coil current. Calculated results for exposure system are very similar to those for the Merritt-coil system.

Although the uniform field volume obtained in ECS is slightly smaller than in the Merritt-coil system, the ECS is suitable for laboratory experiments. Calculated results were confirmed by the measurements.

5 Appendix

For a rectangular coil with side dimensions $2a$ and $2b$, as shown in Figure 7, the

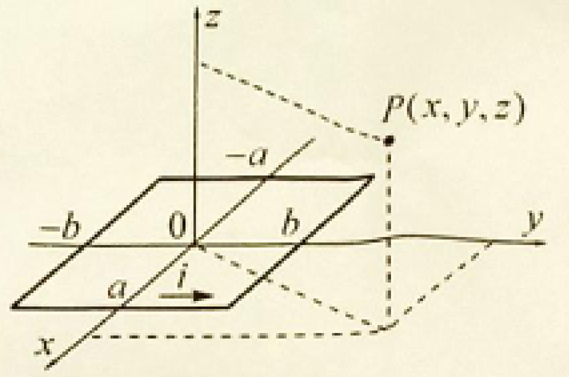

Fig. 7. Geometry for a single rectangular coil.

components of magnetic flux density vector at point $P(x,y,z)$ are

$y = \frac{f(x)}{g(x)} = f g^{-1}$

$y' = \frac{f'g - g'f}{g^2} = f'g^{-1} - \frac{g'f}{g^2}$

$$B_x = \frac{\mu_0 i}{4\pi}\sum_{k=1}^{k=4}\frac{(-1)^{k+1}z}{r_k(r_k+d_k)},$$

$$B_y = \frac{\mu_0 i}{4\pi}\sum_{k=1}^{k=4}\frac{(-1)^{k+1}z}{r_k(r_k+c_k)},$$

$$B_z = \frac{\mu_0 i}{4\pi}\sum_{k=1}^{k=4}(-1)^k\left(\frac{c_k}{r_k(r_k+d_k)}+\frac{d_k}{r_k(r_k+c_k)}\right),$$

$\frac{\partial r}{\partial x} = \frac{1}{2}(r)^{-\frac{1}{2}} . 2c = \frac{c}{\sqrt{r}}$

$\frac{\partial r}{\partial y} = \frac{1}{2} r^{-\frac{1}{2}} . 2d = \frac{d}{\sqrt{r}}$

where

$\frac{\partial c}{\partial x} = 1$

$\frac{\partial d}{\partial y} = 1$

$\frac{\partial r}{\partial z} = \frac{z}{\sqrt{r}}$

$$\begin{aligned}
c_1 &= x+a, & d_1 &= y+b, & r_1 &= \sqrt{(x+a)^2+(y+b)^2+z^2},\\
c_2 &= x-a, & d_2 &= y+b, & r_2 &= \sqrt{(x-a)^2+(y+b)^2+z^2},\\
c_3 &= x-a, & d_3 &= y-b, & r_3 &= \sqrt{(x-a)^2+(y-b)^2+z^2},\\
c_4 &= x+a, & d_4 &= y-b, & r_4 &= \sqrt{(x+a)^2+(y-b)^2+z^2}.
\end{aligned}$$

The expressions for more coils can be easily derived using superposition theorem, and replacing z with $(z-z_i)$, where z_i determines the position of the i-th coil. For ECS $a=b=d/2$.

$$\frac{\partial B_x}{\partial x} = \frac{\mu_0 i}{4\pi}\sum\left(\frac{(-1)^{k+1}\left(0-\left(\frac{\partial r}{\partial x}(r+d)+r\left(\frac{\partial r}{\partial x}\right)\right)z\right)}{r^2(r+d)^2}\right)$$

$$\frac{\partial B_x}{\partial y} = \frac{\mu_0 i}{4\pi}\sum\left(\frac{(-1)^{k+1}\left(0-\left(\frac{\partial r}{\partial y}(r+d)+r\left(\frac{\partial r}{\partial y}+1\right)\right)z\right)}{r^2(r+d)^2}\right.$$

