

Fundamentals of Power Electronics
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Lecture - 79
Area products and mfiles

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Area products

1. Push pull converter -
$$A_p = \frac{\sqrt{2} \cdot P_o \left(1 + \frac{1}{\eta}\right)}{4 \cdot K_w \cdot J \cdot B_m \cdot f_s}$$
2. Half bridge converter -
$$A_p = \frac{P_o \left(\sqrt{2} + \frac{1}{\eta}\right)}{4 \cdot K_w \cdot J \cdot B_m \cdot f_s}$$
3. Full bridge converter -
$$A_p = \frac{P_o \left(\sqrt{2} + \frac{1}{\eta}\right)}{4 \cdot K_w \cdot J \cdot B_m \cdot f_s}$$

We discussed 3 converters; push pull converter, the half bridge converter and the full bridge converter. How do we design the transformers for this converters? We go by the area convert area product method we have discussed the area product method and then we use it to design the forward converter and we had developed generic area product equation. Using the generic area product equation we can find out the area product the push pull, I will give you the final derived formula for the push pull converter area product is equal to root 2 P naught 1 plus 1 by efficiency. Here efficiency is taken to be 0.8 first case.

So, efficiency will always be better than 0.8 and the denominator you have 4 K window factor J current density which is 3 into 10 to the power of 6 ampere meter square B m for ferrites its point 2 for the transformer point 2 Tesla and then fs the switching frequency.

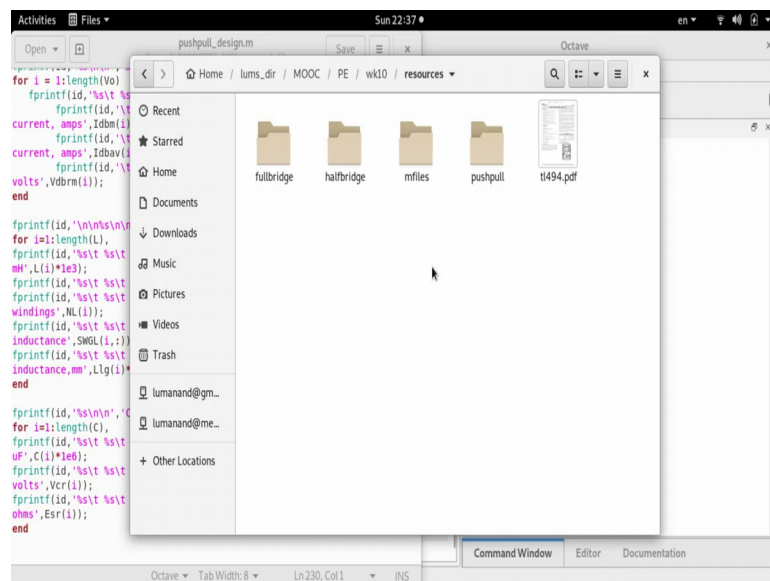
So, this is the area product for the push pull converter. If you use the same generic formula and then plugin the voltage and the power voltage and power into the generic

equation, that is a half cycle average voltage you will get this. Likewise for the half bridge converter; half bridge converter transformer also the area product I will be providing you, here derived along same lines P naught into root 2 plus 1 by efficiency 1 by 0.8 divided by 4 K w J B m and f s.

The full bridge converter half bridge converter the transformers are very similar and the voltage wave shape across the primary and the current through them are all similar and therefore, you will have a similar area product equation. The difference of course, will come in the actual values the currents and the amplitude of the voltage. So, this is the area product for the full bridge converter.

