User's Manual

FRANK HERTZ EXPERIMENT

Model: FH-3001

(Rev : 01/04/2010)

Manufactured by:
SES Instruments Pvt. Ltd.
452, Adarsh Nagar,
Roorkee-247 667 UK
Ph.: 01332-272852, Fax: 277118
Email: info@sestechno.com
sestechnio.india@gmail.com
Website: www.sestechno.com

ISO 9001:2008
CERTIFIED COMPANY

CONTENTS

IMPORTANT

1) **Please read the User's Manual carefully before the unit is switched 'ON'.**
2) **When the Frank-Hertz Tube is in the socket, the attention is particularly drawn to the precaution no. 4 on page 11 of this Manual.**

COPYRIGHT AND WARRANTY

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COPYRIGHT NOTICE

LIMITED WARRANTY

SES Instruments Pvt. Ltd warrants this product to be free from defects in materials and workmanship for a period of one year from the date of shipment to the customer. SES Instruments Pvt. Ltd will repair or replace, at its option, any part of the product which is deemed to be defective in material or workmanship. This warranty does not cover damage to the product caused by abuse or improper use. Determination of whether a product failure is the result of manufacturing defect or improper use by the customer shall be made solely by SES Instruments Pvt. Ltd. Responsibility for the return of equipment for warranty repair belongs to the customer. Equipment must be properly packed to prevent damage and shipped postage or freight prepaid. (Damage caused by improper packaging of the equipment for return shipment will not be covered by the warranty). Shipping costs for returning the equipment, after repair, will be paid by SES Instruments Pvt. Ltd.

EQUIPMENT RETURN

Should this product have to be returned to SES Instruments Pvt. Ltd, for whatever reason, notify SES Instruments Pvt. Ltd BEFORE returning the product. Upon notification, the return authorization and shipping instructions will be promptly issued.

Note : No equipment will be accepted for return without an authorization.

When returning equipment for repair, the units must be packed properly. Carriers will not accept responsibility for damage by improper packing. To be certain the unit will not be damaged in shipment, observe the following rules:

1. The carton must be strong enough for the item shipped.
2. Make certain there is at least two inches of packing material between any point on the apparatus and the inside walls of the carton.
3. Make certain that the packing material can not displace in the box, or get compressed, thus letting the instrument come in contact with the edge of the box.

SAFETY INFORMATION

This Section addresses safety considerations and describes symbols that may appear on the Instrument or in the manual.

A **Warning** Statement identifies conditions or practices that could result in injury or death. A **Caution** statement identifies conditions or practices that could result in damage to the Instrument or equipment to which it is connected.

Warning

To avoid electric shock, personal injury, or death, carefully read the information in Table-1, "Safety Information," before attempting to install, use, or service the Instrument.

GENERAL SAFETY SUMMARY

This equipment is Class 1 equipment tested in accordance with the European Standard publication EN 61010-1.

This manual contains information and warnings that must be observed to keep the Instrument in a safe condition and ensure safe operation.

To use the Instrument correctly and safely, read and follow the precautions in Table 1 and follow all safety instructions or warnings given throughout this manual that relate to specific measurement functions. In addition, follow all generally accepted safety practices and procedures required when working with and around electricity.

SYMBOLS

Table 2 lists safety and electrical symbols that appear on the Instrument or in this manual.

Table 2. Safety and Electrical Symbols

Symbols	Description	Symbols	Description
	Risk of danger. Important information. See Manual.		Earth ground
	Hazardous voltage. Voltage >30Vdc or ac peak might be present.		Potentially hazardous voltage
	Static awareness. Static discharge can damage parts.		Do not dispose of this product as unsorted municipal waste. Contact SES or a qualified recycle for disposal.

