Fermilab

$\bar{P}$ NOTE #356

CALCULATION OF IMPEDANCES AND SENSITIVITIES IN SUM AND DIFFERENCE MODES FOR 1-2 GHz AND 2-4 GHz PICKUP ELECTRODES

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I. Introduction

To better understand power absorption by the pickup (PU) electrodes, we calculated the characteristic impedances and sensitivities in both sum and difference modes for the 1-2 GHz and 2-4 GHz PU electrodes.[1] Since the design for the 1-2 GHz system essentially has been settled, our investigations are of more importance for the 2-4 GHz design which has not been finalized. One main feature of our results is that sum (Z_Σ) and difference (Z_Δ) mode impedances are not equal,

as is often assumed.

In our method, we numerically solve the 2-dimensional Laplace's equation to obtain the electric field and potential using the CERN-Poisson Program Package.[2] As shown in Fig. 1, the boundary conditions for a given PU geometry are $V=0$ on the walls, $V=+1$ on the top electrode, and $V=+1\ (-1)$ on the bottom electrode in the Σ (Δ) mode.

On a contour surrounding one of the PU electrodes, we apply the 2-dimensional Gauss' Law

$$\epsilon_0 \oint E_\perp \, dl = Q/m \left(\frac{\text{coulombs}}{\text{meter}}\right). \quad (1)$$

And since the capacitance/length is

$$C = \frac{Q/m}{V_{electrode}} \quad (2)$$

and $V_{electrode} = 1$, the characteristic impedance is

$$Z = \frac{1}{cC} = \frac{1}{cQ/m}. \quad (3)$$

We define Σ-mode sensitivity $s(0,0)$ as the potential $V(0,0)$ at the center of the PU geometry. Likewise, the Δ-mode sensitivity $d(0,0)$ is $E(0,0)/V_{electrode}/h$ and $E(0,0) = \sqrt{E_x^2 + E_y^2}\Big|_{(0,0)}$.

II. 1-2 GHz PU System

In Fig. 2, we show the geometry of the 1-2 GHz PU system. Our numerical analysis gives

$$Z_{\Sigma} = 108.5\ \Omega$$

$$s(0,0) = 0.853$$

$$Z_{\Delta} = 70.0\ \Omega$$

$$d(0,0) = 1.927$$

III. 2-4 GHz PU System

In this case, we considered a variety of geometries in an effort to increase power absorption in the Δ-mode. The present 2-4 GHz geometry is shown in Fig. 3. We tried different pocket widths w:

w (cm)	Z_Σ (Ω)	s(0,0)	Z_Δ (Ω)	d(0,0
3.0	96.6	0.593	82.7	1.58
3.5	102.3	0.625	85.0	1.62
4.0	105.7	0.652	85.5	1.66
4.5	106.6	0.674	84.5	1.69
5.0	109.1	0.693	84.8	1.71

Since Power $\propto d^2 Z_\Delta$, $w = 5.0$ cm absorbs 20% more power than $w = 3.0$ cm. We also tried increasing both the pocket depth to 2 cm and pocket width to 4 cm. For this configuration we obtained

$Z_\Sigma(\Omega)$	$s(0,0)$	$Z_\Delta(\Omega)$	$d(0,0)$
119.1	0.659	93.6	1.67

which gives a 26% or 1 dB improvement over the 1.25 x 3 cm geometry.

In summary, among the various 2-4 GHz designs we considered, the best for power absorption was the 2cm x 4cm geometry; however, none showed any significant dB gain.