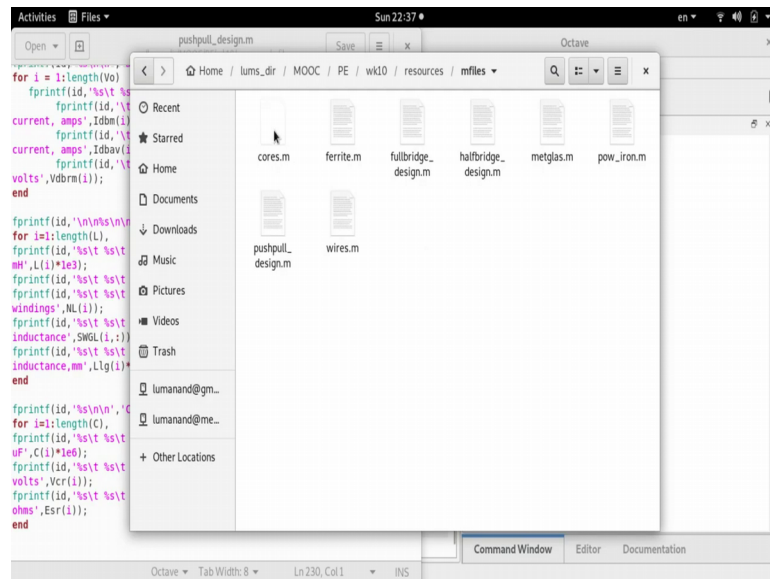
So, you can try to derive these and verify them by using the same generic method, for deriving the area products. That we discussed for the forward converter as an example and also the low frequency AC 50 Hertz transformers to. So, use all these transformers have the same generic basis.

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Let us now look at some m-files for designing the push pull converter the half bridge converter and the full bridge converter.

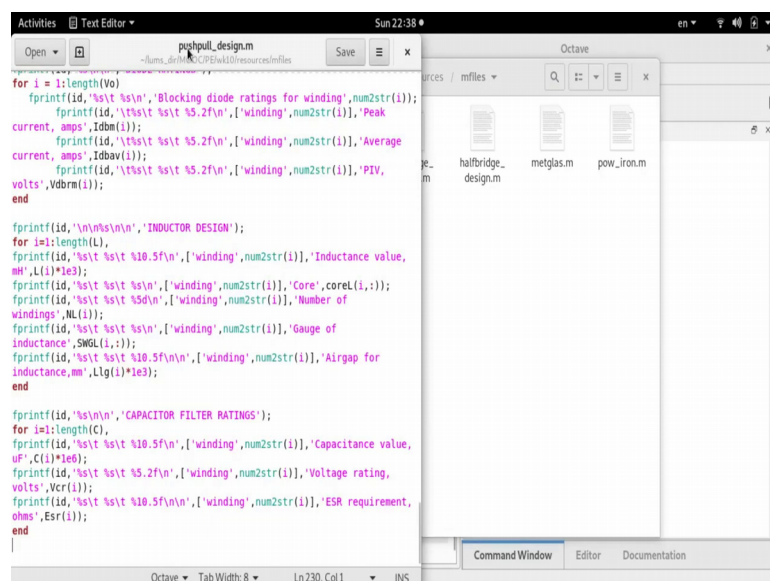
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So, I have in the resources section a folder called mfiles within that like for the forward converter, we have some common mfiles that is a course, the ferrite, the ferrite course, the metglas core powder iron core and there is another m file on wire wires and wire gauges. So, these are common for all the converter design in the sense that they are data bases of the course and the wires.

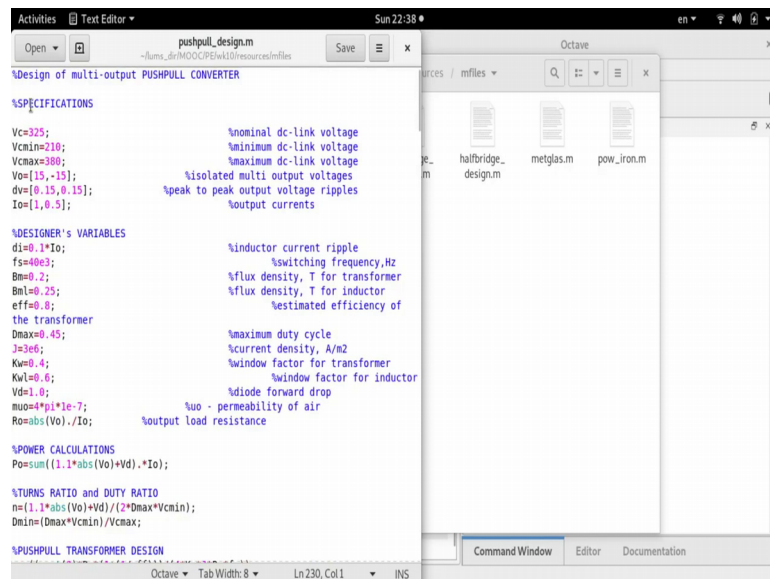
You have 3 design files; one is the pushpull design dot m half bridge design dot m and the fullbridge design dot m and these are the design mfiles which you can run and they will make use of this course for right wires and other core and wire detail a details from these other mfiles. So, let me look at let me open the pushpull.