Table 1. Safety Information

⚠⚠ Warning

To avoid possible electric shock, personal injury, or death, read the following before using the Instrument:

- **Use the Instrument only as specified in this manual, or the protection provided by the Instrument might be impaired.**
- **Do not use the Instrument in wet environments**
- **Inspect the Instrument in wet environments.**
- **Inspect the Instrument before using it. Do not use the Instrument if it appears damaged.**
- **Inspect the connecting lead before use. Do not use them if insulation is damaged or metal is exposed. Check the connecting leads for continuity. Replace damaged connecting leads before using the Instrument.**
- **Whenever it is likely that safety protection has been impaired, make the Instrument inoperative and secure it against any unintended operation.**
- **Have the Instrument serviced only by qualified service personnel.**
- **Always use the power cord and connector appropriate for the voltage and outlet of he country or location in which you are working.**
- **Never remove the cover or open the case of the Instrument before without first removing it from the main power source.**
- **Never operate the Instrument with the cover removed or the case open.**
- **Use only the replacement fuses specified by the manual.**
- **Do not operate the Instrument around explosive gas, vapor or dust.**
- **When servicing the Instrument, use only specified replacement parts.**
- **The equipment can remain Switched on continuously for five hours**
- **The equipment must remain Switched off for at least fifteen minutes before being switched on again.**
- **The equipment is only for the intended use**
- **Use the equipment only as specified in this manual.**

Unpacking and Inspecting the Instrument

Every care is taken in the choice of packing material to ensure that your Instrument will reach you in perfect condition. If the Instrument has been subject to excessive handling in transit, there may be visible external damage to the shipping container and packing material for the carrier's inspection.

Carefully unpack the Instrument from its shipping container and inspect the contents for damaged or missing items. If the Instrument appears damaged or something is missing, contacts the carrier and SES immediately. Save the container and packing material in case you have to return the Instrument.

Storing and Shipping the Instrument

To prepare the Instrument for storage or shipping, if possible, use the original shipping container alongwith thermocoal corners, as it provides shock isolation for normal handling operations. If the original shipping container is not available, use any good cardboard box which is at least 2-3 inches bigger than the instrument on all sides, with cushioning material (thermocoal or styrofoam etc) that fills the space between the Instrument and the side of this box.

To store the Instrument, place the box under cover in a location that complies with the storage environment specification described in the "Environment Sections" below.

Environment

Temperature

Operating ……. 0°C to 50°C

Storage …… 40°C to 70°C

Warm Up ……15 min to full uncertainty specification

Relatively Humidity (non-condensing)

Operating …….Uncontrolled (<10°C)

<90 % (10°C to 30°C)

<75 % (30°C to 40°C)

<45 % (40°C to 50°C)

Storage…….. -10°C to 60°C <95 %

Power Considerations

The Instrument operates on varying power distribution standards found throughout the world and must be set up to operate on the line voltage that will power it. The Instrument is packed ready for use with a line voltage determined at the time of ordering.

Replacing the Fuses

The Instrument uses one fuse to protect the line-power input and two fuses to protect current-measurement inputs.

Line-Power Fuse

The Instrument has a line-power fuse in series with the power supply. Table 3 indicates the proper fuse for each of the four line-voltage selections. The line-power fuse is accessed through the real panel.

1. Unplug the power cord.
2. Rotate the fuse holder cap to the right until the fuse POPS out.
3. Remove the fuse and replace it with a fuse of an appropriate rating for the selected line-power voltage. See Table 2.

⚠⚠ Warning

To avoid electric shock or fire, do not use makeshift fuses or short-circuit the fuse holder.

Table 2. Line Voltage to Fuse Rating

Line Voltage Selection	Fuse Rating
220/ 240 V	1A, 250V (Slow blow)
100/ 120 V	2A, 250V (Slow blow)

Connecting to Line Power

⚠⚠ Warning

To avoid shock hazard, connect the factory supplies three conductor line power cord to a properly grounded power outlet. Do not use a two-conductor adapter or extension cord, as this will break the protective ground connection. If a two conductor power cord must be used, a protective grounding wire must be connected between the ground terminal and earth ground before connecting the power cord or operating the Instrument.

1. Verify that the Line voltage is set to the correct setting.

2. Verify that the correct fuse for the line voltage is installed.

3. Connect the power cord to a properly grounded three-prong outlet. See Figure 1 for line-power cord types available from SES. Refer to Table 3 for description of the line-power cords.

