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Design of the hidden device resonant multi-slit antenna used for vehicle Doppler speed meter radio-electronic repression

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Abstract: *Hidden device resonant multi-slit antenna used for vehicle Doppler speed meter radio-electronic repression designing stages are considered. ISKRA-1 is used as vehicle Doppler speed meter. Radar-detector Escort Passport 9500ix is used together with hidden device of radio-electronic repression. Imitation distraction interferences are generated for radio-electronic repression and well-known decision of the signal one coordinate elimination is used in the subject area didn't connected with the armed forces. Also designing is made taking into account the parameters that are applicable only during vehicles established speed limit monitoring.*

Keywords: *hidden device, resonant multi-slit antenna, vehicle Doppler speed meter, radar-detector, imitation distraction interferences.*

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Проектирование резонансной многощелевой антенны скрытного устройства радиоэлектронного подавления доплеровских измерителей скорости транспортных средств

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Аннотация: *Рассмотрены этапы проектирования резонансной многощелевой антенны скрытного устройства радиоэлектронного подавления доплеровских измерителей скорости транспортных средств. В качестве доплеровского измерителя скорости транспортных средств использован ИСКРА-1, совместно со скрытным устройством радиоэлектронного подавления использован радар-детектор Escort Passport 9500ix. Для радиоэлектронного подавления формируются ответные имитационные уводящие помехи и известное решение по устранению сигнала по одной из координат применяется в предметной области, не связанной с вооруженными силами. Также проектирование устройства формирования помех производится с учетом параметров, применимых лишь во время контроля установленного скоростного режима траснпортных средств.*

Ключевые слова: *скрытное устройство, резонансная многощелевая антенна, доплеровский измеритель скорости, радар-детектор, ответные иммитационные уводящие помехи.*

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1. Introduction

Not basing on the designing process it could be told that research object is the following: hidden device used for vehicle Doppler speed meter radio-electronic repression (further it would be called as repressor) located under the vehicle hood with length of X centimeters and weight of Y centimeters and can be represented as electromagnetic field generator energizing multi-split antenna executed as rectangular waveguide with specific dimensions (length, width and height) operating in H_{10} wave emitting mode.

As for multi-split antenna designing process is based on antenna designing which provides required directivity pattern or directivity coefficient and it consists of the following stages [1]:

1. Type of antenna and type of slits are made proceeding on required microwave range and required emitting field polarization;
2. Required amplitude-phase distribution is made;
3. Constructive estimation is made where the main role is splits energizing for required amplitude distribution providing;
4. Antenna electrical estimation is made (directivity pattern, directivity coefficient, Z_{IN} and etc.).

Let's separately specify each designing stage to estimate multi-split antenna missing parameters wherein strict estimation methods are connected with significant financial difficulties that's why their usage for engineering estimations is impossible and it means that approximate method appropriate for resonant multi-slit estimation should be used – power method.

2. Type of antenna and type of slits

For required emitting field polarization obtaining cruciform slits slotted in wide waveguide sides at a quarter of its width from the midline are used. For normal emitting maximum formation resonant multi-slit antenna in the form of lengthwise slits system located in chess order at half wavelength apart is used. Waveguide supplied with short-circuited piston in the end. Also for these slits matching possibility with feeder half-wave slits are used. Directivity pattern in the parallel to the waveguide axis plane has a directivity depended on slits quantity. Directivity coefficient is approximately equal to tripled slits quantity [2].

Multi-slit antenna slit width is chosen from electrical durability conditions (for transmitting antenna) and from required bandwidth (for receiving antenna) according to the following formula:

$$d_S = \frac{k_{RES} U_{MAX}}{E_{LIM}}, \qquad (1)$$

where $k_{RES} = 2{:}\,4$ – disruptive voltage reserve coefficient and the more it is the more is reserve that's why let be $k_{RES} = 4$;

$U_{MAX} = \sqrt{\frac{P_\Sigma}{G_\Sigma}}$ – slit center voltage amplitude;

P_Σ – slit emitting power;

G_Σ – slit emitting conductivity calculating in the following way:

$G_\Sigma \approx \frac{0{,}9 R_\Sigma}{7200\pi^2}$,

where $R_\Sigma = 73\ Ohm$ – half-wave symmetric equivalent vibrator emitting resistance referred to slit center current amplitude;

$E_{LIM} = 30\ kW/cm$ – field voltage limit value when electrical disruption is coming under air normal atmospheric conditions.

