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function [zabc,zabcn,yshabc,yshabcn,z012,ysh012] = network(db)
% this routine calculates primitive, three phase and positive sequence
% impedances and admittances for a general two-bus system
%% Load data
L=db(1);%section length
GMRf=db(2);%feet Skin Effect
rf=db(3);%ohm/mile
RDf=db(4);%inches
GMRn=db(5);%feet Skin Effect
rn=db(6);%ohm/mile
RDn=db(7);%inches
f=db(8);%Hz
rvd= db(9);%soil resistivity (ohm-m)
Dab=db(10);%feet
Dbc=db(11);%feet
Dac=db(12);%feet
Dcn=db(13);%feet
Dn =db(14);%feet
Dbn=db(15);%feet
Dan=db(16);%feet
hqa=db(17);%feet
hqb=db(18);%feet
hqc=db(19);%feet
hqn=db(20);%feet
%% Impedance calculation Simplified Carson approach
eta=1.6093;%1 mile = 1.6093 km
re=(pi/4)*4*eta*pi*f*0.0001;%ground resistance
w=2*pi*f;%angular frequency rad/seg
De=2160*sqrt(rvd/f);%equivalent diameter
mu0=4*pi*eta/10000;%H/mile
i=sqrt(-1);
%% Primitive series impedance matrix calculation [zabcn]
zp(1,1)=rf+w*mu0/8+i*((mu0*w/(2*pi))*(log(De/(GMRf))));%ohm/mile
zp(2,2)=rf+w*mu0/8+i*((mu0*w/(2*pi))*(log(De/(GMRf))));%ohm/mile
zp(3,3)=rf+w*mu0/8+i*((mu0*w/(2*pi))*(log(De/(GMRf))));%ohm/mile
zp(4,4)=(rn+re+sqrt(-1)*(mu0*f*(log(2160*sqrt(rvd/f)*inv(GMRn)))));%ohm/mile
zp(1,2)=w*mu0/8+i*((mu0*w/(2*pi))*(log(De/(Dab))));%ohm/mile
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zp(1,3)=w*mu0/8+i*((mu0*w/(2*pi))*(log(De/(Dac))));%ohm/mile
zp(1,4)=w*mu0/8+i*((mu0*w/(2*pi))*(log(De/(Dan))));%ohm/mile
zp(2,3)=w*mu0/8+i*((mu0*w/(2*pi))*(log(De/(Dbc))));%ohm/mile
zp(2,4)=w*mu0/8+i*((mu0*w/(2*pi))*(log(De/(Dbn))));%ohm/mile
zp(3,4)=w*mu0/8+i*((mu0*w/(2*pi))*(log(De/(Dcn))));%ohm/mile
zp(2,1)=zp(1,2);%ohm/mile
zp(3,1)=zp(1,3);%ohm/mile
zp(4,1)=zp(1,4);%ohm/mile
zp(3,2)=zp(2,3);%ohm/mile
zp(4,2)=zp(2,4);%ohm/mile
zp(4,3)=zp(3,4);%ohm/mile
zabcn=zp*L;%ohm [4x4 Primitive series impedance matrix]
zij=[zabcn(1,1) zabcn(1,2) zabcn(1,3);zabcn(2,1) zabcn(2,2) zabcn(2,3);zabcn(3,1) zabcn(3,2) zabcn(3,3)];%ohm
zin=[zabcn(1,4);zabcn(2,4);zabcn(3,4)];%ohm
znj=[zabcn(4,1) zabcn(4,2) zabcn(4,3)];%ohm
znn=zabcn(4,4);%ohm
zabc=(zij-zin*inv(znn)*znj);%Kron's reduction (%ohm) [3x3 Three-phase series impedance matrix]
a=-0.5+j*sqrt(3)*.5;
As=[1 1 1;1 a^2 a; 1 a a^2];
z012=inv(As)*zabc*As;%ohm
z=z012(2,2);%ohm [Positive sequence series impedance]
%% Primitive shunt admittance matrix calculation [yshabcn]
S(1,1)=(hqa)*2;%feet
S(2,2)=(hqa)*2;%feet
S(3,3)=(hqa)*2;%feet
S(4,4)=(hqn)*2;%feet
S(1,2)=sqrt((hqa)*2+Dab*2);%feet
S(1,3)=sqrt((hqa)*2+(Dab+Dbc)*2);%feet
S(2,3)=sqrt((hqa)*2+(Dbc)*2);%feet
S(1,4)=sqrt((hqn+hqa)+(Dab+Dbc-Dn)*2);%feet
S(2,4)=sqrt((hqn+hqa)+(Dbc-Dn)*2);%feet
S(3,4)=sqrt((hqn+hqa)+(Dn)*2);%feet
P(1,1)=11.17689*log(S(1,1)/(RDf/12));%mile/microF
P(2,2)=11.17689*log(S(2,2)/(RDf/12));%mile/microF
P(3,3)=11.17689*log(S(3,3)/(RDf/12));%mile/microF
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P(4,4)=11.17689*log(S(4,4)/(RDn/12));%mile/microF
P(1,2)=11.17689*log(S(1,2)/Dab);%mile/microF
P(1,3)=11.17689*log(S(1,3)/Dac);%mile/microF
P(2,3)=11.17689*log(S(2,3)/Dbc);%mile/microF
P(1,4)=11.17689*log(S(1,4)/Dan);%mile/microF
P(2,4)=11.17689*log(S(2,4)/Dbn);%mile/microF
P(3,4)=11.17689*log(S(3,4)/Dcn);%mile/microF
P(2,1)=P(1,2);%mile/microF
P(1,3)=P(1,3);%mile/microF
P(3,2)=P(2,3);%mile/microF
P(4,1)=P(1,4);%mile/microF
P(4,2)=P(2,4);%mile/microF
P(4,3)=P(3,4);%mile/microF
C=inv(P);%microF/mile
yshabcn=(2*pi*f*C*0.000001*L)*i;%siemens [4x4 Primitive shunt admittance matrix]
yij=[yshabcn(1,1) yshabcn(1,2) yshabcn(1,3);yshabcn(2,1) yshabcn(2,2) yshabcn(2,3);yshabcn(3,1) yshabcn(3,2) yshabcn(3,3)];
yin=[yshabcn(1,4);yshabcn(2,4);yshabcn(3,4)];
ynj=[yshabcn(4,1) yshabcn(4,2) yshabcn(4,3)];
ynn=yshabcn(4,4);
yshabc=yij-yin*inv(ynn)*ynj;%Kron's reduction (siemens) [3x3 Three-phase shunt admittance matrix]
a=-0.5+j*sqrt(3)*.5;
As=[1 1 1;1 a^2 a; 1 a a^2];
ysh012=imag(inv(As)*yshabc*As)*i;%siemens
ysh=ysh012(2,2);%ohm [Positive sequence shunt admittance]
end
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