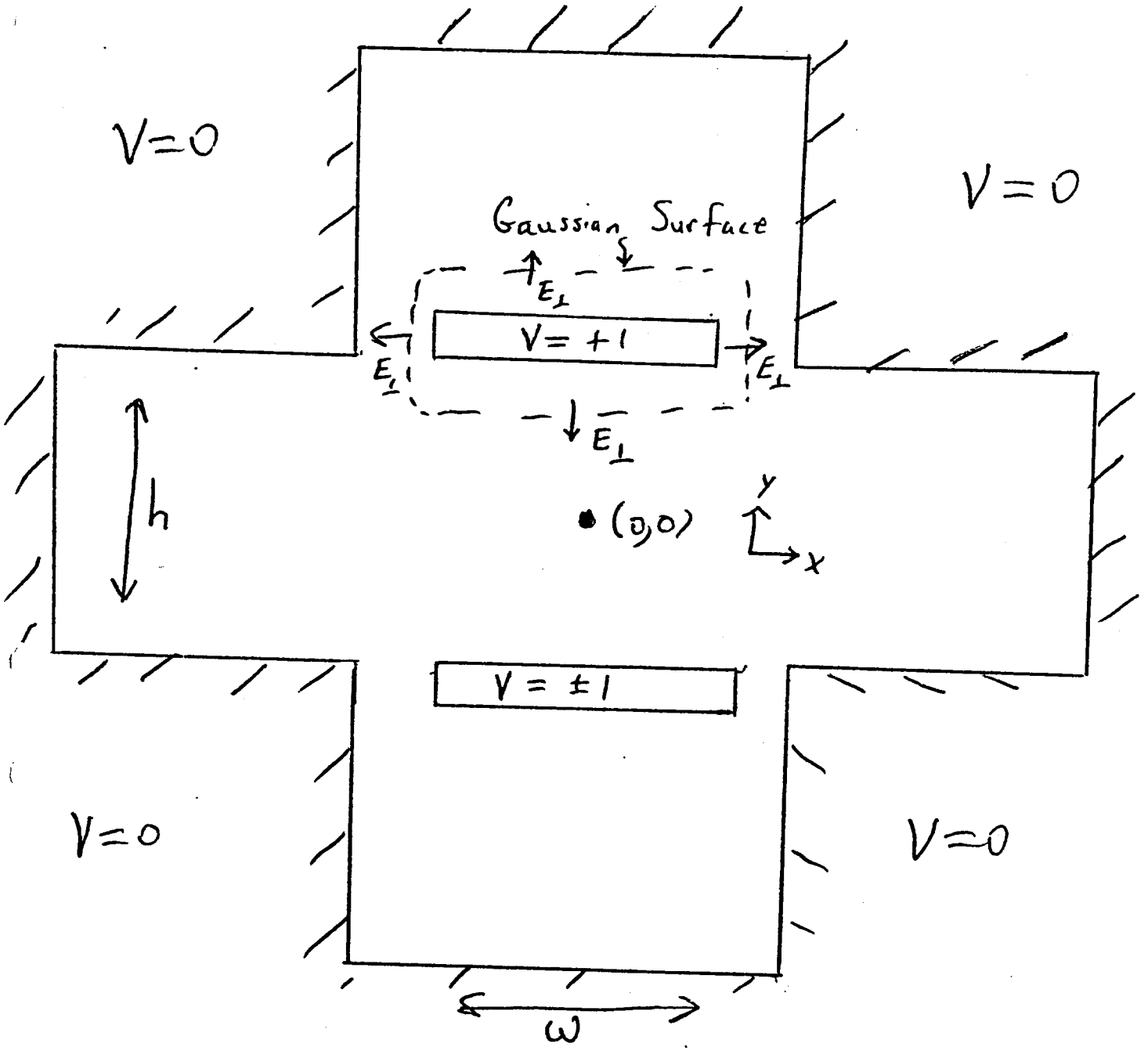

FIGURE 1

PU GEOMETRY

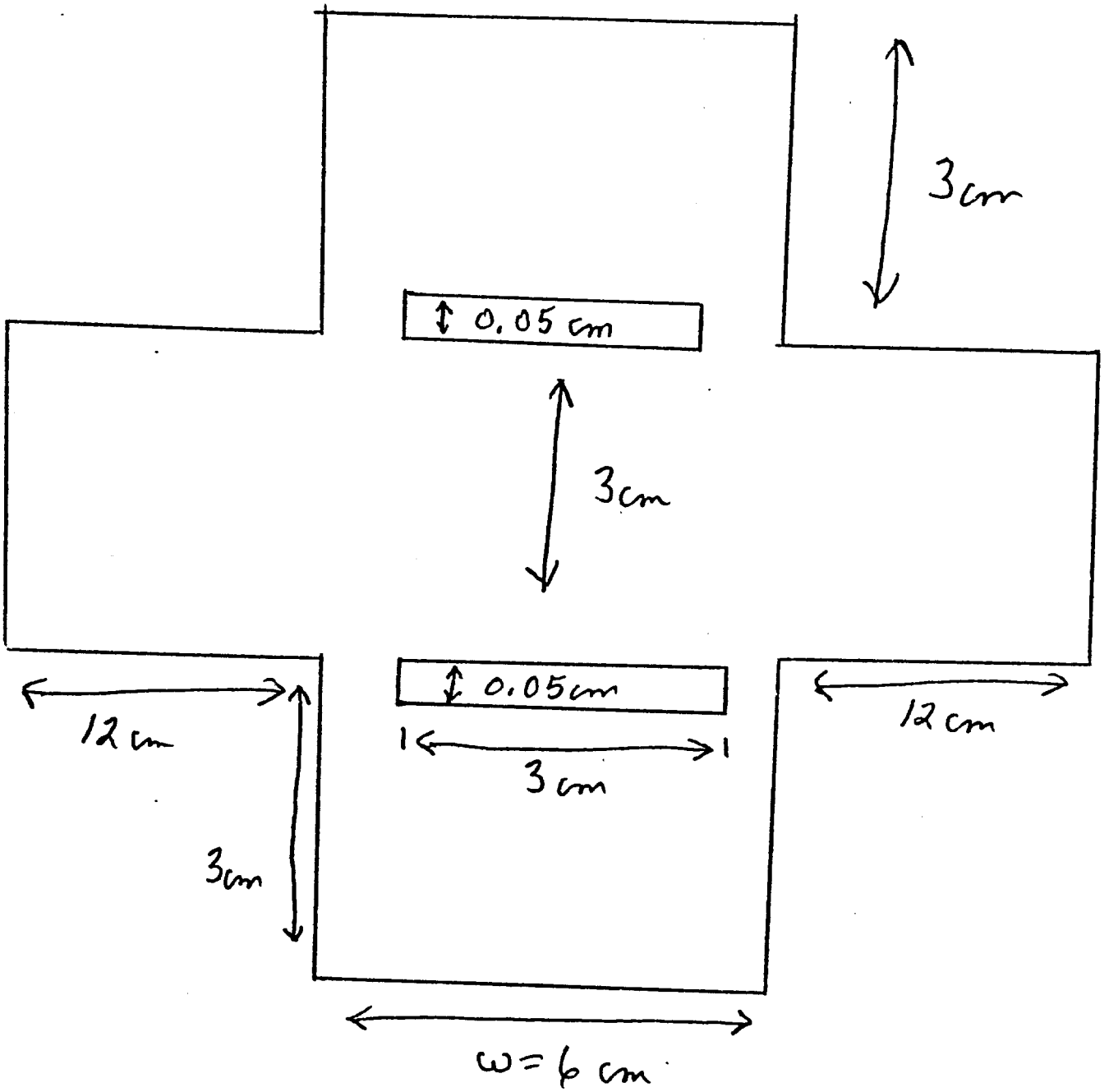

FIGURE 2

1-2 GHz GEOMETRY

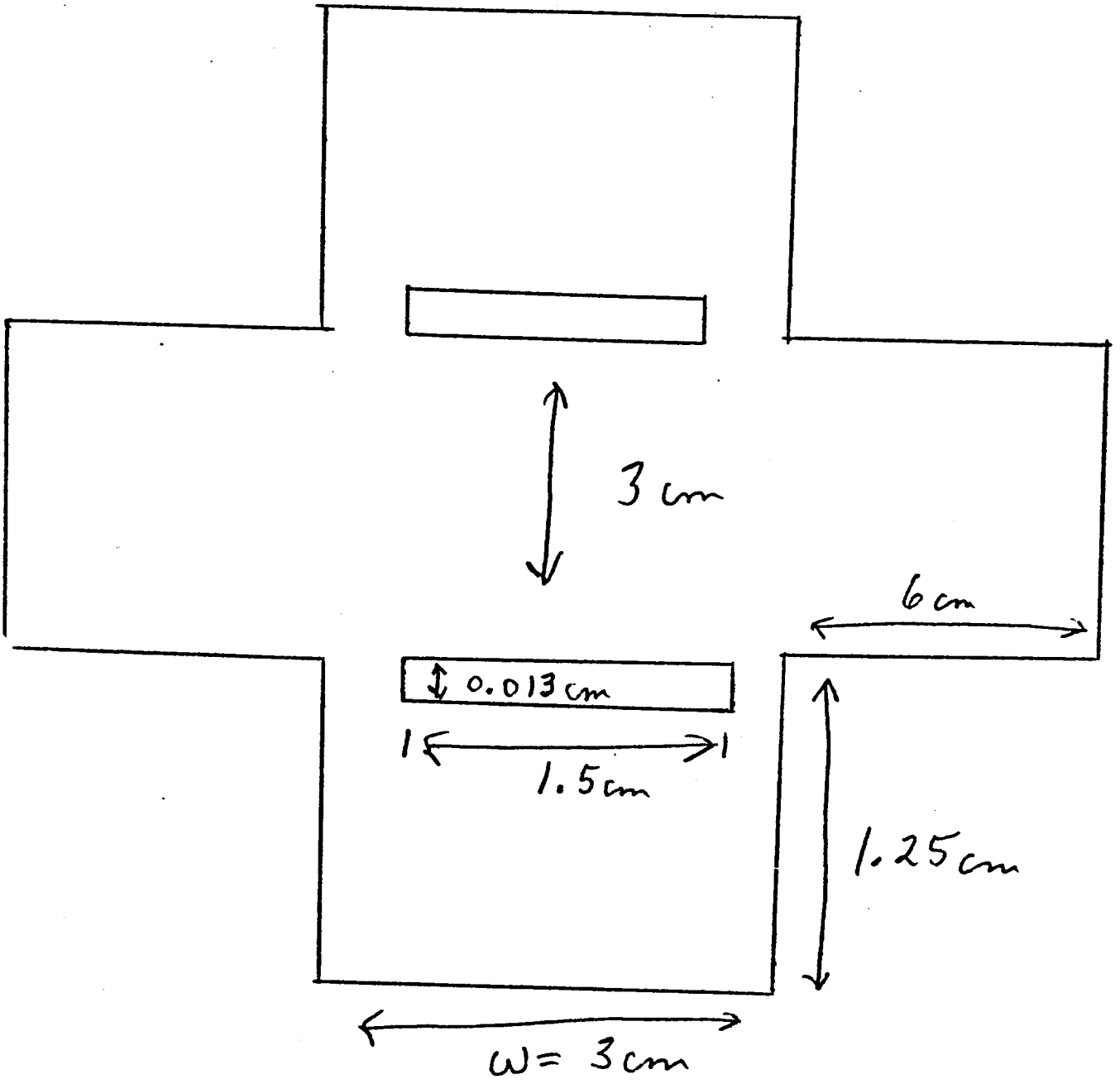

FIGURE 3

2-4 GHz GEOMETRY

Since Power $\propto d^2 Z_\Delta$, $w = 5.0$ cm absorbs 20% more power than $w = 3.0$ cm. We also tried increasing both the pocket depth to 2 cm and pocket width to 4 cm. For this configuration we obtained

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References

1. For previous results, see A. Ruggiero, $\bar{p}$ Notes #148 and #199; D. Neuffer, $\bar{p}$ Note #201; K. Takayama, $\bar{p}$ Note #264; H. Umstatter, unpublished (1982).

2. R. Holsinger and C. Iselin, The CERN-Poisson Program Package (POISCR-T604), CERN Computer Centre Program Library, 1982.