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Noise Reduction in Cross field Devices

Prof. Dr. Raad .H. Thaher[1], Assist. L. Mr. Abdulkareem .W.Hammad[2]

[1,2]Electrical engineering Dept. College of engineering Al-Mustansirya university Baghdad- Iraq

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Corresponding Author:
Dr. Raad .H. Thaher[1]

ABSTRACT

In this paper we the studied the noise reduction factor caused by the space change and its relation with frequency and applied voltage which can be extended to cross field devices, in which electric and magnetic fields are perpendicular and both are perpendicular to the direction of the wave propagation. The effect of space charge at high frequencies was studied and computer results were presented.

1. Introduction

Noise can be defined [2, 4, 5] as any unwanted form of energy tending to interfere with the proper and easy reception of wanted signals. Its effect is to limit the performance of the system. Noise can be classified into two main groups.

a. External noise in which the sources are external to the receiver and it is difficult to treat with quantitively. It includes atmospheric noise, man-made noise, extraterrestrial noise .

b. Internal noise: this is a generally random noise and it can be treated by statistical methods because it is distributed over the radio spectrum. It is proportional to band width and includes white noise, shot noise, transit time noise, and miscellaneous noise.

The main sources of noise in electron tubes are:
(1). The random emission of electrons from the cathode.
(2) . Random variation in velocity in which the electron are emitted.
(3). Non-uniform emission over the cathode surface.
(4). Random interception of electrons by the grid.
(5). Secondary emission of electrons from the collector.

2. Noise and High Frequencies .

The effect of space charge is clear at high frequencies because as the emission is increased the potential minimum voltage becomes more negative and less electrons will reach the anode, hence the output current will contain less amount of noise. Generally there are two methods for calculating noise at high frequencies. The first method make use a Fourier spectrum of current pulse produced by a single electron, the second method can by applied in presence and absence of space charge using Llewellyn-Peterson equations

3. Derivation Of Smoothing Factor

Assuming the steady state condition exist with In the diode and velocity group $\mathbf{v_s}$ to $\mathbf{V_S+AV}$. Now let us assume the cathode to be by injecting a small current which contains electrons with velocities of emission . $V_s$to $Vs+\Delta V$. The fluctuation current is given by (2e Is $\Delta f)^{1/2}$ and I_S represent the current carried by the at zero potential and define the parameter.

Where V_m = negative quantity.
The fluction due to incremental current ΔI_S may be expressed as:

$$\lambda = -\frac{e(v_s + v_m)}{kT} \quad \text{……………………….(1)}$$

$$\overline{\Delta I_S^2} = 2|e|\Delta I_S \Delta f \quad \text{………………………..(2)}$$

where ΔI_s is the emission current containing the electrons with emission velocity between $\lambda$and$\lambda+\Delta\ \lambda$Therefore :

$$\Delta I_S = I e^{-\lambda} \Delta\lambda \quad \text{……………………….(3)}$$

From eq (2) and (3) we get

$$\overline{\Delta I_S^2} = 2|e| I e^{-\lambda} \Delta\lambda\Delta f \quad \text{…………………..(4)}$$

The anode current will be changed due to fluctuation by a factor $\gamma(\lambda)$ then.

$$\overline{\Delta I_S^2} = 2|e| I e^{-\lambda} d\lambda \gamma^2(\lambda) \Delta f \quad \text{…………………………….(5)}$$

Therefore the total fluctuations in the anode current

$$\overline{\Delta I_S^2} = 2|e|I\Delta f \int_{-\eta_c}^{\infty} \gamma^2(\lambda) e^{-\lambda} d\lambda = 2|e|I\Delta f \Gamma^2 \quad \ldots\ldots\ldots\ldots(6)$$

Where Γ^2 =space charge reduction factor $= \Gamma_\alpha^2 + \Gamma_\beta^2$

and

$$\left.\begin{aligned} \Gamma_\alpha^2 &= \int_{-\eta_c}^{0} \gamma^2(\lambda).e^{-\lambda} d\lambda \\ \Gamma_\beta^2 &= \int_{0}^{\infty} \gamma^2(\lambda).e^{-\lambda} d\lambda \end{aligned}\right\} \quad \ldots\ldots\ldots\ldots(7)$$

Where α refers to the group of electrons that do not have initial velocities at the cathode sufficient to overcome the potential minimum and refers to that group of electrons which pass the potential minimum I_t is found that [4].

$$\gamma(\lambda) = 1 - \frac{1}{2D}\left[\int_0^{\eta_c} \frac{F(\eta,\lambda)}{\Phi_\alpha(\eta)^{3/2}} d\eta + \int_0^{\eta_a} \frac{F(\eta,\lambda)}{\Phi_\beta(\eta)^{3/2}}\right] \quad \ldots\ldots (8)$$