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So, you see that here you have the pushpull design dot mfile.

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```
%Design of multi-output PUSH PULL CONVERTER

%SPECIFICATIONS
Vc=325; %nominal dc-link voltage
Vcmin=210; %minimum dc-link voltage
Vcmax=380; %maximum dc-link voltage
Vo=[15,-15]; %isolated multi output voltages
dv=[0.15,0.15]; %peak to peak output voltage ripples
Io=[1,0.5]; %output currents

%DESIGNER'S VARIABLES
di=0.1*Io; %inductor current ripple
fs=40e3; %switching frequency,hz
Bm=0.2; %flux density, T for transformer
Bml=0.25; %flux density, T for inductor
eff=0.8; %estimated efficiency of
the transformer
Dmax=0.45; %maximum duty cycle
j=3e6; %current density, A/m2
Kw=0.4; %window factor for transformer
Kwl=0.6; %window factor for inductor
Vd=1.0; %diode forward drop
muo=4*pi*1e-7; %muo - permeability of air
Ro=abs(Vo)./Io; %output load resistance

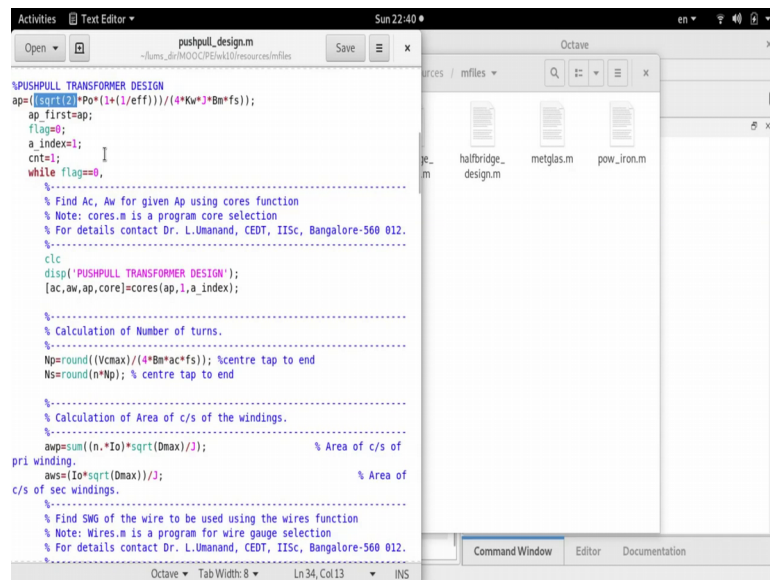
%POWER CALCULATIONS
Pos=sum(1.1*abs(Vo)+Vd).*Io);

%TURNS RATIO and DUTY RATIO
n=[1.1*abs(Vo)+Vd]/(2*Dmax*Vcmin);
Dmin=(Dmax+Vcmin)/Vcmax;