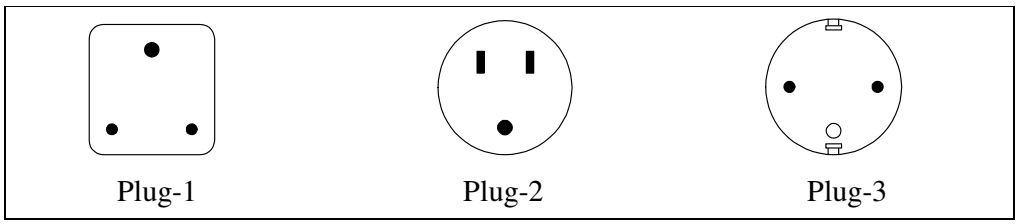

Figure 1. Line-Power Cord Types Available from SES

Table 3. Line-Power Cord Types Available from SES

Type	Voltage/Current	SES Model Number
India	240 V/ 5 A	Plug-1
North America	120 V/15 A	Plug-2
Universal Euro	220 V/16 A	Plug-3

Turning Power On

The On-Off switch on the front panel when points towards "ON" signs, indicates that the equipment has been switched on.

Cleaning the Instrument

Warning

To avoid electric shock or damage to the Instrument, never get water inside the Instrument.

Caution

To avoid damaging the Instrument's housing, do not apply solvents to the Instrument.

If the Instrument requires cleaning, wipe it down with a cloth that is lightly dampened with water or a mild detergent. Do not use aromatic hydrocarbons, alcohol, chlorinated solvents, or methanol-based fluids when wiping down the Instrument.

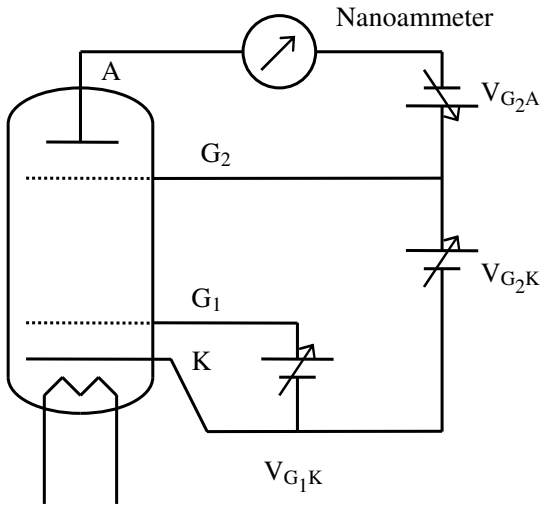

Fig. 1 : Circuit diagram of Frank – Hertz experiment

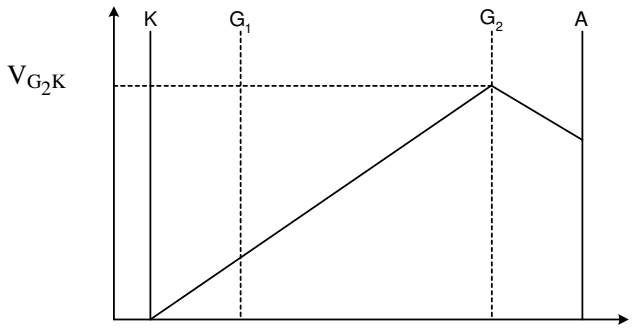

Fig. 2 : Configuration of the Potential in Frank-Hertz Experiment

INTRODUCTION

From the early spectroscopic work it is clear that atoms emit radiations at discrete frequencies. From Bohr's model, the frequency of the radiation ν is related to the change of energy levels through $\Delta E=h\nu$. It is then to be expected that transfer of energy to atomic electrons by any mechanism should always be in discrete amounts. One such mechanism of energy transfer is through inelastic scattering of low-energy electrons.

Frank and Hertz in 1914 set out to verify these considerations.

(i) It is possible to excite atoms by low energy electron bombardment.

(ii) The energy transferred from electrons to the atoms always had discrete values.

(iii) The values so obtained for the energy levels were in agreement with spectroscopic results.

Thus the existence of atomic energy levels put forward by Bohr can be proved directly. It is a very important experiment and can be performed in any college or University level lab.

OPERATING PRINCIPLE

The Frank-Hertz tube in this instrument is a tetrode filled with the vapour of the experimental substance Fig. 1 indicates the basic scheme of experiment.

