Silicon Photon Multiplier

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Abstract—**programmable power supply with temperature compensation is essentially useful for powering a Silicon photon multiplier (Si PM) which is basically an avalanche photodiode detector in reverse bias configuration operating at limited Geiger mode. These devices were operated at atmospheric temperatures and it was observed that the temperature-gain coefficient was 50mV/°C and a method to compensate this shift in operating point was essential wherein actual temperature will be sensed and accordingly a potential will be applied to null the effects of temperature on biasing voltage. The second part of this project deals with high precision power supply as the intrinsic characteristics of Si PM vary from device to device and hence the biasing point is not the same for all devices, to cope with this a programmable DC power supply with high resolution (1mV in 100V) interfaced with computer will serve the purpose.**

Keywords—**Silicon photo multiplier, Geiger mode, temperature, gain coefficient, programmable power supply, GUI**

I. INTRODUCTION

Tata institute of fundamental research has established a cosmic ray laboratory in Ooty, where GRAPES3 experiment is being held to detect presence of air showers coming from outer space. Currently, photo multiplier tubes are being used which are to be replaced by Si PM since the operating voltage range for Si PM is from 60V to 120V which is much smaller than PMT(-2400V) and Si PM has higher gain and is more stable as compared to PMT[13].

The silicon photomultiplier is operated in Limited Geiger mode where the device is biased to a point above (10%-20%) its breakdown voltage (Avalanche breakdown) by applying an overvoltage which gives the voltage equation as

Bias =Breakdown + Overvoltage.

The gain of device is proportional to the over-voltage which can vary with Si PM temperature because the temperature coefficient of the breakdown voltage of this Si PM is nominally 50mV/°C, thus considering a case where temperature rises by 10°C, then the over voltage will reduce by 0.5V reducing the gain of the Si PM. A compensator was built and tested which is discussed in following part of the paper.

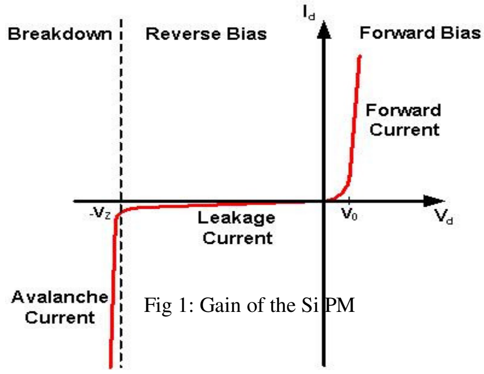

Fig 1: Gain of the Si PM

II. DESIGN

The design can be split into two parts,

a) Compensator
b) Power unit

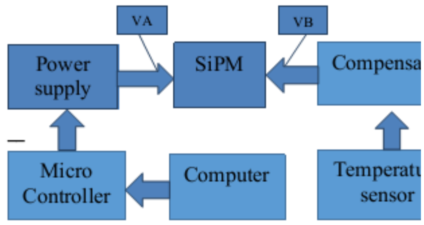

Fig 2: Silicon Photon Multiplier

The compensator is responsible for controlling the variable voltage VB for the [5]

Si PM, this voltage is in range of two to four volts.
The power supply's task is to generate a high constant voltage VA for the Si PM typically in range of 0 to 120volts as per the biasing needs of the device.

A. Compensator:

The main purpose of compensator section of the project is to sense the change in atmospheric temperature and accordingly vary the biasing voltage VB across the Si PM.

1) Temperature Sensor:

The temperature sensing is achieved by using the LM35 linear temperature sensor with 10 mV/˚C scale factor, however in practice the error was high and hence a calibration of LM35 was needed this was achieved with help of PT100 .

The temperature sensor was tested for accuracy by comparing it with PT100 considering it as an accurate reference for duration of 48 hours under atmospheric temperature variations using LABVIEW[4] software and following results were observed:

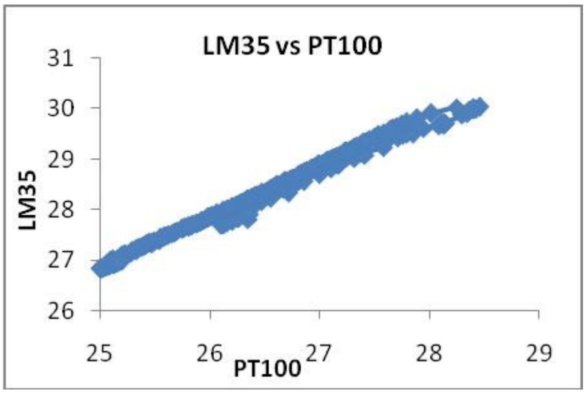

Fig 3. LM vs PT

Thus to have better results a more precise sensor TSIC501F was brought under consideration, this sensor was also tested with PT100 and results show that it is highly accurate as compared to LM35, the following graph is of TSIC501F and PT100:

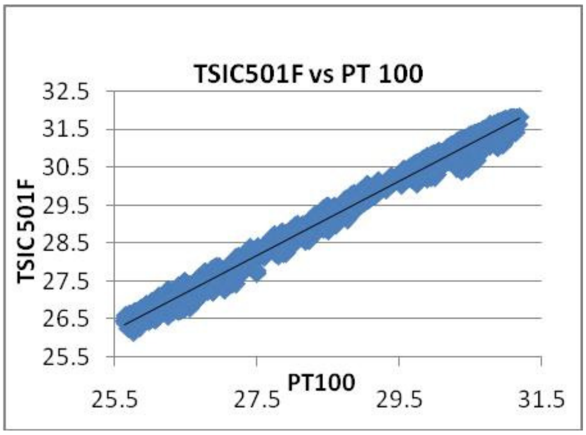

Fig 4: TSIC vs PT

2) Compensation Circuit:

This signal from temperature sensor is given to an operational amplifier which either acts in inverting or non-inverting mode depending on polarity of power supply voltage (VA).

The gain of this op-amp can be varied using potentiometers and any desired slope can be set[15].

The compensator consists of metal film resistors which has temperature coefficient of 300ppm and operational amplifier OP07 with drift of 0.6µV/°C which is negligible and thus can be discarded. The compensator circuit was tested on an actual Si PM and the results were showing variation of 8% in gain without the compensator circuit as against 2% variation with the compensator ON. This error can Further be reduced by using EMI isolation, adding a ground plane, use of SMD components and accurate measurement system to test the circuit.

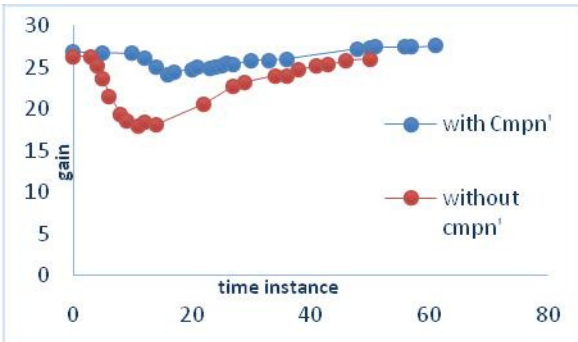

Fig 5: Gain variation with respect to temperature

B. Power supply

The second section of the project deals with power supply unit which is responsible for generating constant voltage VA for the Si PM, the current requirements of Si PM are in order of few ŋA to µA and voltage required for biasing can vary from 0V to -120V.The requirement of power supply deals with its ability to have control over the voltage regulation through a computer and accordingly change the biasing voltage in mili-volts ranges per the need of the user.

1) Computer

A graphical user interface wherein a provision to select a channel in case of multiple Si PM interfacing and the appropriate biasing voltage to be set included. The set values will be sent to the microcontroller via USB or RS232 interface for controlling the onboard devices.

2) Microcontroller

The controller PIC18F452 by microchip is under consideration. The controller will mainly be used to process the signal from PC and select appropriate channel on the DAC card. Also the controlling voltage generated by controller will be sensed by the power supply unit as a reference and accordingly an output voltage will be generated for the Si PM.

3) Power supply

A constant voltage constant current DC power supply with voltage range of 0 to 100V can be interfaced with the controller with the reference voltage generated from controller acting as controlling element. Another method for the power supply module is to have a Voltage doubler circuit which consists of diodes and capacitors to generate a basic DC level and then a high voltage regulator at the output of this circuit to have precise control over the biasing voltage. The regulator circuit which consists of TIP31 and TIP32, a pair of PNP and NPN transistors along with an op-amp as controlling element has been built and tested to give satisfactory results.

III. CONCULSION & FUTURE WORK

Future work for this project includes use of a better temperature sensor like the one mentioned above in the compensator section so that error is minimized and interfacing and control of multiple Si PM using multiple channel DAC.

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