%PUSH PULL TRANSFORMER DESIGN
```

And it has a specification section as specified some things observe here V naught is having is a vector of 2 elements which means it is a isolated multi output. There are two ORed secondaries. You have the delta v ripple and 1 amp and 0.5 amps for the 2 different outputs. And you have the set of designer variables and switching at 40 kilo Hertz here 0.2 Tesla for transformer flux density maximum 0.25 Tesla for inductors, D_{max} of 0.45 which I have taken 3 amp per mm square or 3 into 10 to the power of 6 ampere meter square for the current density and window factors I have chosen like this.

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```
%PUSHPULL TRANSFORMER DESIGN
ap=(sqrt(12)*Po*(1+(1/eff)))/(4*Kw*Bm*fs));
ap_first=ap;
flag=0;
a_index=1;
cnt=1;
while flag==0,
%-----
% Find Ac, Aw for given Ap using cores function
% Note: cores.m is a program core selection
% For details contact Dr. L.Umanand, CEDT, IISc, Bangalore-560 012.
%-----
clc;
disp('PUSHPULL TRANSFORMER DESIGN');
[ac,aw,ap,core]=cores(ap,1,a_index);

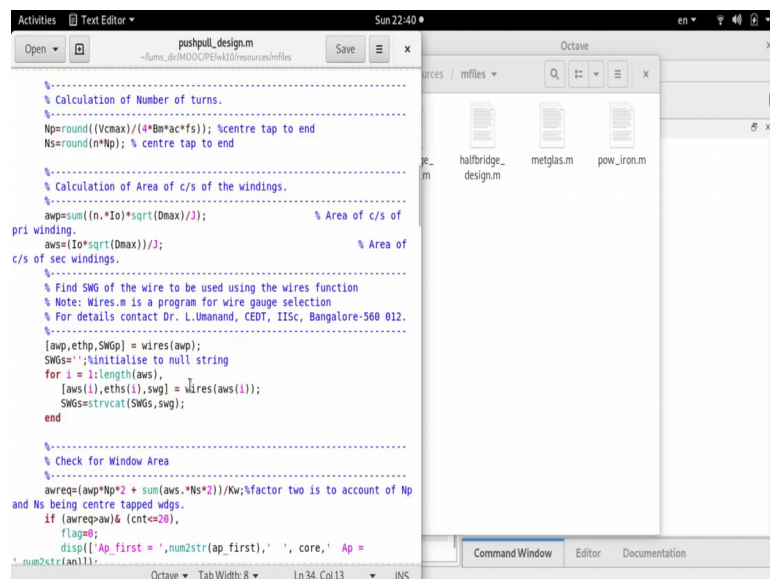
%-----
% Calculation of Number of turns.
Np=round((Vcmax)/(4*Bm*ac*fs)); %centre tap to end
Ns=round(n*Np); % centre tap to end

%-----
% Calculation of Area of c/s of the windings.
%-----
aws=um(n.*Io)*sqrt(Dmax)/J); % Area of c/s of
pri winding,
aws=(Io*sqrt(Dmax))/J); % Area of
c/s of sec windings.
%-----
% Find SWG of the wire to be used using the wires function
% Note: Wires.m is a program for wire gauge selection
% For details contact Dr. L.Umanand, CEDT, IISc, Bangalore-560 012.
%-----
[awp,ethp,SWG]=wires(awp);
SWG='';%initialise to null string
for i = 1:length(aws),
[aws(i),eths(i),svg]=wires(aws(i));
SWG=strvcat(SWG,svg);
end

%-----
% Check for Window Area
%-----
awreq=(awp*Np^2 + sum(aws.*Ns^2))/Kw;%factor two is to account of Np
and Ns being centre tapped wdgs.
if (awreq>aw) & (cnt<=20),
flag=0;
disp(['Ap_first = ',num2str(ap_first),' ', core,' Ap =
',num2str(an1)]);
```

So, there is the power calculation and after you do the power calculation the terms ratio calculation and this is where it will be different from the forward transformer design which is a pushpull transformer. The area product of the pushpull transformer I have taken it according to the area product of the pushpull that I have just listed down. And the part of the design is similar to that in the forward converter where we call the core.

