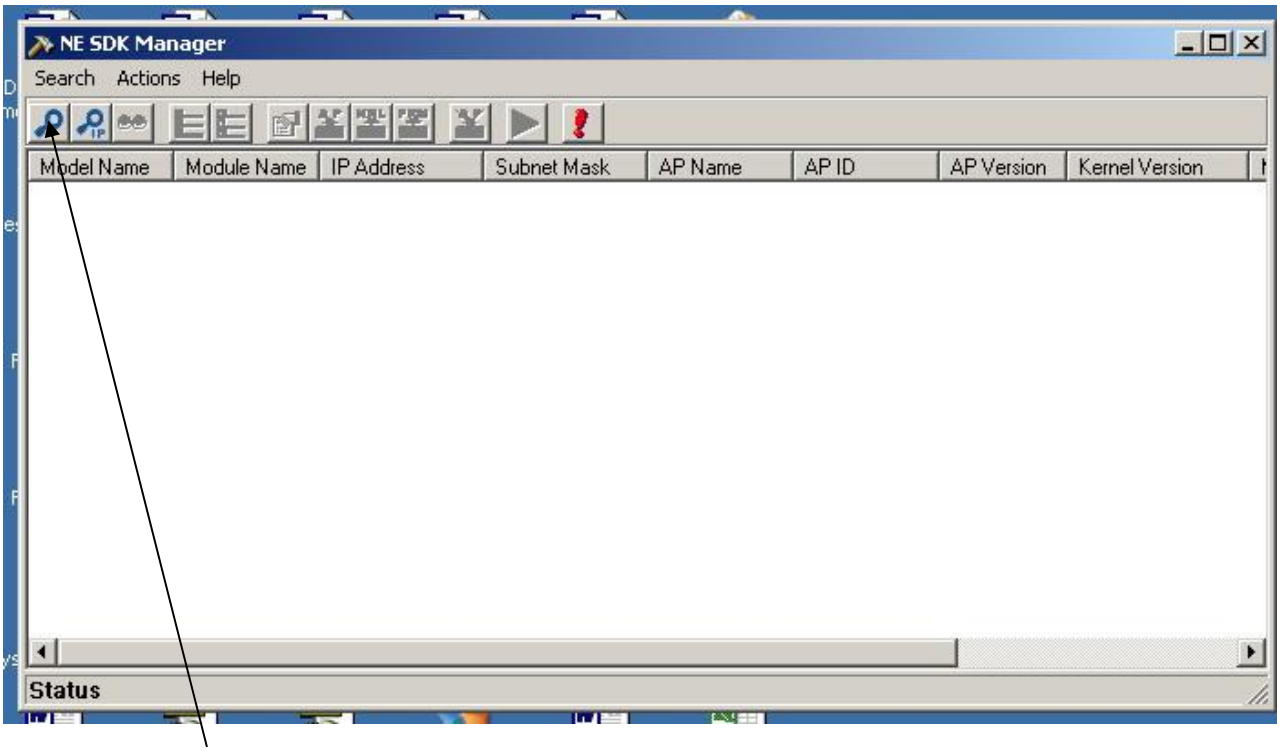
ATTENTION: Every time it is necessary to receive a reply from VCOM source that the command is completed.
If the reply has not been received the command has to be sent again.

The VCOM-10/94/200-DP source has a board for diagnostic and control through Ethernet using SNMP v1 protocol.
The source must be connected to local network or a network board of a separate computer with network cable with RJ-45 connector.

The source has a board Model NE-4110S of MOXA producing
http://www.moxanet.com/product/NE-4110S.htm

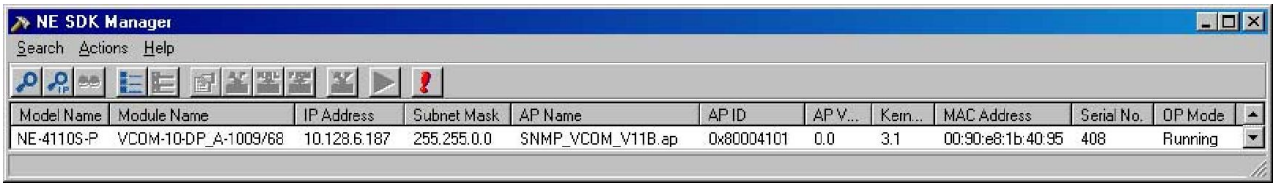
The board has got MAC address. IP address can be set static or DHCP (dynamic). Static IP address is set manually, DHCP address is set by local network server.

