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The Electric Field in the Round Hole of the Air Plane Capacitor

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Introduction

We investigate a plane capacitor with a round hole. The distribution of electric field in the hole is interesting for us when difference of potentials between the plates of capacitor is taken. Let be diameter of the hole incomparably smaller than width and length of capacitor and the distortion of field near the capacitor edge has not influence to the field of hole.

The important case of such capacitor is standard both surfaces copper laminated textolit plate used in electronics. We can have a valve controlled by electric field if we fill the hole of this plate by electrorheological fluid ERF. If electric field is created, ERF become stiff and the valve closes. The perspective application of such valves is the Braille display for the blind.

Mechanical characteristics of ERF valves depend on electric field distribution in the hole. This distribution depends on the diameter of hole, capacitor thickness and difference of potentials between plates.

Theoretical analysis of electric field in the round hole of air plane capacitor is performed in this paper. Next paper will be published later. Theoretical results, obtained there, will be used in the next paper for investigation of cases of capacitor with insulator, of pocket with some layers of capacitors, of liquid in the hole with permittivity different at air and other. The results of mathematical experiment will be presented in the next paper, too.

Electric field near the air plane capacitor

We investigate the air plane capacitor (see Fig. 1). The one edge of capacitor coincides with the plane x=0 and other – with the plane x=-∞. The plane y=0 is in the half distance between capacitors. The voltage between the capacitor plates is $2V_0$, and the thickness of capacitor – $2h$. Let potential of upper plate of capacitor be V_0, and the potential of lower plate - ($-V_0$). The potential of the plane y=0 will be equal to zero in this case, and the distribution of field will have the mirror symmetry with respect to this plane.

The distribution of electric field at the edge of the air plane capacitor is known [1]. It is obtained using conformal mapping. Let the plane, shown in Fig. 1, be complex: $z=x+jy$. We obtain the distribution of potential and electric field in this plane using a transformation:

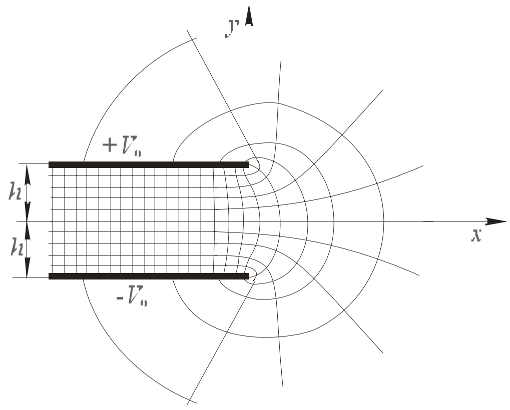

Fig. 1. The two-dimensional model of plane air capacitor and the view of field near the edge of capacitor

$$z = \frac{h}{\pi}\left(e^{\pi\frac{w}{V_0}} + \pi\frac{w}{V_0} + 1\right). \quad (1)$$

There $w=w(z)=v+ju$ is complex potential, $u=u(x,y)$ - potential and $v=v(x,y)$ – flux function. The values of coordinates x and y, corresponding to selected values of u and v, can be calculated as real and imaginary parts of expression (1):

$$x = \frac{h}{\pi}\left(e^{\pi\frac{v}{V_0}} \cos\pi\frac{u}{V_0} + \pi\frac{v}{V_0} + 1\right), \quad (2)$$

$$y- = \frac{h}{\pi}\left(e^{\pi\frac{v}{V_0}} \sin\pi\frac{u}{V_0} + \pi\frac{u}{V_0}\right). \quad (3)$$

We will use in this paper relative coordinates

$$x_s = \frac{x}{h}, \quad y_s = \frac{y}{h} \quad (4)$$

and relative parameters

$$v_s = \frac{v}{V_0}\pi, \quad u_s = \frac{u}{V_0}\pi. \tag{5}$$

The equations (2) and (3) will have the following shape in this case:

$$x_s = \frac{1}{\pi}(e^{v_s}\cos u_s + v_s + 1), \tag{6}$$

$$y_s = \frac{1}{\pi}(e^{v_s}\sin u_s + u_s). \tag{7}$$

Electric field is homogeneous in the internal points of capacitor far from edge:

$$E_0 = E_{y0} = \frac{2V_0}{2h} = \frac{V_0}{h}. \tag{8}$$

The strength of electric field can be calculated in any point of plane z=x+jy , as derivative $E_v = \left|\frac{\mathrm{d}w}{\mathrm{d}z}\right|$. We indicate by index v the strength of electrical field E_v and distribution of potential u_v near the capacitor in absence other objects in surroundings. The relative values of electric field strength with respect to value E_0 are used:

$$E_v^s = \frac{E_v}{E_0} = \frac{1}{E_0}\left|\frac{\mathrm{d}w}{\mathrm{d}z}\right| = \frac{1}{\sqrt{e^{2v_{sv}} + e^{v_{sv}}\cos v_{sv} + 1}}. \tag{9}$$

The y component of the strength of electrical field E_{vy}^s is important in many cases. This component can be calculated by differentiating the expression (3):

$$E_{vy}^s = \frac{E_{vy}}{E_0} = \frac{1}{E_0}\left|\frac{\mathrm{d}u_{sv}}{\mathrm{d}y}\right| = \frac{e^{v_{sv}}\cos u_{sv} + 1}{e^{2v_{sv}} + 2e^{v_{sv}}\cos u_{sv} + 1}. \tag{10}$$

If we want to calculate E_v^s or E_{vy}^s in any point x_s, y_s, the functions $u_{sv}(x_s, y_s)$ and $v_{sv}(x_s, y_s)$ must be calculated in the beginning, using system of equations (6) and (7).

The field between two plane capacitors

We consider two plane air capacitors with parallel edges. Let the distance between edges be $d=2R_0$, the corresponding plates of capacitors be in the same planes and the potentials of corresponding plates be equal. The field of both capacitors is symmetric with respect to plane y_s=0. The potential of this plane is $V_{y=0}$=0, the potentials of upper plates are V_0. Therefore it is sufficient to investigate the field in the upper half-plane y_s≥0 (see Fig. 2).

Origin of the coordinate system is situated in the middle of distance between edges of capacitors, the axis y is parallel to edges and perpendicular to plane of plates. The relative coordinates of the edges of the first and second capacitors are, correspondingly:

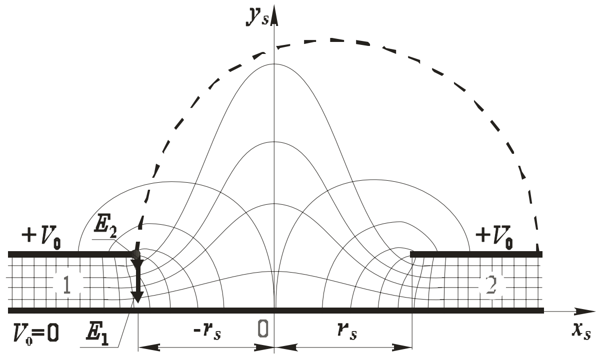

Fig. 2. The field between two plane capacitors

$$y_{s1} = y_{s2} = \frac{h}{h} = 1, \quad x_{s1} = -r_s, \quad x_{s2} = r_s, \quad r_s = \frac{R_0}{h}. \tag{11}$$

The strength of the electric field $\vec{E}^s_{12}(x_s, y_s)$ can be calculated in any point between the capacitors as the sum of the fields which both capacitors create:

$$\boldsymbol{E}_{12}^s(x_s, y_s) = \boldsymbol{E}_1^s(r_s + x_s, y_s) + \boldsymbol{E}_2^s(r_s - x_s, y_s), \tag{12}$$
$$-r_s \le x_s \le r_s, \quad 0 \le y_s \le 1.$$

The equality $\left|\boldsymbol{E}_2^s(r_s, y_s)\right| = \left|\boldsymbol{E}_1^s(r_s, y_s)\right|$ is right on the y axis, therefore:

$$\boldsymbol{E}_{12}^s(r_s, y_s) = 2\boldsymbol{e}_y E_1^s(r_s, y_s). \tag{13}$$

The field is related with the charges distributed on the capacitor plates. The electric charge surface density can be expressed in any point of plate x_s,1 in this way:

$$\sigma(x_s, 1) = \varepsilon_r \varepsilon_0 \left|E(x_s, 1)\right|, \tag{14}$$

where ε_0=8,86·10^{-12}F/m – permittivity of vacuum, ε_r – relative permittivity of material.