$$\frac{\partial B_x}{\partial z} = \frac{\mu_0 i}{4\pi}\sum\left(\frac{(-1)^{k+1}\left(r(r+d)-1\left(\frac{\partial r}{\partial z}(r+d)+r\left(\frac{\partial r}{\partial z}\right)\right)z\right)}{r^2(r+d)^2}\right)$$

$$\frac{\partial B_z}{\partial x} = \frac{\mu_0 i}{4\pi}\sum(-1)^k\left(\frac{1(r)(r+d)-c\left(\frac{\partial r}{\partial x}(r+d)+r\left(\frac{\partial r}{\partial x}\right)\right)}{r^2(r+d)^2}+\frac{-d\left(\frac{\partial r}{\partial x}(r+c)+r\left(\frac{\partial r}{\partial x}+1\right)\right)}{r^2(r+c)^2}\right)$$

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$$\frac{\partial B_x}{\partial x} \propto \sum \frac{(-1)^{k+1}\left(-\frac{c}{\sqrt{r}}(r+d) - r\frac{c}{\sqrt{r}}\right) z}{r^2 (r+d)^2}$$

$$\frac{\partial B_x}{\partial y} \propto \frac{\sum (-1)^{k+1}\left(-\frac{d}{\sqrt{r}}(r+d) - r\left(\frac{d}{\sqrt{r}}+1\right)\right) z}{r^2 (r+d)^2}$$

$$\frac{\partial B_x}{\partial z} \propto \sum (-1)^{k+1} \frac{\left(r(r+d) + \left(-\frac{z}{\sqrt{r}}(r+d) - r\frac{z}{\sqrt{r}}\right) z\right)}{r^2 (r+d)^2}$$

$$\frac{\partial B_y}{\partial x} \propto \sum \frac{(-1)^{k+1}\left(-\frac{c}{\sqrt{r}}(r+c) - r\left(\frac{c}{\sqrt{r}}+1\right)\right) z}{r^2 (r+c)^2}$$

$$\frac{\partial B_y}{\partial y} \propto \frac{\sum (-1)^{k+1}\left(-\frac{d}{\sqrt{r}}(r+c) - r\left(\frac{d}{\sqrt{r}}\right)\right) z}{r^2 (r+c)^2}$$

$$\frac{\partial B_y}{\partial z} \propto \sum (-1)^{k+1} \frac{\left(r(r+c) + \left(-\frac{z}{\sqrt{r}}(r+c) - r\frac{z}{\sqrt{r}}\right) z\right)}{r^2 (r+c)^2}$$

$$\frac{\partial B_z}{\partial x} \propto \sum (-1)^{k} \left(\frac{r(r+d) + \left(\frac{-c}{\sqrt{r}}(r+d) - r\frac{c}{\sqrt{r}}\right) c}{r^2 (r+d)^2} + \frac{\left(-\frac{c}{\sqrt{r}}(r+c) - r\left(\frac{c}{\sqrt{r}}+1\right)\right) d}{r^2 (r+c)^2} \right)$$

$$\frac{\partial B_z}{\partial y} \propto \sum (-1)^{k} \left(\frac{\left(-\frac{d}{\sqrt{r}}(r+d) - r\left(\frac{d}{\sqrt{r}}+1\right)\right) c}{r^2 (r+d)^2} + \frac{r(r+c) + \left(-\frac{d}{\sqrt{r}}(r+c) - r\frac{d}{\sqrt{r}}\right) d}{r^2 (r+c)^2} \right)$$

$$\frac{\partial B_z}{\partial z} \propto \sum (-1)^{k} \left(\frac{\left(-\frac{z}{r}(r+d) - r\frac{z}{\sqrt{r}}\right) c}{r^2 (r+d)^2} + \frac{\left(-\frac{z}{r}(r+c) - r\frac{z}{\sqrt{r}}\right) d}{r^2 (r+c)^2} \right)$$