Run NE SDK Manager program:
Get the window:



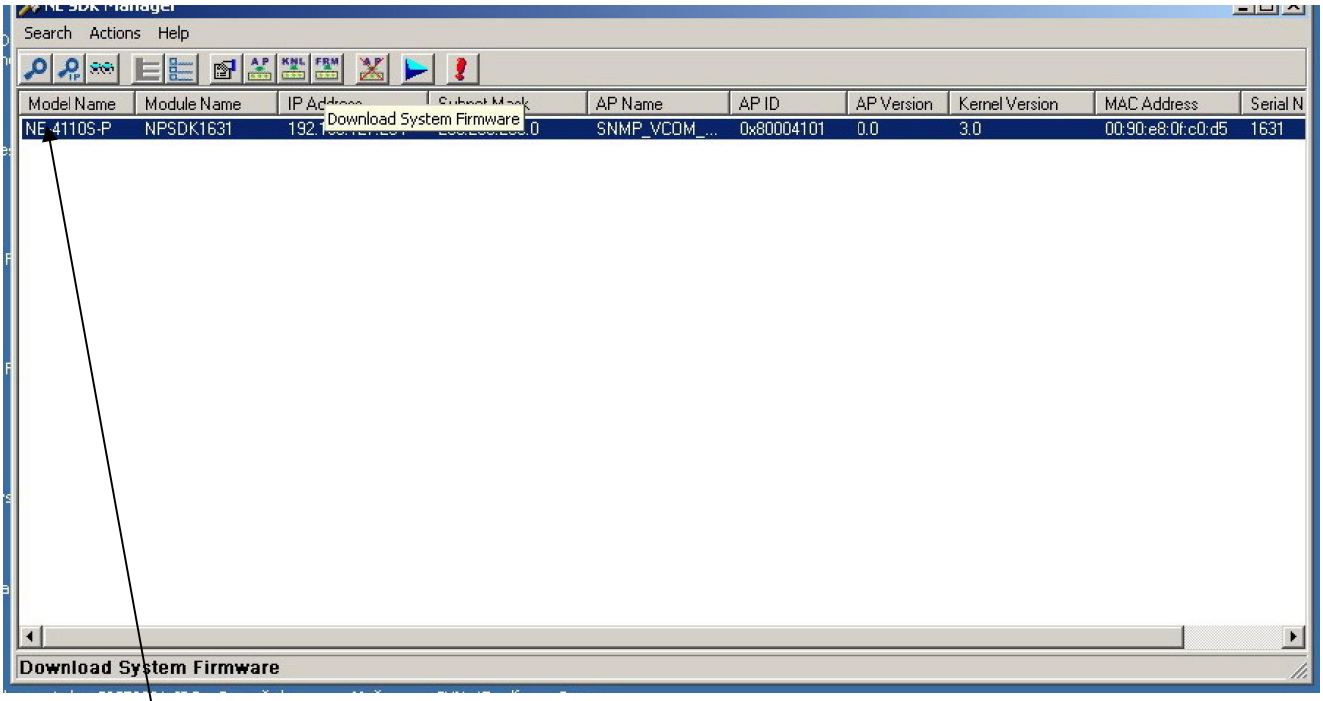
Click the button “IP”.

You will find NE-4110S boards connected to local network:

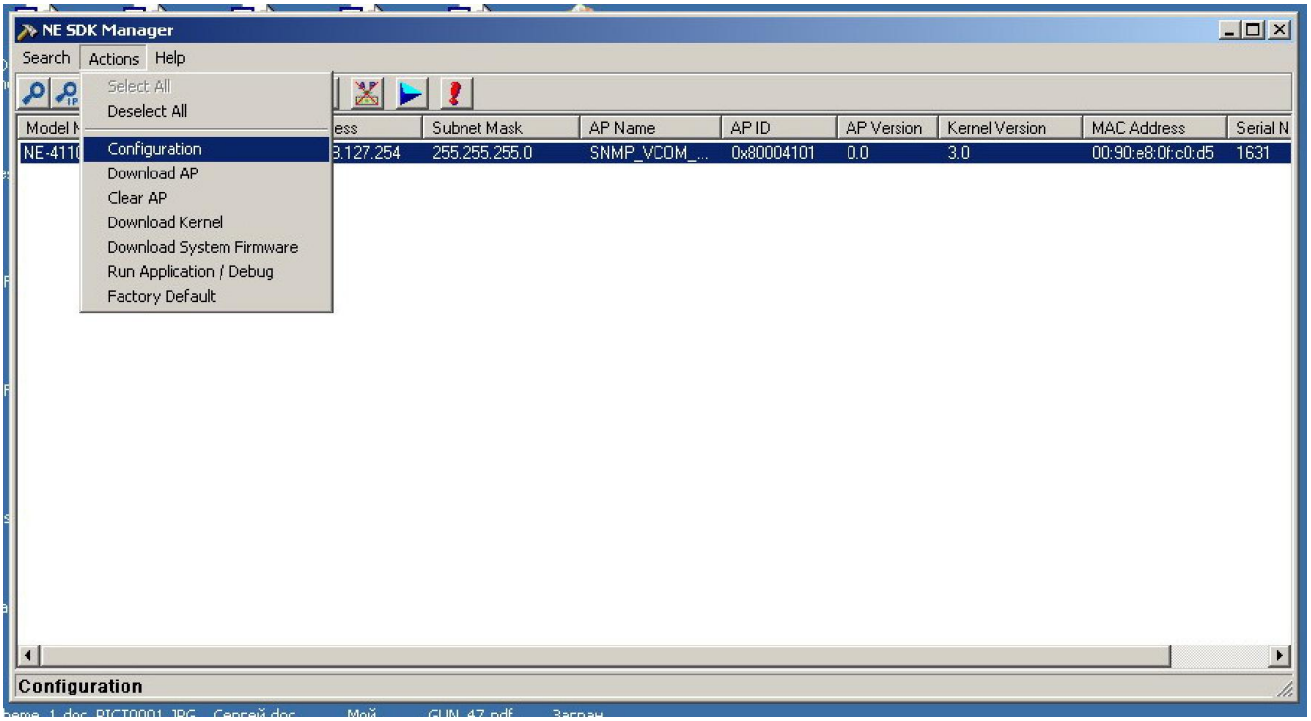


There are indicated IP address of the NE-4110S board and its MAC address in the window.

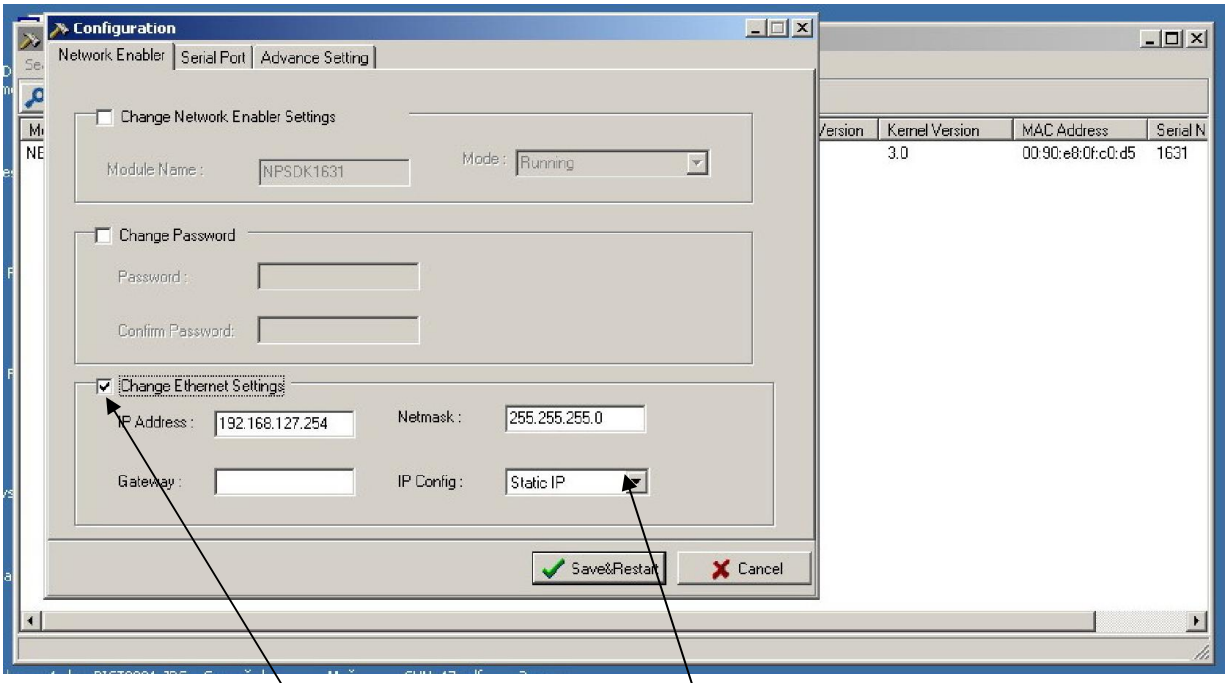
To change settings of the NE-4110S board