The electrons emitted by filament can be accelerated by the potential V_{G_2K} between the cathode and the grid G_2. The grid G_1 helps in minimising space charge effects. The grids are wire mesh and allow the electrons to pass through. The plate A is maintained at a potential slightly negative with respect to the grid G_2. This helps in making the dips in the plate current more prominent. In this experiment, the electron current is measured as a function of the voltage V_{G_2K}. As the voltage increases, the electron energy goes up and so the electron can overcome the retarding potential V_{G_2A} to reach the plate A. This gives rise to a current in the ammeter, which initially increases. As the voltage further increases, the electron energy reaches the threshold value to excite the atom in its first allowed excited state. In doing so, the electrons lose energy and therefore the number of electrons reaching the plate decreases. This decrease is proportional to the number of inelastic collisions that have occurred. When the V_{G_2K} is increased further and reaches a value twice that of the first excitation potential, it is possible for an electron to excite an atom halfway between the grids, loose all its energy, and then again gain enough energy to excite atoms and this lead to a second dip in the current. The advantage of this type of configuration of the potential is that the current dips are much more pronounced, and it is easy to obtain five fold or even larger multiplicity in the excitation of the first level.

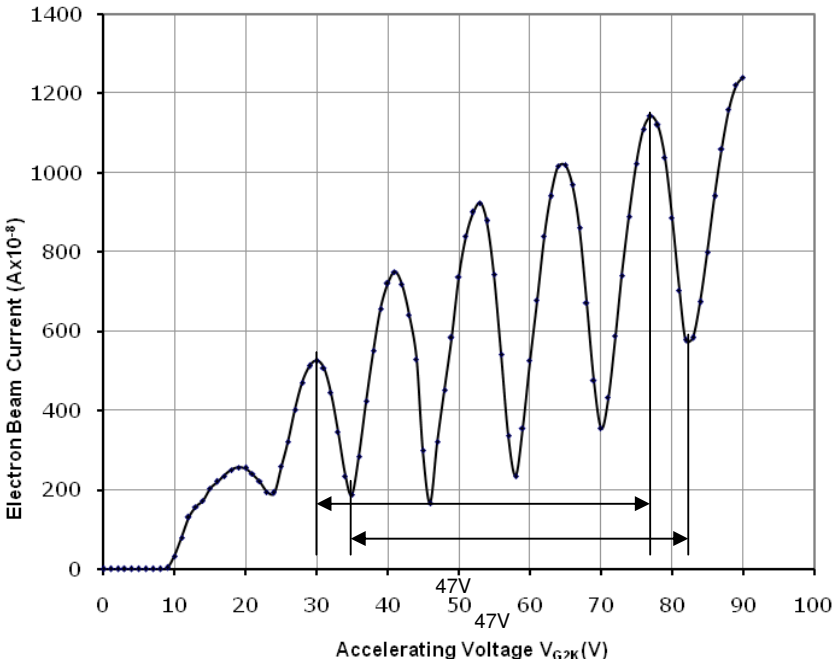

Fig. 3. Plot of Accelerating Voltage Vs Beam Current

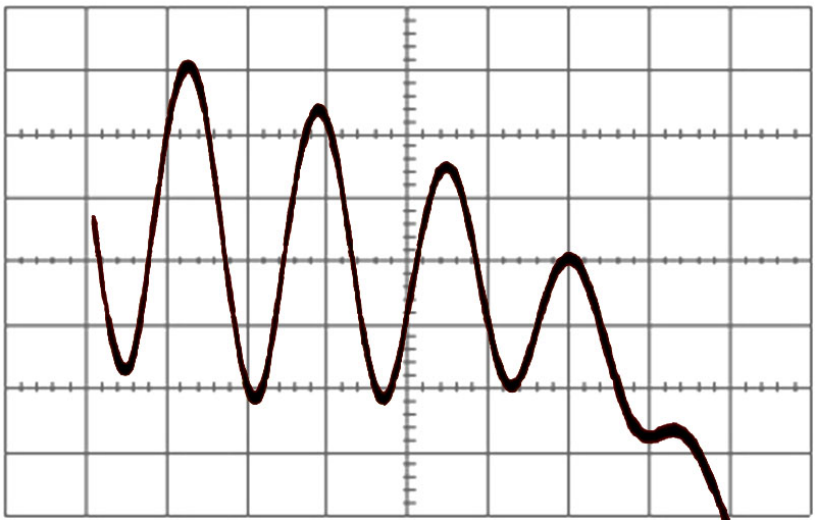

Fig. 4 Oscilloscope display of Frank-Hertz Experiment

Experiment consists of the following :

