# A Proposed Framework for Science and Langmuir Probe Experiment in the Ionosphere of Mars

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***Abstract*** **- A Langmuir probe is being developed for measurement of electron densities, ion densities, and electron temperatures in the MARS ionosphere. This article describes how a Langmuir Probe can be used to study ionosphere irregularities. It begins with the basic principle of the Langmuir Probe, the ionospheric regions where it can be used, various sizes and shapes of the Langmuir Probe sensor. Here In this paper, we present the design and how implementation of Langmuir Probe instrument. I have prepared a block diagram of Langmuir Probe (see figure 2). The Langmuir probe experiment consists of a cylindrical sensor. A conducting sensor called probe is exposed to the medium under study and the current collected by the probe is measured to study various plasma parameters. The probe can be kept ambient plasma potential or given a negative voltage (to collect ion current) or a positive voltage (To collect electron current).After the current and voltage charatertics we analyzed plasma parameters. The operational amplifier will be connected with the sensor. A floating sweep voltage supply will also be applied to the sensor for collect current. Here after than collected current is goes to differential amplifier. The differential amplifier is amplifying the difference between both signals. Later we will use low pass filter for remove the un-wanted frequency of signal. Here the analog to digital convertor for generating a digital signal for processing. The signal output will be displayed on LCD display screen by using microcontroller.**

***Index Terms***- **Sensor, ADC, Sweep voltage, Amplifier, Differential amplifier Low pass filter, microcontroller, LCD display.**

## I. INTRODUCTION

Langmuir probe have been extensively used in the laboratory for a long time measurement of parameters such as electron and ion densities, electron and ion temperature [7]. Here the Langmuir probe experiment is being developed for the find out the find out the plasma parameter like electron density, ion density, electron temperature, ion temperature. Density and temperature is critical quantity to understand in the mars atmosphere. So here in this paper I explain about design of proposed framework and implementation of the Langmuir probe experiment system.

## II. PRINCIPLE OF LANGMUIR PROBE

The theory of Langmuir probe was given by Langmuir and Mott-Smith (1924) and Mott-Smith and Langmuir (1926) in two classical papers. When a metallic probe is kept in plasma it collects certain amount of current which is a function of the applied voltage. It is possible to determine the electron density from the current voltage-characteristics of the probe. Here a device that has been widely use to investigate plasma in the laboratory a conducting probe called a Langmuir probe is invested in plasma and the current I flowing it is plotted as a function of the potential difference voltage between it and MARS.. When the surface of the probe plane the resulting curve is plane the resulting curve likes that of figure.

Fig to show how to current *(i*) flowing from a probe immersed in a plasma depends on the potential *(v*) applied to it *v*=0 corresponds to the floating potential at which $i$ =0, $V_o$ corresponds to space potential at which electron and ion of all velocities reach the probe.

The part (1) correspond to a situation where all indicates positive ions reach the probe but all the electrons are repelled, the part (3) corresponds to the complementary situation where no ions, but all the imminent electrons are collated the part (2) corresponds to the situation where the electron current is carried only by the more energetic electrons. Because the total electron current is so much greater than the total ion current the shape of this part is largely determined by the electron current.

