Appendix

File to evaluate equation 2.17 for a single value

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%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%File to compute the self inductance of a coil next to a conductive sheet
syms x a bessel

L1=0.01;
r1 = 0.02;             % 0.003; % intern radius primary
r2 = 0.02+(0.00126*3); % 0.008; % extern radius primary
l1 = L                 % spacing between bottom of the coil and sheet primary
l2 = L1+0.00126;       % spacing between top of the coil and sheet primary
N  = 3;                % turn density of the primary

c =0.0003;             %thickness of the sheet

mu = pi*4e-7 ;
sigma1 = %50*10^3;      %sheet conductivity
sigma2 = 0;
omega = 2*pi*10*10^6 ;

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
a1 =(a.^2 + i*omega*sigma1*mu)^0.5 ;  % alpha 1
a2 = (a.^2 + i*omega*sigma2*mu)^0.5 ;  % alpha 2
K = (i*omega*pi*mu*N^2)./((l1-l2).^2 .* (r1-r2).^2 ) ;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
phi0 = ( (a-a1).*(a1-a2)+(a+a1).*(a2+a1).*exp(2.*a1.*c));
phi1 = ((a+a1).*(a1-a2)+(a-a1).*(a2+a1).*exp(2.*a1.*c))  ./ phi0;

phi2 =2*exp(-a.*(l2-l1)) - 2 +((exp(-2.*a.*l2)+exp(-2.*a.*l1)-2.*exp(-a.*(l2+l1))).* phi

phi3 = (2*(l2-l1)  +  (1./a).*phi2);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

```
%% besselj(1,Z) comptue de first order bessel function of the first kind in point z
xmin=a*r1 ;
xmax=a*r2 ;
amin = 0 ;
amax = 2000 ;

I = int( x.*besselj(1,x) ,x,xmin,xmax); %simple integration
result =int(K.*(1./a.^5).*(I.^2).*phi3, a, amin, amax)
vpa(result)  %inductance value of the coil next to the conductive sheet

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%SIMULATION PARAMETER USED FOR THE TEST COILS OF CHAPTER 1

%%parameter for Coil1 and coil2
% L1=0.01;
% r1 = 0.016;%0.003;    % intern radius primary
% r2 = 0.01723;% 0.008; % extern radius primary
% l1 = L1; % 0.01;      % spacing between bottom of the coil and sheet primary
% l2 = L1+(0.00126*4);  % 0.011;  % spacing between top of the coil and sheet primary
% N  = 4;               % turn density of the primary

%%parameter for Coil3
% L1=0.01;
% r1 = 0.02;               % intern radius primary
% r2 = 0.02+(0.00126*3);  % extern radius primary
% l1 = L1; % 0.01;         % spacing between bottom of the coil and sheet primary
% l2 = L1+0.00126;         % spacing between top of the coil and sheet primary
% N  = 3;                  % turn density of the primary
```

Evaluation of equation 2.19

```
%Mutual inductance calculation

syms R r a

R1 = 0.0245;                    % intern radius primary
R2 = 0.0255;                    % extern radius primary
L1=0.0004 ;  % 0.01;  % spacing between bottom of the coil and sheet primary
L2 = L1+0.001;                  % spacing between top of the coil and sheet primary
N  = 1;                         % turn density of the primary
```

```
c =0.0003;                    %thickness of the sheet

r1 = 0.00495;                 % intern radius secondary
r2 = 0.00505;                 % extern radius secondary
l1 = -(c+0.0003);             % spacing between bottom of the coil and sheet secondary
l2 = l1 -(0.001);             % spacing between top of the coil and sheet secondary
n  = 1;                       % turn density of the secondary



mu = pi*4e-7 ;                % mu air
sigma1 = 50*10^3;             % sheet conductivity
sigma2 = 0;                   % conductivity on the other side of the sheet
omega  = 2*pi*13.56*10^6 ;    % frequency current primary

%%

a1 = (a.^2 + i*omega*sigma1*mu)^0.5 ;     % alpha sheet

K = (2*pi*n*N*mu)./((l1-l2).* (r2-r1).*(L2-L1).*(R2-R1));

phi1 = exp(-a*L1) - exp(-a*L2);
phi2 = (1./a).*(exp(a*l1)-exp(a*l2));
phi3 = (2*a.*a1.*exp((a+a1).*c)) / ((a-a1).*(a1-a) + (a+a1).^2 .*exp(2*a1*c));

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

Rmin=a*R1 ;
Rmax=a*R2 ;

I1 = int( R.*besselj(1,R) ,R,Rmin,Rmax); %Bessel integration for primary

rmin=a*r1 ;
rmax=a*r2 ;

I2 = int( r.*besselj(1,r) ,r,rmin,rmax); %Bessel integration for secondary
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

amin = 0 ;
amax = 1000; % integration limit, supposed to be +infinity but convergence problem

result =int(1i*omega*K.*(1./a.^5).*I1.*I2.*phi1.*phi2.*phi3, a, amin, amax)
```

```
mutual = imag(vpa(result) )/omega
```