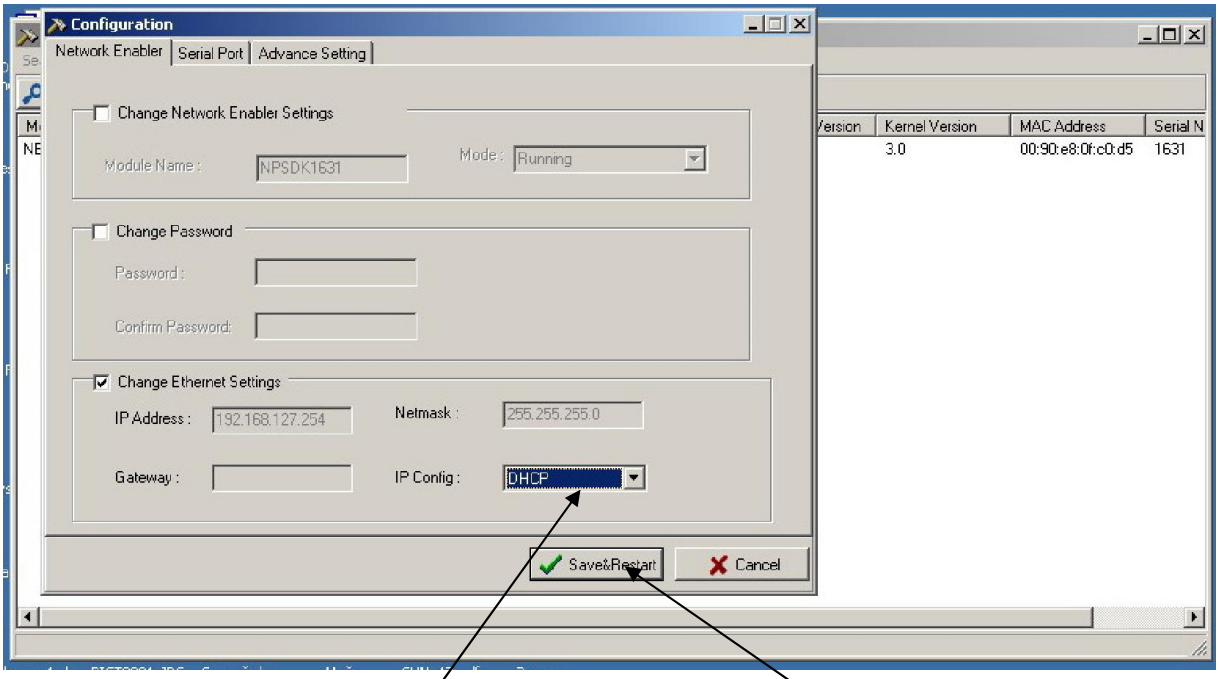
mark the NE-4110S board line (click on the line)



Click on “Action” next on “Configuration”



Tick “Change Ethernet Settings” (Static address is set)



Chose dynamic address DHCP if necessary and press “Save and Restart”

One can use static IP address if the NE-4110S board is connected through RJ-45 to a local computer.
The computer network board is to have also Static IP address.
The first 9 symbols of Static IP address of the computer and NE-4110S must be equal:
Example:
Computer static IP address is: ABC.DEF.GIH.xxx
NE-4110S static IP address is: ABC.DEF.GIH.yyy

Xxx, yyy can be within range: 0…253 and different for computer and NE-4110S board.

Note: do not use 254 for xxx or yyy

Cautions

1. Make sure the VCOM-10/94/200-DP source is protected from water drops falling on its housing. Failure of electronic circuits is possible if water penetrates inside the source.
2. Make sure there is a ventilation clearance between VCOM-10/94/200-DP housing and other surfaces (for example additional waterproof cover). This gap is necessary to prevent the source overheating and do not reduce lifetime of the source.
3. It's strongly recommended to place the VCOM-10/94/200-DP source directly on metal surface with good thermal contact to prevent overheating.
4. Make sure that output waveguide is not curved. To prevent this use screws or another tools to adjust VCOM-10/94/200-DP source position. One should select the source position (to make the waveguide straight) first and then fix the source on the mounting plate.
5. It is prohibited to hit, throw and drop VCOM-10/94/200-DP source. This can cause mechanical or electronics damage.
6. Do not keep waveguide output of the VCOM-10/94/200-DP source open. Metal particles penetrated inside the waveguide channel cause failure of source. This refers to all microwave devices especially to devices containing permanent magnets, e.g. circulators, isolators. Use special covers or an isolation (adhesive) tape or stickers to close any open waveguides.
7. Powerful microwave radiation is dangerous for any biological structures. Do not expose any body regions to microwave radiation; do not place them in front of an open waveguide when microwave source is working. Do not look into the open waveguide.