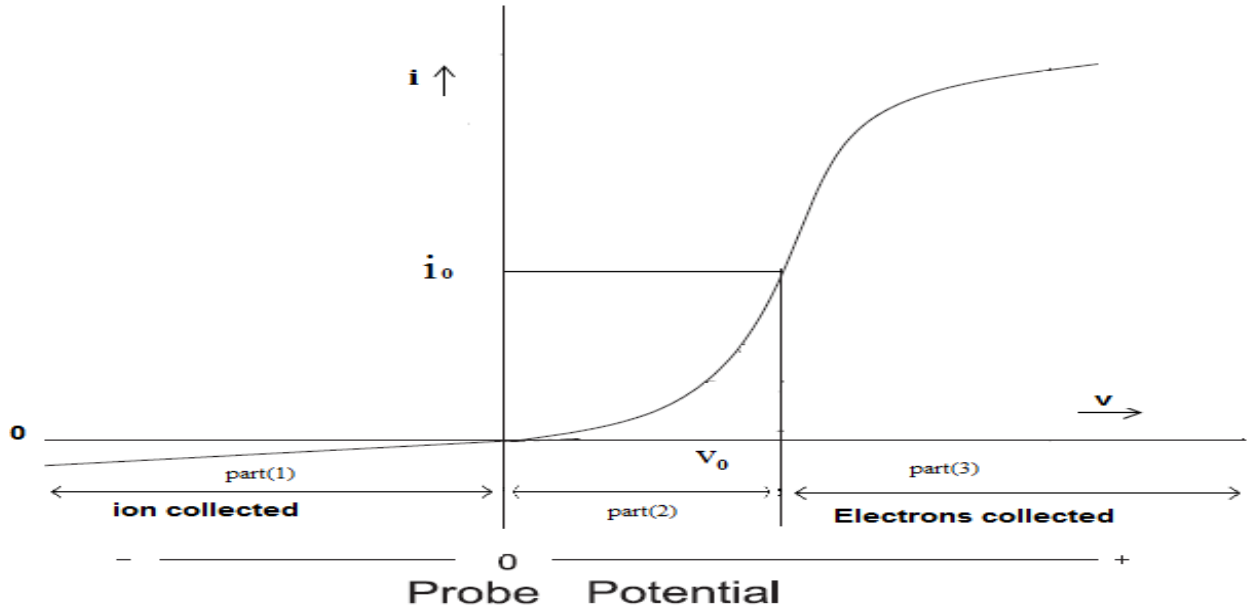



**Figure1. Voltage and current character tics**

If $v$ is component of an electron's velocity perpendicular to the plane of the collector than the number with velocities between $v$ and $v + du$ is proportional to $e^{(-\frac{mv^2}{2kT})}\, du$. If a retarding potential $V$ is applied to the probe all electrons with $v > \sqrt{\frac{2v_e}{m}}$ can reach it. So that the number arriving in unit time or current (i) is proportional to

$$i \propto \int_{\sqrt{\frac{2v_e}{m}}}^{\infty} u \exp(-mv^2/2kT_e)\, du \quad \text{..... (1)}$$

$$\text{Thus } i = i \exp(-\frac{ev}{kte})$$

Where $io = the\ current\ When\ the\ retarding\ potential\ v = o$
$i.e\ When\ the\ current\ is\ a\ space\ potential\ v_1$

The part of the curve marked (2) in figure is describe by the equation (1), if the retarding potential V is measured from negative $V_1$. The object of an experiment is to find out the shape of this curve and form it determine the electron temperature ($T_e$).

To transmit the I-V curve to the ground require a considerable message-carrying capacity in the available telemetry. In one valuable techniques the essential parameters of curve are therefore determine in the satellite itself and are then transmitted to the ground with much less demand on the telemetry facilities. Circuits are arranged that measure directly $\frac{di}{dv}$ and $\frac{d^2i}{dv^2}$ to give.

$$\frac{di}{dv} = \left(-\frac{e}{kTe}\right) i\, exp(-ev/kTe) \quad \text{.....(2)}$$

$$\frac{d^2i}{dv^2} = \left(\frac{e^2}{k^2T_e^2}\right) i_0 \exp(\frac{-ev}{kT_e}) \quad \text{.....(3)}$$

$$\text{Then} \quad \frac{\frac{di}{dv}}{\frac{d^2i}{dv^2}} = -\frac{kT_e}{e}$$

Gives the $e^-$ temperature $T_e$ and when this is known $i_0$ can be calculated from the magnitude of $\frac{di}{dv}$ at a known value of $v$. Knowledge of the probe's area A then allows the concentration n of electron calculated from the relation.

$$\frac{i}{A} = J_0 = \tfrac{1}{4} n_e e v_e = \tfrac{1}{4} n_e (8kT_e/\pi m)^{1/2}$$