- Argon filled tetrode
- Filament Power Supply : 2.6 - 3.4V continuously variable
- Power Supply for V_{G_1K} : 1.3 - 5V continuously variable
- Power Supply for V_{G_2A} : 1.3 - 12V continuously variable
- Power Supply for V_{G_2K} : 2.0 - 90V continuously variable
- Saw tooth waveform for CRO display
  Scanning Voltage : 2.0 - 90V
  Scanning Frequency : 115 ± 20Hz.
- Multirange Digital Voltmeter
  Range : 0 - 100V, with 100% over
  Display: 3 ½ digit 7-segment LED with auto polarity and decimal indication
- Multirange Digital Ammeter
  Range : 0 – 100, 0-10 µA & 0-1µA
  Display: 3 ½ digit 7-segment LED with auto polarity

All the above are housed in a single cabinet and operates at 220V ±10%, 50Hz power source.

The instrument can not only lead to a plot of the amplitude spectrum curve by means of point by point measurement, but also directly display the amplitude spectrum curve on the oscilloscope screen. This instrument can thus be used as a classroom experiment as well as for demonstration to a group of students.

ANALYSIS OF THE DATA

Data obtained for the excitation potential point by point are shown in Fig. 3. The readings are taken for 1V changes on grid 2 (V_{G_2K}). A significant decrease in electron (collector) current is noticed every time the potential on grid 2 is increased by approximately 12V, thereby indicating that energy is transferred from the beam in (bundles) quanta of 12 eV only. Indeed, a prominent line in the spectrum of argon exists at 1048 $\mathring{A}$ corresponding to eV=11.83.

The location of the peaks is indicated in Fig. 3. Average value of spacing between peaks is 11.75 eV compared with the accepted value of 11.83V.

UNPACKING

Unpack the instrument carefully and check the accessories with the packing list. The instrument is checked thoroughly before dispatch, damage/shortage, if any should be reported immediately.

Take out the Frank-Hertz Tube from its window-marked ‘Frank-Hertz Tube Window’ by removing its cover.