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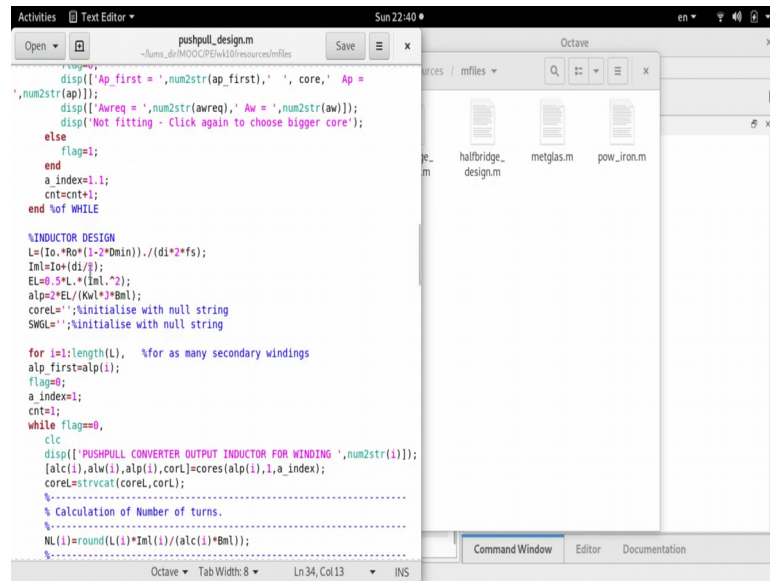
```
%-----
% Calculation of Number of turns.
%-----
Np=round((Vcmax)/(4*Bm*ac*fs)); %centre tap to end
Ns=round(n*Np); % centre tap to end

%-----
% Calculation of Area of c/s of the windings.
%-----
aws=um(n.*Io)*sqrt(Dmax)/J); % Area of c/s of
pri winding,
aws=(Io*sqrt(Dmax))/J); % Area of
c/s of sec windings.
%-----
% Find SWG of the wire to be used using the wires function
% Note: Wires.m is a program for wire gauge selection
% For details contact Dr. L.Umanand, CEDT, IISc, Bangalore-560 012.
%-----
[awp,ethp,SWG]=wires(awp);
SWG='';%initialise to null string
for i = 1:length(aws),
[aws(i),eths(i),svg]=wires(aws(i));
SWG=strvcat(SWG,svg);
end

%-----
% Check for Window Area
%-----
awreq=(awp*Np^2 + sum(aws.*Ns^2))/Kw;%factor two is to account of Np
and Ns being centre tapped wdgs.
if (awreq>aw) & (cnt<=20),
flag=0;
disp(['Ap_first = ',num2str(ap_first),' ', core,' Ap =
',num2str(an1)]);
```

And the core selects the core and then wires for selecting the wire gauges and cross check the design.

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```
disp(['Ap_first = ',num2str(ap_first),' ', core,' Ap = ',num2str(ap)]);
disp(['Awreq = ',num2str(awreq),' Aw = ',num2str(aw)]);
disp('Not fitting - Click again to choose bigger core');
else
    flag=1;
end
a_index=1;
cnt=cnt+1;
end %of WHILE

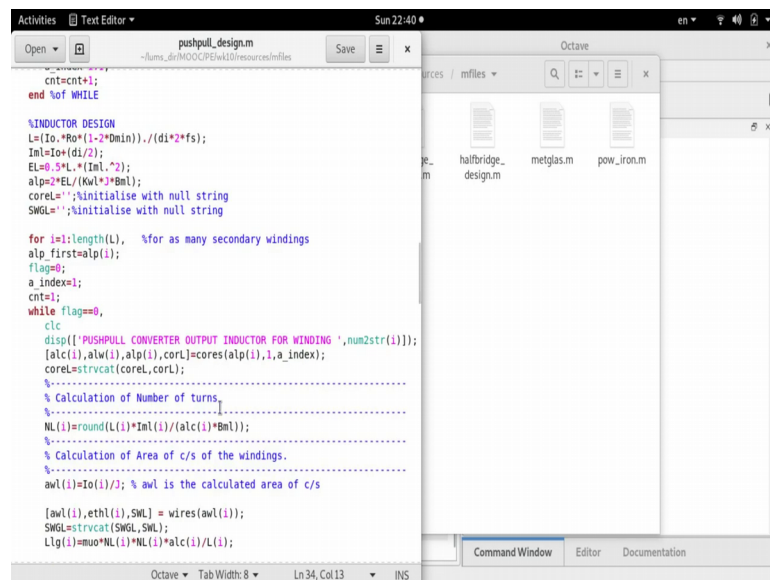
%INDUCTOR DESIGN
L=(Io.*Ro*(1-2*Dmin))./(di.*2*fs);
ImL=Io*(di/2);
EL=0.5*L.*(ImL.^2);
alp=2*EL/(KwL.*BmL);
coreL='';%initialise with null string
SWGL='';%initialise with null string

for i=1:length(L), %for as many secondary windings
    alp_first=alp(i);
    flag=0;
    a_index=1;
    cnt=1;
    while flag==0,
        clc
        disp(['PUSHPULL CONVERTER OUTPUT INDUCTOR FOR WINDING ',num2str(i)]);
        [alc(i),alw(i),alp(i),corL]=cores(alp(i),1,a_index);
        coreL=strvcat(coreL,corL);
        %-----
        % Calculation of Number of turns.
        %-----
        NL(i)=round(L(i)*ImL(i)/(alc(i)*BmL));
        %-----