$$\text{Where } v_e = \sqrt{8kT_e}/\pi m$$

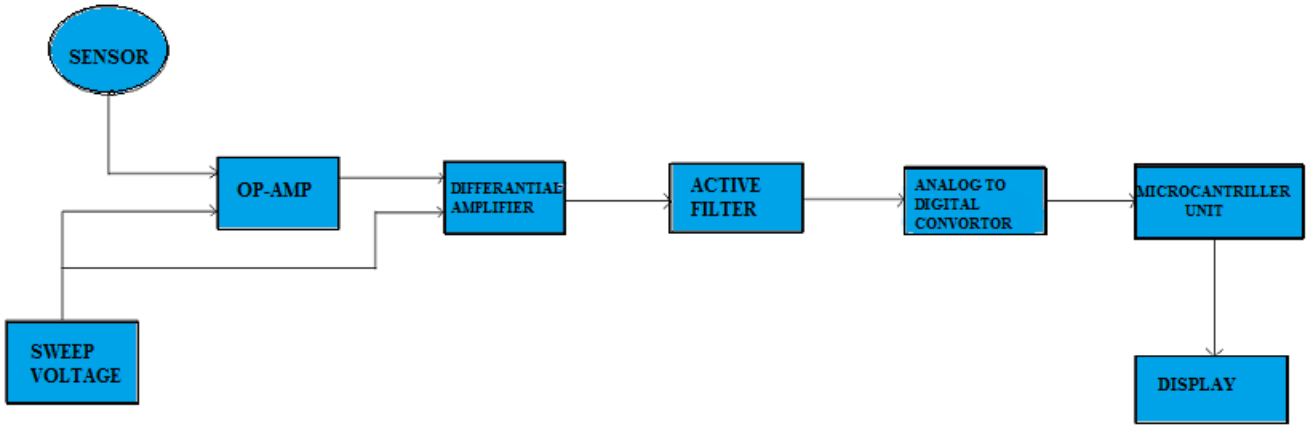
$$J = \frac{1}{4} n_e e v_e = \frac{i_0}{A}$$

## III. LANGMUIR PROBE INSTRUMENT

The technique first used by Irving Langmuir consists of exposing a small metallic probe to the medium under study and measuring the current collected by it as the probe voltage is slowly varies from a convenient negative value through zero to a convenient positive value. [1] The resulting current voltage character tics are analyzed to obtain information about various plasma parameters. [7] The Langmuir probe is being developed to observe the electron-density Mars ionosphere.

The cylindrical sensor is input stage of instrument. The Langmuir probe instrument is designed to measurement the electron density. The current is proportional to using current voltage sweep. [2] Here we discuss proposed work of Langmuir probe instrument. We apply to sweep voltage as a reference to the sensor and the current voltage characteristics are used to derive plasma parameters. [3] The Langmuir probe sensor is split sphere 40 mm diameter and it supported by boom.

The block diagram of the proposed Langmuir probe experiment is shown in figure2. The Langmuir probe sensor is input stage of system. The sensor is consist with titanium nitride it is used for collection of the current .Here for the collection of the current we also generate sweep voltage and generated sweep voltage is apply to cylindrical sensor . After the applying sensor surface has surface potential (Ps) and side ionosphere plasma have plasma potential (Ps).both potential are connected with each other and sensor have generators current. After the generating current we use current and voltage character tics and by using current –voltage character tics we analyzed plasma parameters.




. **Figure2. A Proposed Framework for Langmuir Probe Experiment**

Here the block diagram of Langmuir probe experiment in the sensor is connected with operational. The op-amp is input stage of system. Sensor gives the signal to operational amplifier. The non-inverting input signal of sensor is amplifying by op-amp. After the amplification output signal of the operational amplifier is goes to differential amplifier section. Here we also apply sweep voltage to difference amplifier for find out the actual signal current coming for sensor. Differential amplifier has a two input one is operational amplifier's outputted signal and other one is sweep voltage signal. Differential amplifier is subtraction both signals. After differentiation we get actual sensor's input signal via differential amplifier.

The differential amplifier output is also fed to filter (shown in figure 2).Here we use analog type Low pass filter active RC filter. The low pass filter is filtering the signal and also removes unwanted frequency. It also used to reduce the aliasing error. Here we make 3rd order low pass filter for 100Hz cut-off frequency. After the filtering process the filtered signal is goes to analog to digital convertor section. We used 0804 ADC with 8-bit resolution. The analog signal come from Low pass filter it will converts in digital form by using ADC. Here the low pass filter is connected with microcontroller via ADC. The microcontroller is interfacing with ADC. [6] A microcontroller is used for data controlling. We have used P89V51RE2BN Microcontroller use for controlling data and also for a display so by using microcontroller we will display to electron density on elementary display.

## IV. HARDWARE REQUIREMENTS

### A. Sweep voltage Generating circuit-

The sweep system will generates a sweep which has shape shown in figure. The probe consists of a regulated power supply of a sweep generator amplifier and subsystem needed for telemetry's sweep voltage will be produced from Langmuir Probe. We use LM124 Operational amplifier for a sweep voltage generation. In the portion of the sweep, the sensor voltage varies from -1.0 V to +4.0 V linearly in sec. This portion is used for retarding potential analysis the steady portion, the sensor stays at +4.0 V for about 1 sec so that saturation electron current is measured. The produce range of sweep voltage between +5v to -5v.The voltage sweep is similar to Triangle wave or saw tooth.