If the potentials of capacitor plates are not varied, the electric field and distribution of charges are not varied in both capacitors, too. But some charges on the plates of the first capacitor are induced by the field of the second capacitor and conversely (see the dotted line in Fig.2). Therefore the charges induced by self electric field in any capacitor are redistributed in comparison with the alone capacitor.

We know [1], that the surface charge density σ on the edge of the plane capacitor is out and away greater than in the inner area of the plate of capacitor (if the edge is infinite narrow, $\sigma\to\infty$). Therefore we can evaluate the diminution of field of any capacitor because of the redistribution of charges investigating the electric field in the plane of the edge of the first capacitor x_s=-r_s. The mean value of y component of electric field strength $\overline{E}_{12y}^s$ in the plane x_s=-r_s, is the same as in the alone capacitor:

$$\overline{E}_{12y}^s(-r_s, y_s) = \overline{E}_{v1y}^s(-r_s, y_s) \cong \frac{V_0}{hE_0} = 1, \tag{15}$$

$0 \le y_s \le 1$.

We can express the y component of electric field strength of the second capacitor E^s_{2y} in the plane x_s=-r_s by the y component of the first capacitor, E^s_{v1y} if it could be alone:

$$E^s_{2y}(2r_s, y_s) = m(r_s)E^s_{v1y}(0, y_s)\,, \qquad (16)$$

where the coefficient $m(r_s)$ evaluates the part of field, the second capacitor creates in the plane x_s=-r_s.

This equation is right for any point y_s of the plane x_s=-r_s:

$$\begin{aligned} E^s_{12y}(-r_s, y_s) &= E^s_{1y}(0, y_s) + E^s_{2y}(2r_s, y_s) = \\ &= E^s_{1y}(0, y_s) + m(r_s)E^s_{v1y}(2r_s, y_s) = E^s_{v1y}(0, y_s). \end{aligned} \qquad (17)$$

We use the coefficient K_{12} for evaluating the diminution of field of the alone capacitor, when other capacitor is approached to it:

$$\boldsymbol{E}^s_1(x_s, y_s) = K_{12}\boldsymbol{E}^s_{v1}(x_s, y_s)\,. \qquad (18)$$

We can express K_{12} from the equation (17):

$$K_{12} = K_{12}(r_s) = 1 - m(r_s)\,. \qquad (19)$$

The coefficient $m(r_s)$ can be calculated using the expressions (10), (7) and (8), where $x_s = 2r_s$. For the case r=h, i.e., r_s=1, $m(1)$≅0,166 and K_{12}≅0,834. The electric field is directed along y axis in the middle of distance between capacitors, i.e., on the axis of symmetry x_s=0 and can be calculated in this way:

$$E^s_{12}(0, y_s) = E^s_{12y}(0, y_s) = 2K_{12}E^s_{vy}(r_s, y_s)\,. \qquad (20)$$

The field in the round hole

Electric field in the round hole of plane capacitor is two-dimensional like the field near the plane capacitor. If we use the cylindrical coordinate system r, θ, z, the electric field is the same in any plane θ=const. Such field is axisymmetric. We will use the notes of coordinates accepted for rectangular coordinate system: x_s=r, y_s=z. Let the origin of coordinate system x_s=0, y_s=0 be on the axis of hole. We express field strength $\boldsymbol{E}^s(x_s, y_s)$ in any point of hole by distribution of field on the axis: $\boldsymbol{E}^s_A = \boldsymbol{e}_y E^s_y(0, y_s) = \boldsymbol{e}_y E^s_y(y_s)$, derivatives $[E^s_y(y_s)]', [E^s_y(y_s)]'', [E^s_y(y_s)]''', [E^s_y(y_s)]^{IV}$,... of this distribution and the distance x_s at axis, using equations [2]:

$$\begin{aligned} &\boldsymbol{E}^s = \boldsymbol{e}_x E^s_x + \boldsymbol{e}_y E^s_y, \\ &E^s_y(x_s, y_s) = E^s_y(y_s) - \frac{1}{4}[E^s_y(y_s)]'' x_s^2 + \frac{1}{64}[E^s_y(y_s)]^{IV} x_s^4 - ... \\ &E^s_x(x_s, y_s) = -\frac{1}{2}[E^s_y(y_s)]' \cdot x_s + \frac{1}{16}[E^s_y(y_s)]''' \cdot x_s^3 - ... \end{aligned} \qquad (21)$$