$\lambda \geq 0;$

$$D = \frac{1}{2}(\eta_a - \eta_c) + \Phi_\beta(\eta_a)^{1/2} + \Phi_\alpha(\eta_c)^{-1/2} \quad \ldots\ldots\ldots\ldots (9)$$

$$F(\eta.\lambda) = \frac{2}{\pi}\left(\sqrt{\eta+\lambda} - \sqrt{\lambda}\right) \quad \ldots\ldots\ldots\ldots (10)$$

$$\Phi_\beta = e^\eta + \sqrt{\eta}\left(\frac{2}{\pi}\right) - 1 - e^\eta erf\sqrt{\eta} \quad \ldots\ldots\ldots\ldots(11)$$

Therefore numerical integration must be carried out of equation (8)

To get the relation between the reduction factor in the α-region and β-

Region respectively with η >8.

$$\xi = 1.255\eta^{3/4} + 1.688\eta^{1/4} - 0.51 - 0.1677\eta^{-1/4} \quad \ldots\ldots (12)$$

and

$$erf(x) = \frac{2}{\sqrt{\pi}} \int_0^x e^{-x^2} dx \quad \ldots\ldots\ldots\ldots(13)$$

4. Results and Conclusion

The evaluation of equations , previously mentioned , is too complicated . and much mathematically involved . Hence mathematical tables were use and complementary function The following equations are evaluated

$$\Gamma^2 = \frac{1}{1 + \xi_C / 4\pi a^2} \quad (14)$$

Where

$$a = \frac{\varpi}{2\pi^{1/4}\left(\frac{m}{2kT_C}\right)^{1/4}\left|\frac{eJ_0}{m\epsilon_0}\right|^{1/2}} \quad \ldots\ldots\ldots\ldots (15)$$

$$\xi = 9.19 \times 10^5 \frac{J^{1/2}(x - x_m)}{T_C^{3/2}} \quad \ldots\ldots\ldots\ldots(16)$$

$$J = 2.33 \times 10^{-6} \frac{(\upsilon - \upsilon_m)^{3/2}}{(x - x_m)^2} \quad \ldots\ldots\ldots\ldots(17)$$

There fore. we get;

(I) Graphs of reduction factor and frequency for constant voltage as shown in figures (1) and (2) respectively

(II) Graphs of reduction factor and voltage for constant frequencies as shown in figure (3). Microwave frequencies were considered because it,is the normal range of operation for cross field devices

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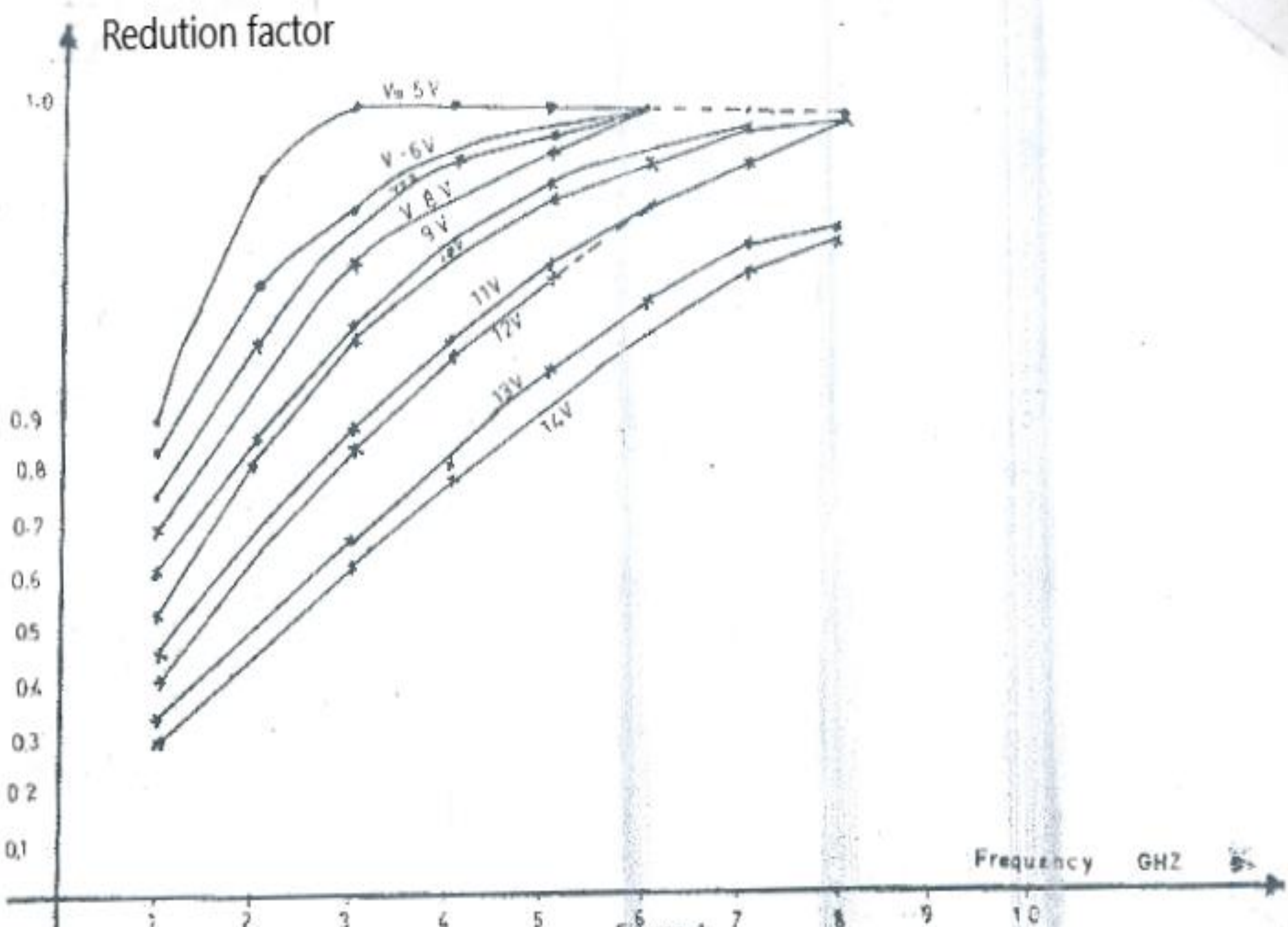