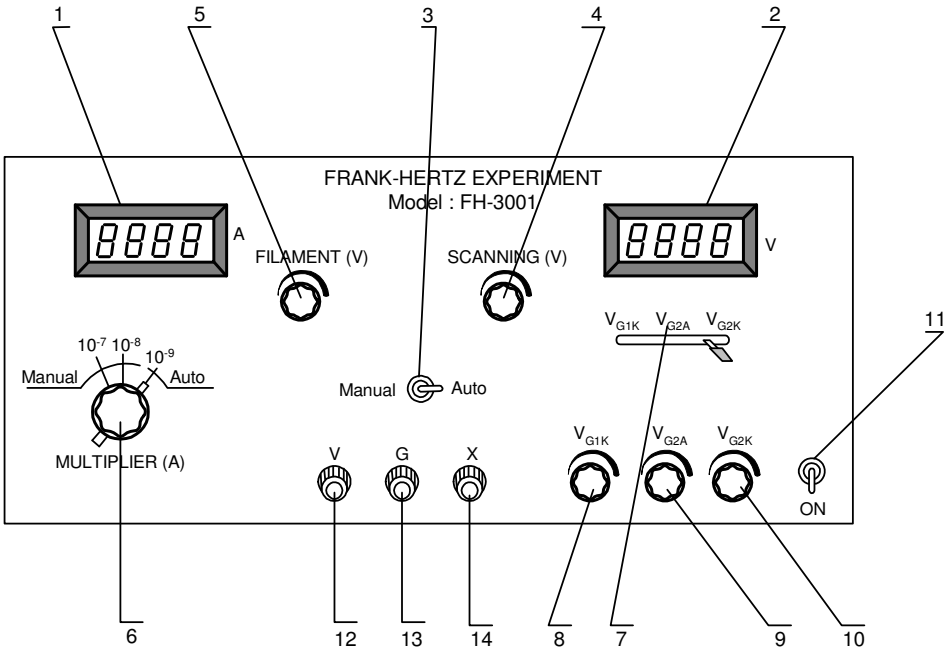

Fig.5 : Panel diagram of Frank-Hertz Experiment, FH-3001

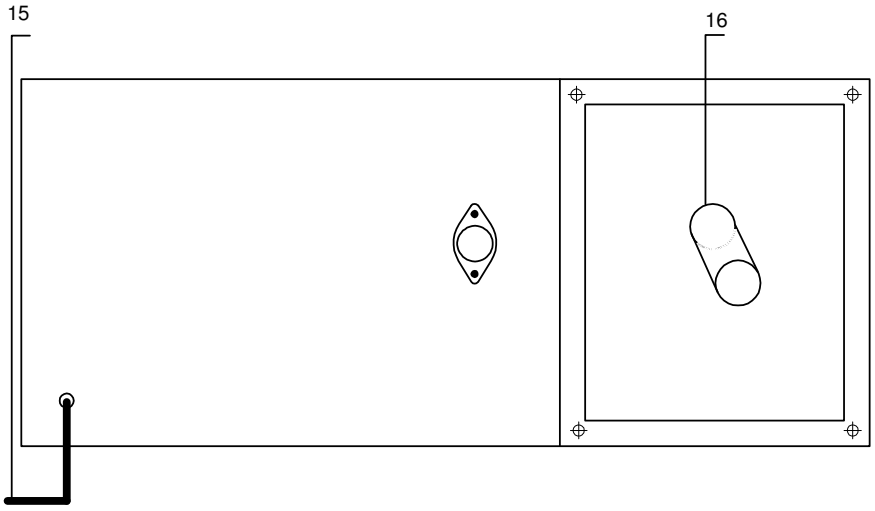

Fig.6 : Back side of Frank-Hertz Experiment, FH-3001

PACKING LIST

1. Frank Hertz, FH-3001 (Main Unit) : One
2. Frank Hertz Tube (Inside its Chamber- not Connected)
3. Dust Cover : One

PANEL CONTROLS AND THEIR FUNCTIONS

1) Ammeter
2) Voltmeter
3) Manual - Auto Switch
4) Scanning Voltage Knob
5) Filament Voltage Knob
6) Current Multiplier Knob
7) Voltage Display Selector: V_{G_1K}, V_{G_2A} or V_{G_2K}
8) V_{G_1K} Adjust knob : 1.3 - 5V
9) V_{G_2A} Adjust Knob : 1.3 - 15 V
10) V_{G_2K} Adjust knob : 2.0 - 90V
11) Power Switch
12) Y-Output Terminal
13) Ground Terminal
14) X-output Terminal
15) Power Lead
16) Frank Hertz Tube

INSTALLATION

Before the Frank-Hertz tube is put in its socket, make sure the power supplies-'V_{G_1K}, V_{G_2A} & V_{G_2K} are working properly. For this proceed as follows.

1. Put all the control knobs (Scanning Voltage V_{G_1K}, Filament Voltage V_{G_2A} & Accelerating Voltage V_{G_2K} Knobs) to their minimum position by rotating anticlockwise.
2. Turn the Manual-Auto switch to Manual
3. Turn Voltage Display Selector to V_{G_1K} and rotate the V_{G_1K} knob clockwise to see if the power supply is working properly. Similarly turn the Voltage Display Selector to V_{G_2A} and V_{G_2K} and check if these power supplies are also O.K.
4. Switch 'OFF' the power and put Frank-Hertz tube in the socket. **As the tube is delicate and very expensive this operation must be handled very carefully and by a trained technical hand only.**

The instrument is now ready for operation

OPERATING INSTRUCTIONS

1) Ensure that the Electrical power is 220V ±10%, 50Hz.
2) Before the power is switched 'ON' make sure all the control knobs are at their minimum position and Current Multiplier knob at 10^{-7} position.
3) Switch 'ON' the power.
4) Turn the Manual-Auto Switch to Manual, and check that the Scanning Voltage Knob is at its minimum position.
5) Turn Voltage Display Selector to V_{G_1K} and adjust the V_{G_1K} knob until voltmeter reads 1.5V.
6) Turn Voltage Display Selector to V_{G_2A} and adjust the V_{G_2A} knob until the voltmeter read 7.5.

