Destructive Electromagnetic Impact, Caused by the Spot Beam Gamma-Quant Source

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Let's estimate electromagnetic impact in the radio electronics equipment body caused by gamma-quant beam impact. Such beam can be generated by the beam of electrons, in the output of the diaphragm of the linac, that bombard the target. When narrow directed electrons beam with the energy ~ 300 MeV reaches the target, *gamma-quant with the energy ~ 250 MeV and with angular spreading* 10^{-3} rad are born. Coefficient of efficiency of such transformation is 5- 10%.

Diffusion of such gamma-quant beam has it's features. When high-energy gamma-quant interacts with air molecules electron-positron pair is born. The energy of initial gamma-quant decreases to the value of ~ 40-50 MeV with the conservation of former angular divergence. As the electronic beam being in the output of the accelerator has a characteristic length 10^{-11} sec, and a period of impulse is 10^{-10} sec, than gamma-quant generate electromagnetic impact passing through the bodies of the radio electronics equipment.

Let the number of gamma-quant from the source, based on the aircraft, falling on the unit of the surface of the radio electronic equipment, when the distance between the correspondents, being equal to R at the divergence angle equal to 0,001 rad be $N_l = 8\ 10^{11}$ $(\pi\ R^2[\text{km}])^{-1}$. Taking the wave train frequency F = 10 Hz into account with duration $\Delta t = 1$ mcs and the accelerator's pumping rate $f = 10$ GHz, we see, that on the one period of pumping the number of gamma-quant will be $N_f = 8\ 10^9\ (\pi\ R^2[\text{km}])^{-1}$. Let S - be the area of the radio electronic equipment, than total amount of gamma-quant, bombarding this area will be $N_s = 8\ 10^9\ S\ (\pi\ R^2[\text{km}])^{-1}$.

The average energy of gamma-quant, bombarding the surface of the radio electronic equipment will be $E_\gamma = 30$ MeV, than the electrons with the energy $E_e = 3$ MeV will mainly born in the material (Al) of the body of the radio electronic equipment. Let the absorption factors for the gamma-quant and born electrons in the body of the radio electronic equipment be agreeably μ_γ and μ_e. Now we can define the total number of born electrons, penetrating into the body of the radio electronic equipment:

$$N_e = 8\ 10^9\ S\ (\pi\ R^2[\text{km}])^{-1}\ (E_\gamma/E_e)\ \mu_\gamma\,(1 - \mu_e). \qquad (1)$$

As the gamma-quant track length with the energy 30 MeV in Al is 16 cm, and the track length of the electrons with the energy 3 MeV is 2 cm, then if the wall thickness of Al is 3-5 mm:$\mu_\gamma = 0.025$ and $(1\text{-}\mu_e) = 1$. Taking absorption into account, the umber of electrons, getting in the body of the radio electronic equipment will be:

$$N_e = 6{,}4\ 10^8\ S\ (R^2[\mathrm{km}])^{-1}. \qquad (2)$$

Let's define the ЭМИ dipole radiation, inside the body of the radio electronics equipment. While calculating that value we suppose that gamma-quant radiation impact length during the one pumping period is $\tau = 10^{-11}$ sec. We'll suppose that radiation with length τ arrive to the body of the radio electronics equipment with the frequency f=10 GHz. The estimate, done before will be considered as the upper estimate.

The dipole is born inside the body of the radio electronics equipment $d(t) = e\ n_e\ c\ t\ \eta(t)$, where e – is the charge of the electron, c – is the speed of light. The second derivative of the dipole is:

$$d''(t) = e\ c\ N_e\ [2\ \delta(t) + t\ \delta'(t)] \approx 2\ e\ c\ Ne\ /\tau. \qquad (3)$$

Inside the body of the radio electronics equipment the electrical component of the electromagnetic field is born::

$$E[\mathrm{W/m}] \approx e\ N_e\ (4\pi\ \varepsilon_0\ l\ \tau)^{-1} \approx 2 10^8\ (R[\mathrm{km}])^{-2}. \qquad (4)$$

The estimation (4) is made for $S = 0{,}02\ \mathrm{m}^{-2}$ (15x15 cm), $l = 0{,}1$ m.

Let's estimate the intensity of the electrical field, that will be enough to break the modern chip. Let the average total capacity of a chip be 100 pF. Let the power line have the effective height of antenna h = 0,5 cm with the effective capacity 0,5 pF. Let the breakdown voltage of the chip be 100 V. Then if the intensity of the electrical field is $E > 4\ 10^5$ [W/m], the achieved breakdown voltage can not be considered enough to fully destroy the chip. At first the inside connections of the chip with its external contacts will be damaged. In our case the radio electronics equipment will be damaged, when the distance between the correspondents will be R = 33 km. If the gamma-quant source is placed on the board of the aircraft at the altitude 16km, than the radio electronics equipment of the spacecraft, being in the point under the satellite at the altitude of 400 km from the Earth's surface may be damaged.

It is important to notice, that when we estimated the chip's breakdown voltage, we didn't take the induction of the internal wires into account. These inductions can either increase the needed intensity of the breakdown voltage or decrease it if the resonating frequency of the connecting wire matches the frequency of pumping of the linear accelerator.