        [awL(i),eth(i),SWL] = wires(awL(i));
        SWGL=strvcat(SWGL,SWL);
        Llg(i)=muo*NL(i)*NL(i)*alc(i)/L(i);
```

Then you have the inductors; inductors for every output mm isolated output we have 2 isolated output. So, 2 times it has to be done. So, inductor value calculation followed by energy calculation.

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```
cnt=cnt+1;
end %of WHILE

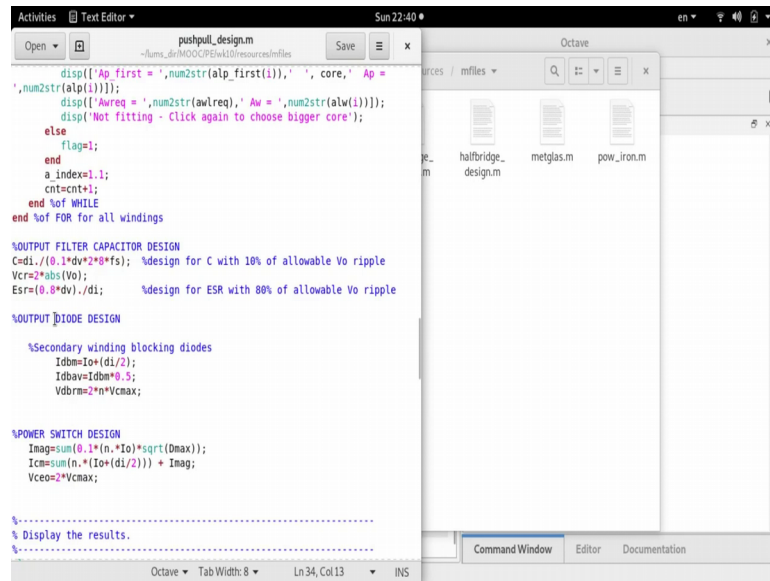
%INDUCTOR DESIGN
L=(Io.*Ro*(1-2*Dmin))./(di.*2*fs);
ImL=Io*(di/2);
EL=0.5*L.*(ImL.^2);
alp=2*EL/(KwL.*BmL);
coreL='';%initialise with null string
SWGL='';%initialise with null string

for i=1:length(L), %for as many secondary windings
    alp_first=alp(i);
    flag=0;
    a_index=1;
    cnt=1;
    while flag==0,
        clc
        disp(['PUSHPULL CONVERTER OUTPUT INDUCTOR FOR WINDING ',num2str(i)]);
        [alc(i),alw(i),alp(i),corL]=cores(alp(i),1,a_index);
        coreL=strvcat(coreL,corL);
        %-----
        % Calculation of Number of turns.
        %-----
        NL(i)=round(L(i)*ImL(i)/(alc(i)*BmL));
        %-----
        % Calculation of Area of c/s of the windings.
        %-----
        awL(i)=Io(i)/3; % awL is the calculated area of c/s

        [awL(i),eth(i),SWL] = wires(awL(i));
        SWGL=strvcat(SWGL,SWL);
        Llg(i)=muo*NL(i)*NL(i)*alc(i)/L(i);
```

Then the selection of the core from the course function file and then the wires from the wires function file.

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```
disp(['Ap first = ',num2str(alp_first(i)), ' ', core,' Ap = ',num2str(alp(i))]);
disp(['Avreq = ',num2str(awlreq),' Av = ',num2str(alw(i))]);
disp('Not fitting - Click again to choose bigger core');
else
    flag=1;
end
a_index=1;
cnt=cnt+1;
end %of WHILE
end %of FOR for all windings

%OUTPUT FILTER CAPACITOR DESIGN
C=d1./(0.1*dv*2*0*fs); %design for C with 10% of allowable Vo ripple
Vcr=2*abs(Vo);
Esr=(0.0*dv)./di; %design for ESR with 80% of allowable Vo ripple