   When you have finished step 1-5, you are ready to do the experiment with following parameters.

Filament voltage	: 2.6 V (minimum position)
$\mathbf{V_{G_1K}}$	: 1.5 V
$\mathbf{V_{G_2A}}$	: 7.5 V
$\mathbf{V_{G_2K}}$	: 2.0 V
Current multiplier	: 10^{-7}A

   These are suggested values for the experiment. The experiment can be done with other values also.

7) Rotate V_{G_2K} knob and observe the variation of plate current with the increase of V_{G_2K}. The current reading would show maxima and minima periodically. The magnitude of maxima could be adjusted suitably by adjusting the filament voltage and the value of Current Multiplier. Now take the systematic readings, V_{G_2K} vs. plate current. For better resolution, the reading may be taken at a interval of 1V. Plot the graph with output current on Y-axis and accelerating voltage V_{G_2K} at X-axis.
8) Turn the Manual-Auto switch to 'Auto', connect the instruments Y, G, X sockets to Y, G X of oscilloscope. Put the Scanning Range switch of oscilloscope to X-Y mode/external 'X'. Switch on the power of oscilloscope, adjust the Y and X shift to make the scan base line on the bottom of screen. Rotate the 'Scanning Knob' of the instrument and observe the wave-form on the oscilloscope screen. Adjust the 'Y-gain' and 'X-gain' of oscilloscope to make wave-form clear and Y amplitude moderate. Rotate the scanning potentiometer clockwise to end. Then the maximum scan voltage is 85V. Measure the horizontal distance between the peaks. The distance of two consecutive peaks (count the grids) and multiply it by V/grid factor (X-gain) of oscilloscope. This would give the value of argon atom's first excitation potential in eV.

PRECAUTION

1) Before taking the systematic readings, gradually increase the value of V_{G2k} to a maximum. Adjust the filament voltage if required such that max. readings is about 1000 on $X10^{-8}$ range. This will insure that all the readings could be taken in the same range.

2) During the experiment (manual), when the voltage is over 60V, please pay attention to the output current indicator, If the ammeter reading increases suddenly, decrease the voltage at once to avoid the damage of the tube.

3) Whenever the Filament Voltage is changed, please allow 2/3 minutes for its stabilisation.

4) **When the Frank-Hertz Tube is already in the socket, please make sure the following before the power is switched 'ON' or 'OFF', to avoid damage to the tube.**

   a) Manual - Auto switch is on Manual and Scanning and Filament Voltage knob at its minimum position (rotate it anticlockwise) and Current Multiplier knob at 10^{-7}.

   b) V_{G_1K}, V_{G_2A}, and V_{G_2K} all the three knobs are at their minimum position.

TECHNICAL SUPPORT

Feed Back

If you have any comments or suggestions about this product or this manual please let us know. **SES Instruments Pvt. Ltd.** appreciates any customer feedback. Your input helps us evaluate and improve our product.

To reach SES Instruments Pvt. Ltd.

* Phone : +91-1332-272852, 277118
* Fax : +91-1332 - 277118
* e-mail : info@sestechno.com; sestechno.india@gmail.com

Contacting for Technical Support

Before you call the SES Instruments Pvt. Ltd. Technical Support staff it would be helpful to prepare the following information:

- If you problem is with the SES Instruments Pvt. Ltd apparatus, note :
  - Model number and S. No (usually listed on the label at the backside of instrument).
  - Approximate age of the apparatus.
  - A detailed description of the problem/ sequences of events may please be sent by email or Fax.
- If your problem relates to the instruction manual, note;
  Model number and Revision (listed by month and year on the front cover).
  Have the manual at hand to discuss your questions.