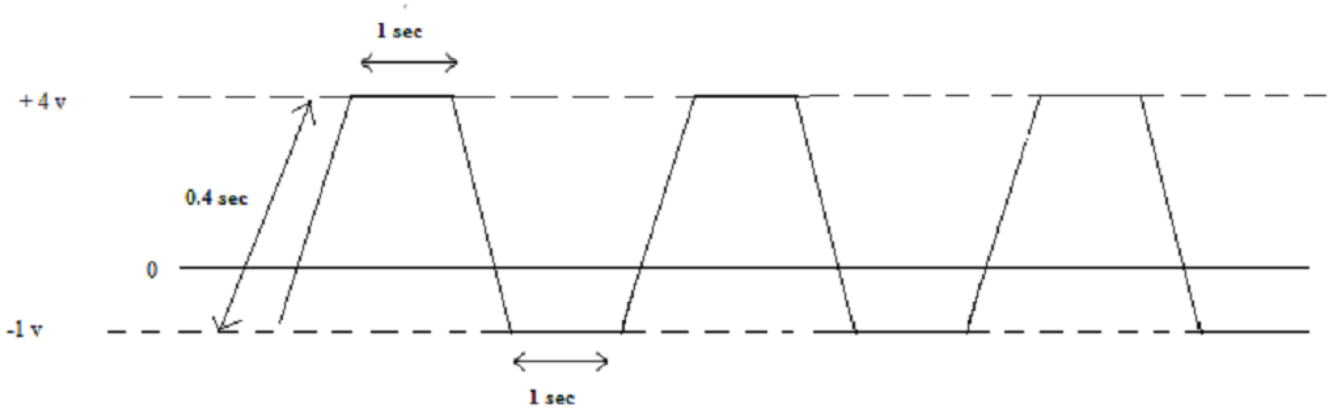



**Figure3. A sweep voltage wave form for Langmuir Probe**

Theoretical result of sweep voltage it should be.

1. T (rise) = 0.4 sec of ramp from -1v to+4 v
2. T (steady) = 1 sec of fixed dc at +4 v
3. T (fall) = 0.4 sec of ramp from +4 v to -1 v
4. T (steady) = 0.2 sec of fixed dc at -1v

**B. sensor -**

The Langmuir probe sensor consists a cylinder shape of 40 mm diameter with tin coated and is supported with a long boom. The cylinder will be used for the collection of the current via the Langmuir Probe electronics and the cable which will pass through boom. The sensor has spherical, planer and cylindrical geometry.

**Figure4. A Langmuir probe cylindrical sensor [9]**

**C. Operational Amplifier -**

Operational amplifier is input stage of the Langmuir probe experiment system. Sensor current is passing in to operational amplifier. Here we use OPR445AP high voltage op-amp. The OPA445AP is capable to handle ±45V. The OPA445AP have two different inputs and one single output. So the signal come from sensor is current and also we apply sweep voltage to op-amp both of the signals are amplify in this stage. The OPA445AP operational amplifier is able to handle both of the input.

**D. Differential Amplifier –**

The amplifier signal coming from operational amplifier is input stage of the differential amplifier. Here we also use OPA445AP high voltage amplifier in below figure 5 differential amplifier have a two input one is sensor current and second one is sweep voltage. Here we also apply sweep voltage to differential amplifier. The reason of the sweep voltage applies to differential amplifier after differentiation we got an actual signal coming from sensor. Here blown figure of the properly indication of the operation of the differential amplifier. Two input if the differential amplifier one is the sensor current and second one is the sweep voltage(Vs).both are the difference is amplify by the OPA445AP differential amplifier and after the hole operation we will got a one single ended output. And the output is current of the cylindrical sensor.