Figure -1-

Graph of Reduation factor against frequency for Constant voltage

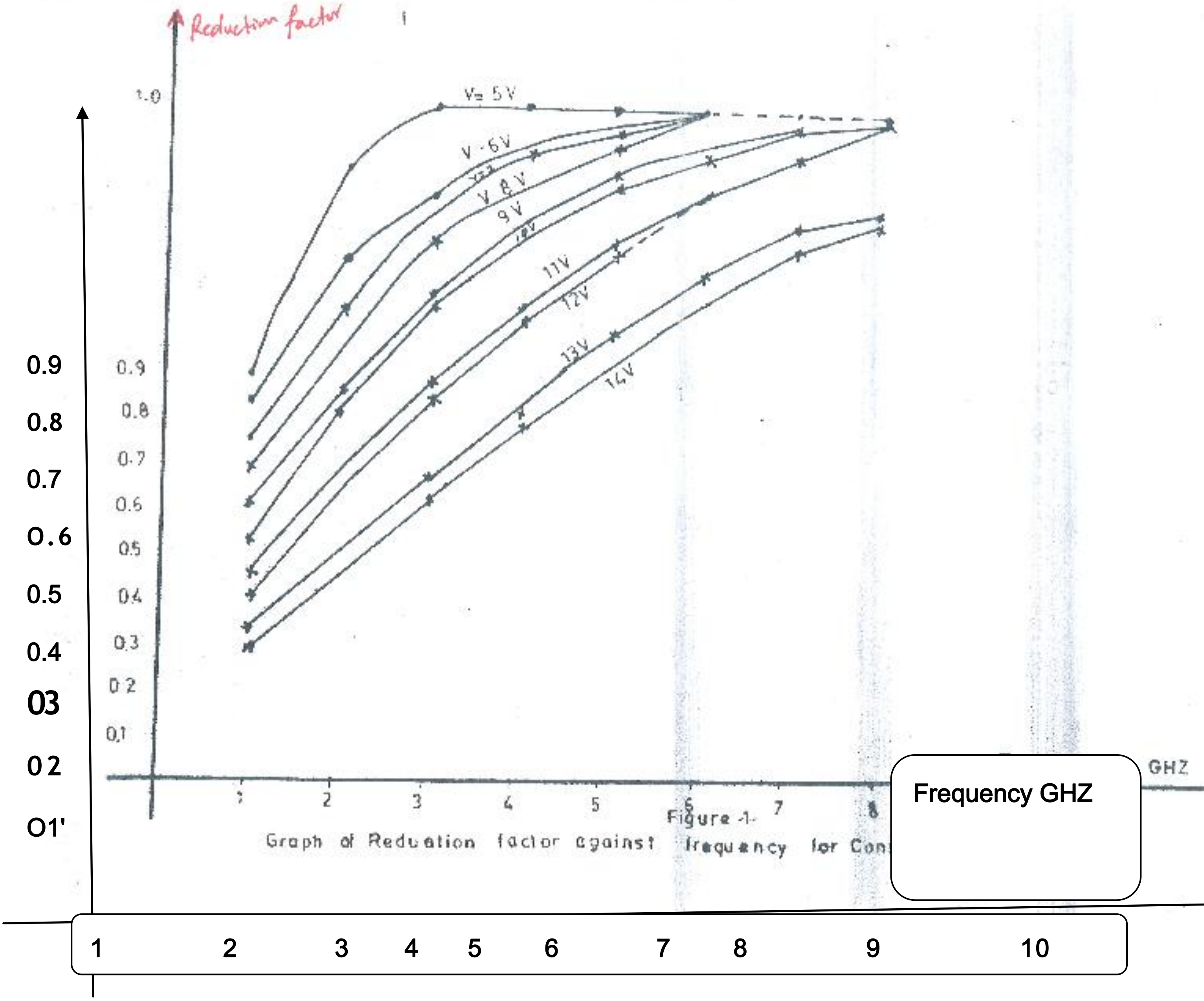

Figure 2 -Graph of R e d u c t i o n factor