%OUTPUT DIODE DESIGN

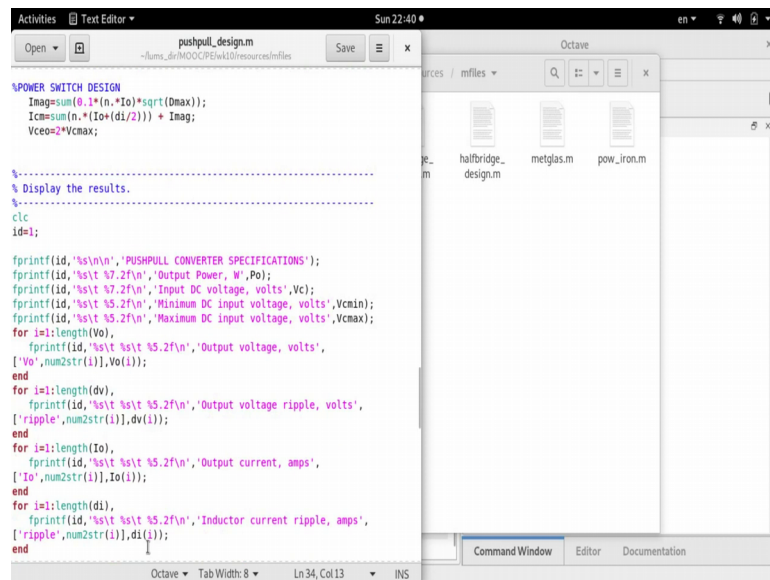
%Secondary winding blocking diodes
Idbm=Io*(di/2);
Idbav=Idbm*0.5;
Vdbrm=2*n*Vcmax;

%POWER SWITCH DESIGN
Imag=sum(0.1*(n.*Io)*sqrt(Dmax));
Icmsum(n.*(Io+(di/2))) + Imag;
Vceo=2*Vcmax;

%-----
% Display the results.
%-----
```

Then you have the design of the capacitors the output diodes power switch and then finally, to display the results.

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```
%POWER SWITCH DESIGN
Imag=sum(0.1*(n.*Io)*sqrt(Dmax));
Icmsum(n.*(Io+(di/2))) + Imag;
Vceo=2*Vcmax;

%-----
% Display the results.
%-----
clc
id=1;

fprintf(id,'s\n\n','PUSHPULL CONVERTER SPECIFICATIONS');
fprintf(id,'s\t %7.2f\n','Output Power, W',Po);
fprintf(id,'s\t %7.2f\n','Input DC voltage, volts',Vc);
fprintf(id,'s\t %5.2f\n','Minimum DC input voltage, volts',Vcmin);
fprintf(id,'s\t %5.2f\n','Maximum DC input voltage, volts',Vcmax);
for i=length(Vo)
    fprintf(id,'s\t %5.2f\n','Output voltage, volts',
    ['Vo',num2str(i)],Vo(i));
end
for i=length(dv),
    fprintf(id,'s\t %5.2f\n','Output voltage ripple, volts',
    ['ripple',num2str(i)],dv(i));
end
for i=length(Io),
    fprintf(id,'s\t %5.2f\n','Output current, amps',
    ['Io',num2str(i)],Io(i));
end
for i=length(di),
    fprintf(id,'s\t %5.2f\n','Inductor current ripple, amps',
    ['ripple',num2str(i)],di(i));
end
```

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```
%Design of multi-output PUSHPULL CONVERTER

%SPECIFICATIONS
Vc=325; %nominal dc-link voltage
Vcmin=210; %minimum dc-link voltage
Vcmax=380; %maximum dc-link voltage
Vo=[15,-15]; %isolated multi output voltages
dv=[0.15,0.15]; %peak to peak output voltage ripples
Io=[1,0.5]; %output currents

%DESIGNER'S VARIABLES
di=0.1*Io; %inductor current ripple
fs=40e3; %switching frequency
Bm=0.2; %flux density, T for transformer
Bml=0.25; %flux density, T for inductor
eff=0.8; %estimated efficiency
Dmax=0.45; %maximum duty cycle
J=3e6; %current density, A/m2
Kw=0.4; %window factor for transformer
Kwl=0.6; %window factor for inductor
Vd=1.0; %diode forward drop
muo=4*pi*1e-7; %mu - permeability of air
Ro=abs(Vo)./Io; %output load resistance

%POWER CALCULATIONS
P=sum((1.1*abs(Vo)+Vd).*Io);

%TURNS RATIO and DUTY RATIO
n=(1.1*abs(Vo)+Vd)/(2*Dmax*Vcmin);
Dmin=(Dmax*Vcmin)/Vcmax;