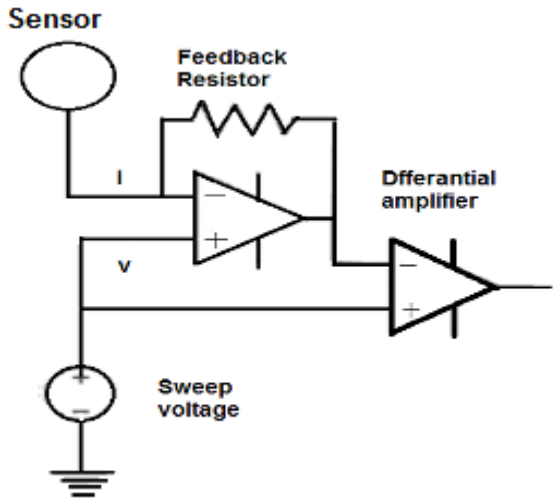



**Figure5. Differential amplifier for Langmuir probe system**

### E. Active Filter –

The active filter is analog type filter. We use analog components like resistors (R), capacitor (c) and amplifier. Here we use amplifier to increase the performance of the filter. Here we will make a 3rd order Low pass filter using LM741 operational amplifier IC. It is used for all the data handling system to reduce the aliasing error. The output of the differential amplifier is input stage of the low pas filter. We will make 3 rd order low pass filter it is passed signal of the frequency lower than the cut-off frequency and remove the frequency higher than cut-off.

Here we make Low pass filter there were 3 poles in filter bank. The operational amplifier LM741 IC we used for filter. We make 3 re order filter for 100Hz frequency. Here for the testing theoretical result should be this. When apply DC voltage in between 0 to 5 volt or sine wave of frequency 0 to 100 Hz and output offset voltage measure and apply 200Hz and cut off frequency at -3db decade. And finally Gain of low pass filter 0.5v and for voltage out of range between 0v or 2.5v limit. Cut-off frequency should be 100Hz and at cut-off frequency gain should be -3 db.

### F. Analog to Digital convertor-

Analog to Digital Convertor (ADC) is next stage of the Langmuir probe experiment system. The output of active filter is input of the analog to digital convertor. Here we use ADC0804 Analog to Digital convertor with 8-bit resolution. An Analog o Digital Convertor it is device that converts physical quantity in digital number form. Here as shown in figure 1 the analog to digital is interface with microcontroller P89V51RD2BN. The analog signals are digitized in an 8 -bit analog-to-digital converter (ADC) and all sampled signal is simultaneously controlled with a microcontroller.

### G. P89C51RD2BN Microcontroller Unit

A microcontroller is small programmable computer integrated circuit. It is programmable unit of the Langmuir probe experiment system. We use 89c51 series P89C51RD2BN microcontroller. A system is 8-bit microcontroller with 32 I/O lines with 5 operating voltage from 0 MHz to 40 MHz there were also 3 timer/ counter and 9 interrupts'. This microcontroller is operate on 11.0592 MHz clock rate achieve the bode rate of 9600. And this slandered baud rate use for communication with PC using UART protocol. Here we also use MAX232 for serial communication with Personal computer. By using this microcontroller we will display the electron density on 16*2 LCD display. A microcontroller is an input/output peripheral programmable unit. So by using programming analog to digital convertor and 16*2 Liquid Crystal display are interface with microcontroller. As shown in figure 1 microcontroller unit have interface with analog to digital convertor Here output of the analog to digital converter it is input of the microcontroller unit. A microcontroller is controlled all the digital data coming from analog to digital convertor. So the sensor's input current finally converts in digital number form by using analog to digital convertor. [8]

### H. Display-

In the Langmuir probe system we use 16x2 LCD (Liquid Crystal Display) to display electron density. A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. Here The 16 x 2LCD is capable to display alphanumeric word and total 224 different characters also. The LCD is interface with microcontroller. So finally signal come from sensor it is Display on LCD. The plasma parameter like electron density, ion density and other parameters are display on LCD properly.

## V. Conclusion

A new concept of Langmuir probe system is being developed, making it possible to derive the electron density with high resolution. The Langmuir Probe is being devolved for the measurement for the ionospheric property of the Mars. The Langmuir

probe has a one cylindrical sensor to collect current. We also apply the sweep voltage for surface potential of the sensor and it is able to generate current and by using current to voltage character tics we analyzed the plasma property. Here we used low pass filter for proper signal. Later using analog to digital convertor we convertor data in digital form and by using microcontroller unit we will display electron density properly. The exact value of the plasma potential provided the probe is biased at a positive value well above the estimated plasma potential. Also the wide dynamic range of the Langmuir probe mode voltage sweep enables measurements of electron density. So proposed Langmuir probe system is more efficient and high reliable.

## VI. ACKNOWLEDGMENT

In engineering one of the best ways of studying is, while doing project, since it helps the practical knowledge of the subject, which can be achieved successfully by putting efforts in making it successful with co-operation of teacher. I would like to express our best regards to my project guide Prof S.A.Haider whose valuable guidance, encouragement, and provision of necessary facilities made this work possible.

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