The value of the field E^s_A on the hole axis can be calculated using the expression (20) of field $E^s_{12}(0, y_s)$ on the axis of symmetry between two plane capacitors.

Relation between axisymmetric field and plane parallel field on the axis of symmetry

We can calculate field on the axis of hole using known distribution of plane parallel field on the axis of symmetry (20). But we must evaluate two moments in this case: 1) total three-dimensional field on the axis y (Fig. 2) is obtained by different ways for plane parallel field and for axisymmetric field; 2) charges are redistributed on the edges of plane parallel capacitors and on the edge of round hole in different way.

The section of capacitor with round hole in the plane xy, containing the hole axis, is shown in Fig. 3, a. The view of analogical section of two plane capacitors is the same. The view of two plane capacitors from above, i.e., on the plane xz is shown in the Fig. 3, b and d. The view of the capacitor with round hole on the same plane is shown in the Fig. 3, c and e.

The field on the axis point A is created by the charge located in any point P of capacitor plate with round hole (Fig. 3, c) or in any points P or P′ of the first or the second plane capacitor plates (Fig. 3, b). Let r be the distance between points A and P (or P′), ρ - the distance PO′(or P′O′) between the point P(or P′) and y axis on the plate plane, α - the angle between the line r and the plane z=0, β - the angle between the line r and the plate plane. Strength of electric field E_A in the point A can be calculated using the same expression for both cases:

$$E_A = |\boldsymbol{E}_A| = \frac{4}{\varepsilon_0}\int_0^{\pi/2}\int_{R_0}^{\infty} \frac{\sigma(\rho)}{r^2(\rho,\alpha)} r(\rho,\alpha)\,\mathrm{d}\rho\,\mathrm{d}\alpha\,, \qquad (22)$$

where $\sigma(\rho)$ – the distribution of the surface charge density on the capacitor plate. This distribution is the same for both cases.

We can write the integral (22) otherwise:

$$E_A = \frac{4}{\varepsilon_0}\int_{R_0}^{\infty} I(\rho)\sigma(\rho)\,\mathrm{d}\rho\,, \qquad (23)$$

where $I(\rho)$ has the same form for both cases:

$$I(\rho) = \int_0^{\pi/2} \frac{\mathrm{d}\alpha}{r(\rho,\alpha)}\,. \qquad (24)$$

The distance $r(\rho,\alpha)$ can be expressed as relation $r = \dfrac{r'}{\cos\beta} = \dfrac{\rho}{\cos\alpha\cos\beta}$ for the case of plane capacitors (see Fig. 3, a and b). We use index p for the integral $I(\rho)$ in this case:

$$I_p(\rho) = \frac{1}{\varepsilon_0}\int_0^{\pi/2} \frac{\cos\beta\cos\alpha}{\rho}\,\mathrm{d}\alpha = \frac{\cos\beta}{\varepsilon_0\rho}\,. \qquad (25)$$

The expression $r = \dfrac{\rho}{\cos\beta}$ is right for the round hole (see Fig. 3, a and c). The index r is used for the integral $I(p)$ in this case:

$$I_{\mathrm{r}}(\rho) = \frac{1}{\varepsilon_0}\int_0^{\pi/2}\frac{\cos\beta}{\rho}\mathrm{d}\alpha = \frac{\pi}{2}\frac{\cos\beta}{\varepsilon_0\rho}. \qquad (26)$$

Dividing I_{r} to I_{p}, we obtain the coefficient K_a, which show how many the electric field on the axis of symmetry would be greater in the axisymmetric case than in the plane parallel case if the redistribution of charges is not evaluated:

$$K_a = \frac{I_{\mathrm{r}}(p)}{I_{\mathrm{p}}(p)} = \frac{\pi}{2}. \qquad (27)$$

