REPUBLIK INDONESIA
KEMENTERIAN HUKUM DAN HAK ASASI MANUSIA

SURAT PENCATATAN CIPTAAN

Dalam rangka pelindungan ciptaan di bidang ilmu pengetahuan, seni dan sastra berdasarkan Undang-Undang Nomor 28 Tahun 2014 tentang Hak Cipta, dengan ini menerangkan:

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Jenis Ciptaan : Program Komputer
Judul Ciptaan : MENGHITUNG REFLEKSI YANG HILANG DARI GELOMBANG ELEKTROMAGNETIK DARI MULTI LAPISAN BAHAN
Tanggal dan tempat diumumkan untuk pertama kali di wilayah Indonesia atau di luar wilayah Indonesia : 21 April 2018, di Jakarta
Jangka waktu pelindungan : Bertalu selama 50 (lima puluh) tahun sejak Ciptaan tersebut pertama kali dilakukan Pengumuman.
Nomor pencatatan : 000109841

adalah benar berdasarkan keterangan yang diberikan oleh Pemohon.
Surat Pencatatan Hak Cipta atau produk Hak terkait ini sesuai dengan Pasal 72 Undang-Undang Nomor 28 Tahun 2014 tentang Hak Cipta.

a.n. MENTERI HUKUM DAN HAK ASASI MANUSIA
DIREKTUR JENDERAL KEKAYAAN INTELEKTUAL

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According to transmission line theory, reflection loss (RL) ability were calculated and simulated on the electromagnetic data through the NRW formula of following equations.

\[
\text{Reflection Loss (dB)} = 20 \log \left[ \frac{(Z - 1)}{(Z + 1)} \right] \quad (1)
\]

\[
Z = \sqrt{\frac{\mu}{\varepsilon}} \tanh \left[ \left(-j2\pi f d / c \right) \sqrt{\mu \varepsilon} \right] \quad (2)
\]

where \( Z \) is characteristic impedance of samples, \( \varepsilon \) is complex relative permittivity \( (\varepsilon = \varepsilon' - j\varepsilon'') \) and \( \mu \) is complex relative permeability \( (\mu = \mu' - j\mu'') \), \( f \) is frequency of the electromagnetic wave, \( c \) is the light velocity and \( d \) is the thickness of the samples.

1. TEORI DASAR

   **A. Sample Preparation and Transmission Line Method**

Fig. 1 shows transmission line methods involve placing hexagonal ferrite material inside a portion of an enclosed transmission line. The transmission line used here is a section of rectangular waveguide for X-Band Applications. The complex relative permittivity \( (\varepsilon_r) \) and permeability \( (\mu_r) \) are then calculated for given thickness according to Nicolson-Ross-Weir (NRW) method from the measurement of the reflected signal \( (S11) \) and transmitted signal \( (S21) \). Hexagonal ferrite composite with sample holder (Fig. 1) is placed in a waveguide with width 22.86 mm, height 10.16 mm and thickness 2 mm. The complex-valued S-parameters are obtained by a vector network analyzer measurement (Fig. 2). The NRW method is then formulated using the following steps.
Firstly, for simplification we used the following number,

\[ K = \frac{(S_{11})^2 - (S_{21})^2 + 1}{2(S_{11})} \]  \hspace{1cm} (1)

Then, the reflection coefficient (\( \Gamma \)) is then given by

\[ \Gamma = K \pm \sqrt{K^2 - 1}, \quad |\Gamma| \leq 1, \] \hspace{1cm} (2)

and the transmission coefficient (T) is given by equation

\[ T = \frac{(S_{11}) + (S_{21}) + \Gamma}{1 - (S_{11} + S_{21}) \Gamma} \] \hspace{1cm} (3)

Finally the complex relative permeability and permittivity of hexagonal ferrite can be formulated by

\[ \mu = \frac{1 + \Gamma}{\Lambda(1 - \Gamma) \sqrt{\frac{1}{\lambda^2} - \frac{1}{\lambda^2_0}}} \] \hspace{1cm} (4)

\[ \varepsilon = \frac{\mu_0}{\mu} \left( \frac{1}{\lambda^2_0} - \left[ \frac{1}{2\pi d ln \left( \frac{1}{r} \right)} \right]^2 \right) \] \hspace{1cm} (5)
where $\lambda_0$ and $\lambda_c$ are the free space and the cutoff wavelength and with

$$\frac{1}{\lambda^2} = \left( - \left[ \frac{1}{2\pi d} \ln \left( \frac{d}{\lambda} \right) \right]^2 \right)$$  \hspace{1cm} (6)

By equating the equation (4) and (5), the relative complex permeability can be determined and hence the complex relative permittivity value.

The magnetic and electric loss tangent of a material is defined as

$$\tan \delta_m = \frac{\mu''}{\mu'}$$  \hspace{1cm} (7)

and

$$\tan \delta_c = \frac{\varepsilon''}{\varepsilon'}$$, \hspace{1cm} (8)

the greater the loss tangent of the material, the greater the attenuation as the wave travels through the material.

**B. S-Parameter Measurement**

Fig. 2 shows the measurement results of s parameters at frequencies ranging from 7 to 14 GHz. S11 is intensities level as a function of frequency. The results confirm that in the range 7 to 14 GHz, barium hexaferrite absorb the wave which have various reflection intensity. Its suggested from the reflection factor (S11) which has value between -10 dB to -15 dB. Further results show there is no transmission detected in the range of frequencies 7 up to 14 GHz. It can be understood from the transmission intensity which has value ranging from -20 to -25 GHz.

