Introduction
The use of solar cells as auxiliary power sources on satellites has introduced a new research to the group of radiation sensitive components important in military and civilian applications. With this as an incentive, measurements have been made to predict the performance of silicon solar cells, irradiated with gamma rays. The passage of gamma rays through matter produces electrons and secondary photons in the material. The electrons pass through the material and some collide with the lattice. Atoms are bound to lattice sites and a certain amount of energy must be imparted to the atom in order to displace it from its normal site and create a vacancy-interstitial pair (Frenkel Defect) [1].

Co$^{60}$ gammas are widely used to study ionization induced damage in devices. [2]. In this experiment mono-crystalline silicon solar cell has been irradiated with Co$^{60}$ gamma rays, and the results presented using C-V and I-V characteristics.

Experiment
Boron-doped p-type (100) oriented Si wafers were used with a resistivity of 0.01–1.5 Ω-cm. Si substrates with a size of 10×10 mm were cleaned by standard RCA method followed by a 20-sec dip in 10:1 H2O:HF. After de-ionized water rinse and N2 blow, wafers were baked for 10 min at 100°C to drive out moisture. PN junction was made at 1000°C in a quartz tube furnace. Back side contact was made with aluminium on the whole back surface, while front side with silver (350nm) followed by Al (300nm) using metal grid mask. The grid structure of solar cells consists of metal mask grid pattern with finger spacing of 0.65mm, and finger width of 0.30mm. After fabrication the device was characterized using C-V, I-V measurements and irradiated using Co$^{60}$ gamma rays (1μCi). The activity of Co$^{60}$ was 24864.37 atoms Bq at the time of experiment calculated from the half-life. Sample was irradiated with Co$^{60}$ gamma rays emitting at solid angle 2π, while following method was used to measure the amount of atoms reaching the sample at a distance of 0.7cm$^2$ from the gamma source.

$$\Delta_1 = \frac{A}{x^2}$$

$$\Delta_2 = \frac{d}{r}$$

$$\Delta_3 = \frac{\Delta_2}{x^2}$$

Results and Discussion
The effects of Gamma radiations on the solar cell performance are shown in Fig. (1-4) as dark I-V and C-V characteristics. As the time of irradiation, the cell capacitance shifts towards lower values, as shown in Fig. (2-4), which depicts the existence of interface states [3]. This increase of interface states manifests itself as an increase of the low frequency capacitance with irradiation time as illustrated in Fig. (2-4). The barrier height can be deduced from 1/C$^2$-V curves measured at 10 kHz for different periods of time Fig. (6). The high frequency capacitance is represented as a straight line having an intercept with the x-axis equal to $V_b$:

$$\sqrt{C^2} = \frac{1}{\varepsilon(S_0N_d)}(V - V_b)$$

Where $\varepsilon$ semiconductor permittivity Na concentration of acceptor atoms.

The growth of interface states density due to irradiation of Co$^{60}$ gamma rays will reduce the built-in potential and consequently the barrier height. These states will be heavily occupied by electrons and will tend to contribute a negative charge, reducing the barrier height and consequently enhancing the saturation current and the dark current as was indicated in Fig. (1).

Conclusion
So we can confirm that the main effect of gamma radiation on monocrystalline solar cell is the growth of interface states density. This growth will reduce the overall efficiency.

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Bibliography