against the frequency far Constant Voltage

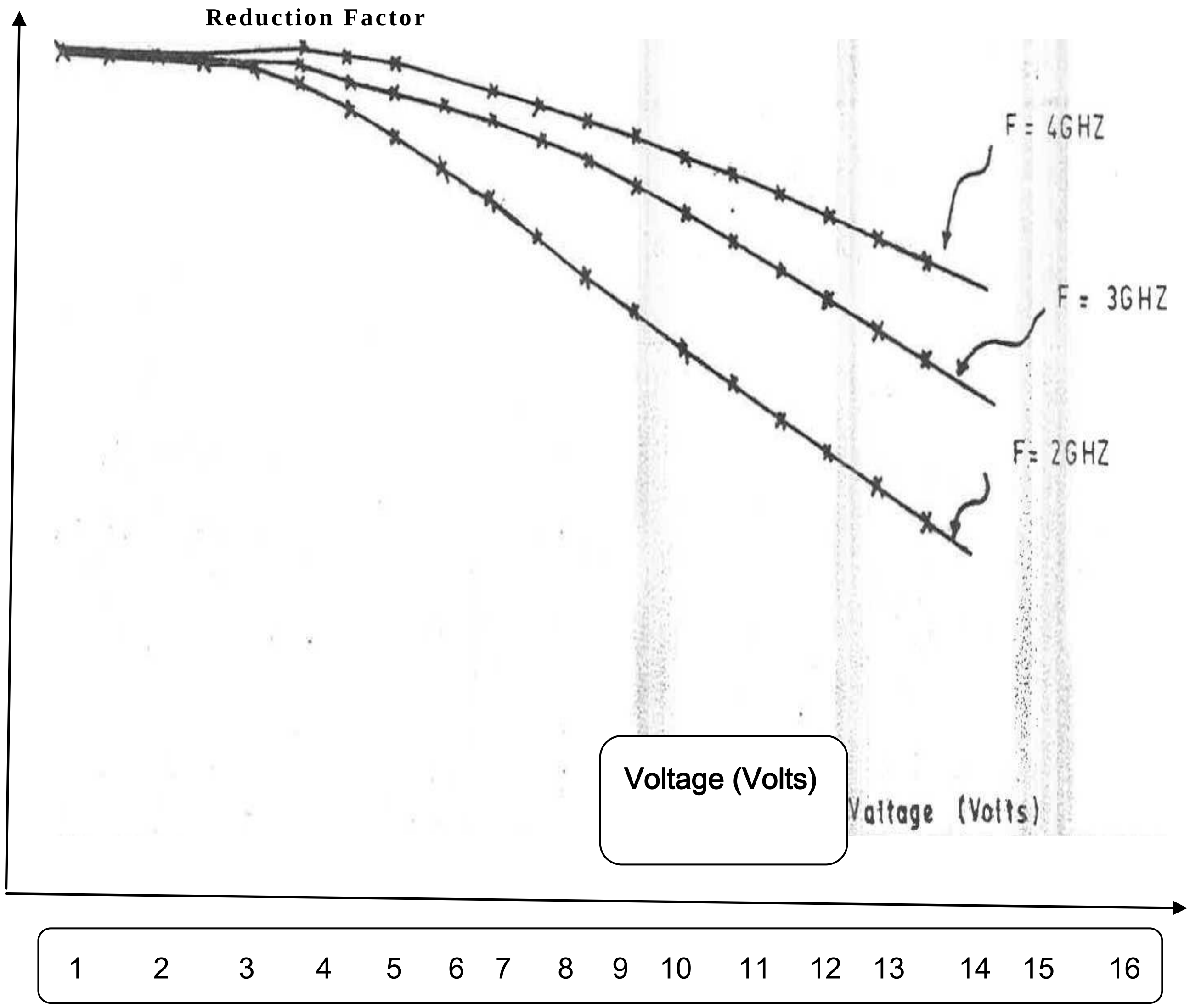

Figure -3- Graph of Reduction factor against voltage for Constant frequency