It was shown above, that if we approach two plane capacitors one to other the field diminishes in any capacitor. It is happened since the charges situated on the plate of first capacitor act the charges situated on the plate of other capacitor. The charges redistribute. They redistribute in the case of round hole, too. This redistribution is different in both cases. We evaluate the differences between the charge distributions in both cases investigating the interaction between the charges, distributed on the edge. The variation of field because of the redistribution of charges was evaluated by the coefficient $m(r_{\mathrm{s}})$ in the plane parallel case. This coefficient defines the action of charge, situated in the point M, to the charge, situated in the point N. The action can be evaluated by the *x* component of field strength, in the point N created by a charge, situated in the point M (see Fig 3, d and e). But all charges situated on the edge of plate or hole create the field in the point N. For the plane parallel case total value of *x* component of field strength $E_{\mathrm{Mp}x}$ in the point M can be calculated (see Fig. 3, d), using integral:

$$E_{\mathrm{Mp}x} = \frac{1}{\varepsilon_0}\int_{-\pi/2}^{\pi/2}\frac{\tau_{R0}(2R_0/\cos\alpha)}{(2R_0/\cos\alpha)^2}\cos\alpha\mathrm{d}\alpha = \frac{\tau_{R0}}{2\varepsilon_0 R_0}\frac{\pi}{2}, \qquad (28)$$

where τ_{R0} – linear electric charge density on the edge.

For the case of round hole (Fig.3, e) the *x* component $E_{\mathrm{Mr}x}$ of total strength of electrical field in the point M can be expressed

$$E_{\mathrm{Mr}x} = \frac{1}{\varepsilon_0}\int_{-\pi/2}^{\pi/2}\frac{\tau_{R0}\cdot 2R_0}{(2R_0\cos\alpha)^2}\cos^2\alpha\mathrm{d}\alpha = \frac{\tau_{R0}}{2\varepsilon_0 R_0}\pi. \qquad (29)$$

In comparison with plane parallel field the action to a charge in point M increases two times: $E_{\mathrm{Mr}x}/E_{\mathrm{Mp}x} = 2$. Therefore, the field because the redistribution of charge must decrease by part $2m(r_{\mathrm{s}})$. The field on the axis of hole varies because of the redistribution of charges by part:

$$K_{\mathrm{s}} = 1 - 2m(r_{\mathrm{s}}). \qquad (30)$$

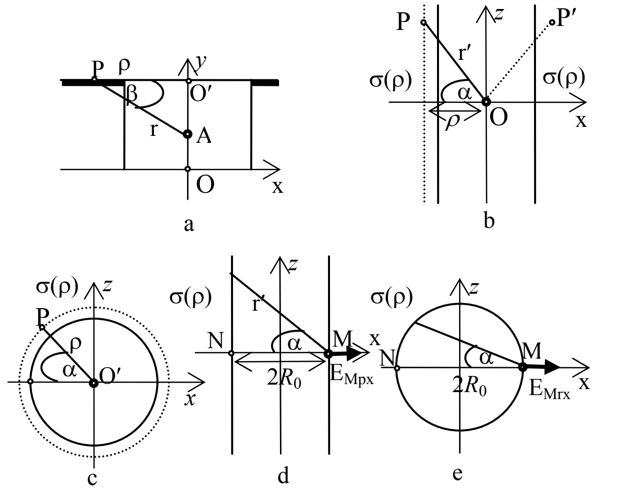

Fig. 3. The comparison of plane parallel and axisymmetric fields: a, b and c – formation of total field on the axis, d and e formation of charge pushing field

In the plane parallel case the field varies on the axis of symmetry by part $K_{12}=1-m(r_{\mathrm{s}})$.