**C. Magnetic and Dielectric Properties**

With the measured S-parameters, the complex relative permeability and permittivity can be calculated by eq. (4) and (5). Fig. 3 shows the results. As we can see, the real part of the relative permeability changes significantly from about 60 at lower frequencies to about 5 at higher frequencies. We see also radical changes in imaginary part of the relative permeability. Which means, the magnetic losses are smaller at higher frequencies than at lower frequencies.
The real part of the relative permittivity, as given in Fig. 3, changes from about 7 at lower frequencies to about 3 at higher frequencies, whereas its imaginary part increases from lower frequency, then decreases again at higher frequencies.

Fig. 2. Results of measurement of the S-parameter of hexagonal ferrite

Fig. 3. Complex relative permeability and permittivity of hexagonal ferrite
MENGHITUNG REFLEKSI YANG HILANG DARI GELOMBANG ELEKTROMAGNETIK.

CODING PROGRAM :

```matlab
clc; clear;

for i=1:nLayer
    prm    = sprintf('Masukan nama file ke-%d',i);
    prompt = {prm};
    titlez = 'RL Program';
    dims   = [1 35];
    definput = {'1'};
    answer = inputdlg(prompt,titlez,dims,definput);

    namafile{i} = answer{1};
end

for i=1:nLayer
    [num,txt,raw] = xlsread(namafile{i});
    n             = length(raw);
```
allraw{i} = raw;

end

for i=1:length(allraw)
    zz = length(allraw{i});
    cc(i) = zz;
end

n_obs = min(cc);
n = n_obs;
% impedance of free space
z0 = 376.73;
c = 3e8;

for w = 2:n

    for vv = 1:nLayer
        f0(vv){w-1} = allraw{vv}{w,1}*1e9;
        all_d(vv){w-1} = allraw{vv}{2,6}*1e-2;
        m_real = allraw{vv}{w,2};
        m_imag = -(allraw{vv}{w,3});
        e_real = allraw{vv}{w,4};
        e_imag = -(allraw{vv}{w,5});
        m = complex(m_real, m_imag);
        e = complex(e_real, e_imag);
        allm2(w-1) = m;
        zc = z0 * sqrt(m/e);
        v = ((2 * pi * f0{vv}{w-1} )/c)*j) * sqrt(m*e);
        all_zc_0{vv} = zc;
        all_v_0{vv} = v;
    end
    all_zc_1{w-1} = all_zc_0;
    all_v_1{w-1} = all_v_0;
end

obs_ = 1;
yrl_ = 1;
for zzx = 1:nLayer
    for i = 1:length(all_zc_1)
        zcx(obs_,yrl_) = all_zc_1{i}{zxx};
        vx_(obs_,yrl_) = all_v_1{i}{zxx};
        obs_ = obs_ + 1;
    end
    yrl_ = yrl_ + 1;
    obs_ = 1;
end

zc = zcx;
v = vx_;  
for nmn = 1:length(all_d)  
d(nmn) =  all_d{nmn}{1};  
end

for j = 1:length(v)  
zin = 0;  
zin(1) = z0;  
    for i = 1:length(all_d)  
zin(i+1) = zc(j,i) * (((zin(i)  + zc(j,i) * tanh(v(j,i)*d(1))) / (zc(j,i)+ zin(i)  * tanh(v(j,i)*d(1))));  
     end  
    %     zin = zin(end);  
    %     all_zin(j) = zin;  
    RL = 20 * log10(abs((zin(end) - zin(1))/(zin(end) + zin(1))));  
    allRL(j) = RL;  
    allf(j)  = f0{1}{j};  
end

figure(1)  
plot(allf,allRL,'-or')  
title(judul)  
xlabel('frequency (Hz)')  
ylabel('reflection loss (dB)')  
grid on;

% zin(2) = zc(1,1) * (((zin(1)  + zc(1,1) * tanh(v(1,1)*d(1))) / (zc(1,1)+ zin(1)  * tanh(v(1,1)*d(1))));  
% zin(3) = zc(1,2) * (((zin(2)  + zc(1,2) * tanh(v(1,2)*d(1))) / (zc(1,2)+ zin(2)  * tanh(v(1,2)*d(1))));  
% zin(4) = zc(1,3) * (((zin(3)  + zc(1,3) * tanh(v(1,3)*d(1))) / (zc(1,3)+ zin(3)  * tanh(v(1,3)*d(1))));  

% %     zin2 = zc2 * (((zin1  + zc2 * tanh(v2*d2)) / (zc2 + zin1  * tanh(v2*d2))));  
    % for w = 1:n  
% %     zin_old = z0;  
% %     for r = 1:nLayer  
% %         zin = zc(w,r) * (((zin_old + zc(w,r) * tanh(v(w,r)*all_d{r}{1})) / (zc(w,r) + zin_old * tanh(v(w,r)*all_d{r}{1}) ))));  
% %         zin_old = zin;  
% %     allf(w)  = f0(r){j};  
% %     end  
%
RL = 20 * log10(abs((zin - z0)/(zin + z0)));
allRL(w) = RL;

z1 = zc1 * (((z0 + zc1 * tanh(v1*d1)) / (zc1 + z0 * tanh(v1*d1))));

z2 = zc2 * (((zin1 + zc2 * tanh(v2*d2)) / (zc2 + zin1 * tanh(v2*d2))));

RL = 20 * log10(abs((zin2 - z0)/(zin2 + z0)));
allRL(w-1) = RL;
allf(w-1) = f0_1;

HASIL PENGOLAHAN:

M-type and W-type

f0 = 1e12