Let's find slit emitting power P_Σ taking into account reemitting with signal generated interference on the vehicle Doppler speed meter (further it would be called as meter) receiver input operating power – P_S [3]; taking into account wave fading coefficient in the meter waveguide taking into account waveguide length in the receiving side – α' [4]; taking into account meter horn-lens antenna gain coefficient using it as receiving one – D_{RCV} [4]; taking into account reemitting with signal generated interference distribution way losses – α_{DISTR} [5]:

$$P_\Sigma = P_S + \alpha' - D_{RCV} + \alpha_{DISTR} = (-130{,}4) + (-2{,}9) - 17{,}9 + 123{,}3$$
$$= -27{,}9\ dB = 10^{-2{,}79}\ W = 1620 \times 10^{-6}\ W. \ (2)$$

Let's find slit emitting conductivity G_Σ:

$$G_\Sigma \approx \frac{0{,}9 R_\Sigma}{7200\pi^2} = \frac{0{,}9 \times 73}{7200\pi^2} = 925 \times 10^{-6}\ W. \ (3)$$

Let's find slit width d_S:

$$d_S = \frac{k_{RES}\sqrt{\frac{P_\Sigma}{G_\Sigma}}}{E_{LIM}} = \frac{4\sqrt{\frac{1620 \times 10^{-6}}{925 \times 10^{-6}}}}{30 \times 10^3} = 1{,}76\ \mu m. \ (4)$$

In order to provide resonant multi-slit antenna construction manufacturability all slits width should be equal to $d_S = 1{,}76\ \mu m$.

For wide waveguide side half-wave lengthwise slit resonant length estimation let's used the following formula:

$$l_S = 2(l - \Delta l) = 2\left(l - \frac{0{,}225 l}{ln\frac{2\lambda_0}{\pi d}}\right) = 2\left(\frac{\lambda_0}{4} - \frac{0{,}225\frac{\lambda_0}{4}}{ln\frac{2\lambda_0}{\pi\frac{\lambda_0}{2}}}\right)$$

$$= 2\left(\frac{0{,}0124}{4} - \frac{0{,}225\frac{0{,}0124}{4}}{ln\frac{4}{\pi}}\right) = 425\ \mu m. \quad (5)$$

In order to provide resonant multi-slit antenna construction manufacturability lengthwise and slantwise (angle incline should not exceed 15^0 otherwise parasitic polarization emitting power exceed 1% from all emitting power) length of all slits (cruciform slits) should be equal to $l_S = 425\ \mu m$.

3. Required amplitude-phase distribution

Let be amplitude distribution along resonant multi-slit antenna as uniform one then slits equivalent conductivity can be found according to the following formula:

$$g'_n = \frac{1}{N}, \qquad (6)$$

where $N \approx \frac{G_S}{3}$ – slits quantity approximately equal to resonant multi-slit antenna directivity coefficient;

$G_S \approx G_{HL} = 138$ – let be resonant multi-slit antenna and horn-lens antenna directivity coefficients are the same [4].

4. Constructive estimation

Knowing resonant multi-slit antenna main maximum direction θ_m – normal ($\theta_{max} = 90^0, n = 0$), and its way of energizing – π, let's set maximum possible generator wave delay coefficient in the rectangle waveguide $\beta = \frac{\lambda}{\lambda_0} =$ $= 0{,}91 \rightarrow 1$ and let's find wave in waveguide to narrow waveguide ratio from the nomogram of the figure 1 in case of $\frac{\lambda_0}{a} = 1{,}82$ [2]:

Second stage conductivities provisioning should be made by slits displacement on wide waveguide side b at a quarter of its width from the midline x_n according to the following formula:

$$x_n = \frac{a}{\pi} arcsin\sqrt{\frac{g'_n}{g'_{max}}}, \qquad (7)$$

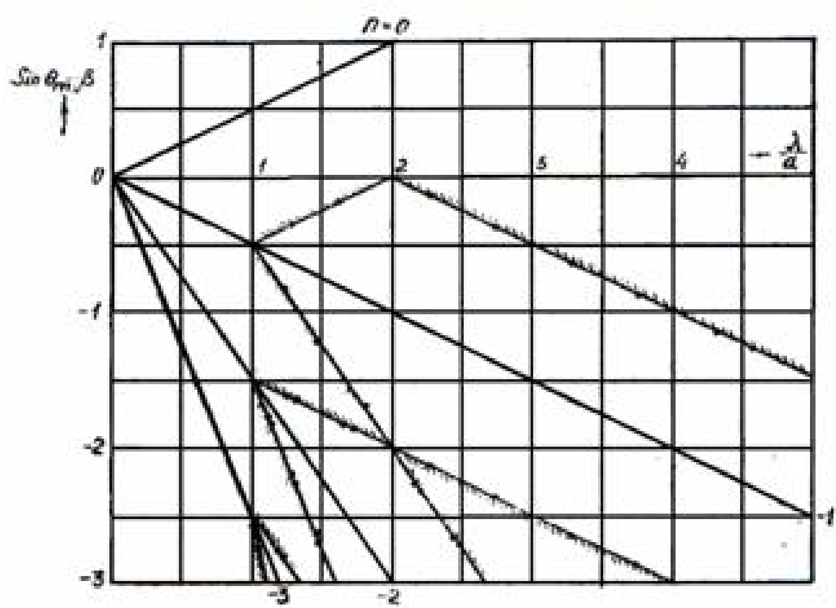

Fig. 1. Multi-slit antenna estimation nomogram for π way of energizing.

Рис. 1. Номограмма для расчета многощелевых антенн при π способе возбуждения

where $g'_{max} = 2{,}09\frac{a\beta}{b}cos^2\frac{\pi\beta}{2}$ from where based on (6) and wave in waveguide to narrow waveguide ratio $\frac{\lambda_0}{a}$ let's find the following formula for wide waveguide side b:

$$b = \frac{4\lambda_0}{1{,}82\pi} arcsin\sqrt{\frac{b}{N2{,}09\frac{\lambda_0\beta}{1{,}82b}cos^2\frac{\pi\beta}{2}}}. \quad (8)$$

Based on (8) we found that wide rectangular waveguide side is equal to $b = 0{,}006297\,m$ and narrow rectangular waveguide side is equal to $a = 0{,}006813\,m$ those even if maximum possible generator wave delay coefficient in rectangular waveguide is equal to $\beta = 0{,}91$ variant with wide side b and narrow side a of rectangular waveguide is impossible then let's use square waveguide with sides equaled to $a = b = \frac{(0{,}006813+0{,}006297)}{2} = 0{,}00656\,m$ for which wave delay coefficient is equal to $\beta' = 0{,}99277$.

Also resonant multi-slit antenna for its matching possibility with feeder is supplied with short-circuited piston in the end located from last slit center in the following distance $l_0 = (2n+1)\frac{\lambda_0}{4}$, where $n = 0$ those in the following distance $l_0 = 0{,}0031\ m$.

Final resonant multi-slit antenna length is the following:

$$L = dN + l_0 = \frac{0{,}0124 \times 46}{2} + 0{,}0031. \quad (9)$$

5. Antenna electrical estimation

Resonant multi-slit antenna with short-circuited piston in the end efficiency coefficient is closed to one those $n_S = 0{,}95$. Then resonant multi-slit antenna gain coefficient is equal to D_S and it can be found according to the following formula:

$$D_S = G_S n_S = 138 \times 0.95 = 131 = 21{,}2\ dB. \quad (10)$$

6. Conclusion

So device resonant multi-slit antenna used for vehicle Doppler speed meter radio-electronic repression designing process considered as completed one because all designing stages are considered and all missing antenna parameters are found.

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