Therefore the coefficient K_M, which evaluated the redistribution of charges on the edge of round hole, can be expressed with respect to plane parallel case in this way:

$$K_M = \frac{K_{\mathrm{s}}}{K_{12}} = \frac{1-2m(r_{\mathrm{s}})}{1-m(r_{\mathrm{s}})}. \qquad (31)$$

The field E_A^{s} on the axis of the round hole can be calculated using the field distribution near the alone plane capacitor $E_{\mathrm{v}y}^{\mathrm{s}}(r_{\mathrm{s}}, y_{\mathrm{s}})$ and evaluating (20), (27) and (31):

$$\begin{aligned}E_{\mathrm{A}}^{\mathrm{s}}(y_{\mathrm{s}}) &= E_{\mathrm{A}y}^{\mathrm{s}} = 2K_a K_M K_{12} E_{\mathrm{v}y}^{\mathrm{s}}(r_{\mathrm{s}}, y_{\mathrm{s}}) = \\ &= \pi[1-2m(r_{\mathrm{s}})]E_{\mathrm{v}y}^{\mathrm{s}}(r_{\mathrm{s}}, y_{\mathrm{s}}).\end{aligned} \qquad (32)$$

The distribution of field in the hole if $R_0=h$

The case, when the diameter of hole is equal to distance between plates is important for practice. In this case $r_{\mathrm{s}}=1$. Using the equations (6), (7) and (9) we calculated the relative values of field $E^{\mathrm{s}}_{\mathrm{v}y}(1,y_{\mathrm{s}})$ in plane $x_{\mathrm{s}}=r_{\mathrm{s}}=1$ for some values y_{s} of the interval [0,1]. The calculation results are presented in the table 1.

Table 1. The results of electric field strength calculation

y_{s}	0	0,1	0,2	0,3	0,4	0,5
$E^{\mathrm{s}}_{\mathrm{v}y}$	0,378	0,376	0,371	0,364	0,354	0,342
y_{s}	0,6	0,7	0,8	0,9	1	
$E^{\mathrm{s}}_{\mathrm{v}y}$	0,326	0,308	0,285	0,262	0,235	

The function $E_{\mathrm{v}y}^{\mathrm{s}}(1, y_{\mathrm{s}}) = E_{\mathrm{v}y}^{\mathrm{s}}(y_{\mathrm{s}})$, presented in the table 1, can be approximated with error less than 1% by expression:

$$E_{\mathrm{v}y}^{\mathrm{s}} = 0{,}378\cdot(1-0{,}378 y_{\mathrm{s}}^2). \qquad (33)$$

The field on the round hole axis can be calculated, using expression (32). If $R_0=h$, $r_s=1$, $\pi[1-2m(1)] = 2{,}098$.

Therefore

$$E_a^{s}(y_s) = 0{,}792\cdot(1-0{,}375y_s^2)\,. \qquad (34)$$

Putting this expression into equation (21), we obtain:

$$\begin{cases} E_y^{s}(x_s,y_s) = 0{,}792(1-0{,}375y_s^2+0{,}1875x_s^2), \\ E_x^{s}(x_s,y_s) = 0{,}792\cdot 0{,}375y_s x_s\,, \\ E^{s}(x_s,y_s) = 0{,}3\sqrt{(2{,}67-x_s^2+0{,}5y_s^2)^2+y_s^2x_s^2}\,. \end{cases} \qquad (35)$$

Using these expressions we can calculate the electric field strength in any point of hole.

Conclusions

1. The hole in the plane capacitor can be used as a valve controlled by electric field. It is important to know the distribution of field in the hole.

2. The strength of electric field can be calculated in any point of the round hole if the field distribution on the axis of hole is known.

3. The strength of electric field on the axis of hole can be calculated, as field on the axis of symmetry between two plane capacitors evaluating redistribution of charges on capacitor plates.

4. The field on the axis of symmetry between two plane capacitors can be calculated, using the well known field distribution near the plane capacitor.

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R. Bansevičius, J.A. Virbalis. Plokščiojo orinio kondensatoriaus kiaurymės elektrinis laukas // Elektronika ir elektrotechnika.- Kaunas: Technologija, 2004. – Nr. 2(51). – P. 20-24.