Power transfer efficiency plots of Chapter 2

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%Power transfer plot with 1-element and 2-elements matching for multiples Q values
clear all
close all
fvar = linspace(8*10^6,12*10^6,1000);
omegavar = 2*pi*fvar;
mu0 = 4*10^-7;
omega = 10^7*2*pi;

D = 0.8;            % dematching
L1 = D*5*10^-6;
L2 = D*1*10^-6;
C1 = 1./(omega^2*L1);
C2 = 1./(omega^2*L2);

RL = 10*10^3; %load
k = 0.05;
M = k*sqrt(L1*L2);

Q = D*[5,25, 50, 100, 200];
Z1 = zeros(5,1000);
Z2 = zeros(5,1000);
Pout = zeros(5,1000);
Pin = zeros(5,1000);
R1= omega*L1./(D*Q);
R2= omega*L2./(D*Q);
C2p = 1./(omega^2*L2) .* (1- sqrt((R2.*sqrt(1+Q.*Q*k^2))/RL));
C2s = 1./(omega^2*L2) .* (sqrt((R2.*sqrt(1+Q.*Q*k^2))/RL));

for t = 1:1:5
Z1(t,:) = 1./(1i*omegavar*C1) + 1i*L1*omegavar + R1(t); %impedance primary
%Z2(t,:) = 1./(1i*omegavar*C2 + 1./(1i*omegavar*L2 + R2(t))) + RL;     %impedance second
Z2(t,:) = 1./(1./(1i*omegavar*D*L2 + R2(t)) + 1i*omegavar*C2p(t))
                    + 1./1i*omegavar*C2s(t) + RL ; %impedance 2-elements matching second
Pout(t,:) = (abs((omegavar*M )./((Z1(t,:).*Z2(t,:))+omegavar.^2*M^2))).^2.* RL;
```

```
Pin(t,:) = real( Z2(t,:) ./ ((Z1(t,:).*Z2(t,:))+ omegavar.^2*M.^2));
end
figure
plot(10^-6*fvar, Pout(1,:)./Pin(1,:),'linewidth',2)
hold on
plot(10^-6*fvar, Pout(2,:)./Pin(2,:),'linewidth',2)
hold on
plot(10^-6*fvar, Pout(3,:)./Pin(3,:),'linewidth',2)
hold on
plot(10^-6*fvar, Pout(4,:)./Pin(4,:),'linewidth',2)
hold on
plot(10^-6*fvar, Pout(5,:)./Pin(5,:),'linewidth',2)
%legend('Q = 5', 'Q = 10 ', 'Q = 15', 'Q = 20','Q = 25', 'location','Northwest');
legend('Q = 5', 'Q = 25 ', 'Q = 50', 'Q = 100','Q = 200', 'location','Northwest');

xlabel('Frequency [MHz]');
ylabel('P_{load} / V_s^2');
title('k = 0.1 with 2-elements matching network')% and 50% variation of L_1 and L_2')


figure
plot(10^-6*fvar, Pin(1,:),'linewidth',2)
hold on
plot(10^-6*fvar, Pin(2,:),'linewidth',2)
hold on
plot(10^-6*fvar, Pin(3,:),'linewidth',2)
hold on
plot(10^-6*fvar, Pin(4,:),'linewidth',2)
hold on
plot(10^-6*fvar, Pin(5,:),'linewidth',2)


figure
plot(10^-6*fvar, Pout(1,:),'linewidth',2)
hold on
plot(10^-6*fvar, Pout(2,:),'linewidth',2)
hold on
plot(10^-6*fvar, Pout(3,:),'linewidth',2)
hold on
plot(10^-6*fvar, Pout(4,:),'linewidth',2)
hold on
plot(10^-6*fvar, Pout(5,:),'linewidth',2)
xlabel('Frequency [MHz]');
```

```
ylabel('P_{load} / V_s^2');
title('k = 0.1 with 2-elements matching network')% and 50% variation of L_1 and L_2')
```