Kiaurymė plokščiajame kondensatoriuje gali būti naudojama konstruojant elektros lauku valdomus vožtuvus, todėl svarbu žinoti lauko pasiskirstymą joje. Orinio kondensatoriaus kiaurymėje lauką galima apskaičiuoti, naudojantis žinomu lauko pasiskirstymu plokščiojo kondensatoriaus krašte. Skaičiavimą patogiausia atlikti naudojant santykines koordinates, kaip realių koordinačių verčių santykį su puse kondensatoriaus storio, bei santykinius parametrus, kaip lauko verčių santykį su lauko verte kondensatoriaus viduje. Elektrinio lauko stiprį bet kuriame apvalios kiaurymės taške galima apskaičiuoti žinant lauko pasiskirstymą kiaurymės ašyje. Lauką kiaurymės ašyje galima apskaičiuoti, žinant tarpo tarp dviejų plokščiųjų kondensatorių simetrijos ašyje lauką. Šis laukas gali būti apskaičiuotas kaip abiejų kondensatorių kraštų laukų suma, padauginta iš dviejų faktorių: faktoriaus, vertinančio krūvio persiskirstymą šių kondensatorių plokštėse, bei faktoriaus, vertinančio skirtingą suminio lauko stiprio formavimą plokščiajame lygiagrečiajame ir ašinės simetrijos laukuose. Gautos abiejų šių faktorių išraiškos. Pateiktos suminio lauko ir jo dedamųjų bet kuriame kiaurymės taške išraiškos praktikai svarbiam atvejui, kai atstumas tarp kondensatoriaus plokščių lygus kiaurymės skersmeniui. Radialinė dedamoji aproksimuota tiesine priklausomybe, o vertikali dedamoji – kvadratine. Šis tyrimas bus tęsiamas sudėtingesniems atvejams. Il. 3, bibl. 2 (l anglų kalba; santraukos lietuvių, anglų ir rusų k.).

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The round hole in the plain capacitor can be applied for construction of the valves controlling by electric field. It is important to know distribution of electric field in the hole. The electric field in the round hole can be investigated using known distribution of field near the edge of plain capacitor. The investigation is performed using the relative coordinates as relations of values of real coordinates to the half thickness of capacitor and the relative parameters as relations the values of field to the value of field inside of the capacitor. The field in any point of hole can be calculated when the distribution on the axis of the hole is known. The field on the axis of hole can be calculated using the distribution on the axis of symmetry between two plain capacitors. This field is the superposition of the fields near the both capacitors, which must be multiplied by two coefficients: the coefficient which evaluates the change of distribution of the charges on the plates of capacitor and the coefficient which evaluates different mechanism of formation of total field in the plane parallel field and in the field with axial symmetry. The expressions of both factors are obtained. The expressions of total field and it components are obtained for the important in the practice case when the thickness of capacitor is equal to diameter of hole. The radial component is approximate by linear law and the vertical component – by parabolic law. Ill. 3, bibl. 2 (in English; summaries in Lithuanian, English and Russian).

Р. Бансявичюс, Ю.А. Вирбалис. Электрическое поле в круглом отверстии плоского воздушного конденсатора // Электроника и электротехника. – Каунас: Технология, 2004. – № 2(51). – С. 20-24.

Отверстие в плоском конденсаторе может быть применено для конструирования клапанов, управляемых электрическим полем, поэтому актуально знать, как в таком отверстии распределена напряженность электрического поля. В круглом отверстии поле может быть рассчитано, пользуясь хорошо известным распределением краевого поля плоского конденсатора. Расчет удобно делать, пользуясь отношением значений реальных координат к половине расстояния между платами конденсатора, и рассчитывая отношение напряженности поля в конкретной точке к значению напряженности внутри конденсатора. Электрическое поле в любой точке круглого отверстия можно рассчитать, зная распределение поля на оси отверстия. Поле на оси можно рассчитать, зная поле в середине между двумя плоскими конденсаторами с параллельными краями. Это поле может быть рассчитано как сумма краевых полей обоих конденсаторов, помноженная на два фактора: фактор, учитывающий перераспределение зарядов в платах конденсаторов, и фактор, учитывающий различный механизм образования суммарной напряженности в плоском параллельном и меридианном полей. Получены выражения обоих факторов. Представлены упрощенные выражения поля и их компонент для практически важного случая, когда расстояние между платами конденсатора равно диаметру отверстия. Радиальная составляющая аппроксимирована прямой зависимостью, а вертикальная – параболой. Ил. 3, библ. 2 (на английском языке; рефераты на литовском, английском и русском яз.).

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