%PUSHPULL TRANSFORMER DESIGN
```

So, this is the pushpull design, I have given the specification here you can go into octave or even matlab for that matter go into the respective folder resource folder I already have and I have here full bridge half bridge and pushpull. So, you type in pushpull design and it will ask for the type of the core material I am going to choose 1 which is Ferrite and then it will ask for the shape of the core material I am going to choose EE.

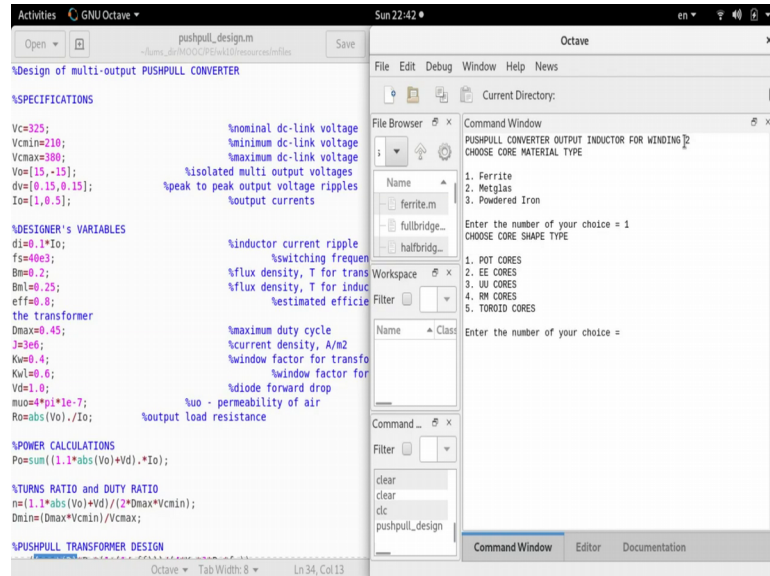
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```
Ap_first = 2.1752e-09 E25/09/06 Ap = 3.12e-09
Awreq = 0.0901095 Aw = 7.8e-05
Not fitting - CLICK again to choose bigger core
PUSHPULL TRANSFORMER DESIGN
CHOOSE CORE MATERIAL TYPE
1. Ferrite
2. Metglas
3. Powdered Iron
Enter the number of your choice = 1
CHOOSE CORE SHAPE TYPE
1. POT CORES
2. EE CORES
3. UU CORES
4. RM CORES
5. TOROID CORES
Enter the number of your choice =
```

And I am going to choose 2 and you see here the area product calculated and then the window area cross check is not fitting. So, again you will have to choose the next bigger

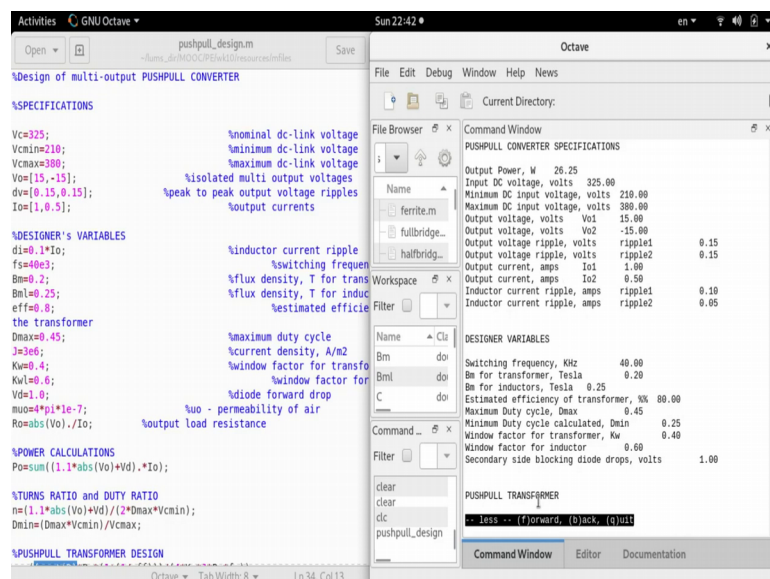
size core you can change the material if you want, but I will strict to ferried go ahead with ferried and the EE core.

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Let it choose the next higher one, it has chosen then it has gone for inductor a winding 1 I will choose Ferrite and EE CORE to keep the same inventory list, then inductor for winding 2 again you choose ferrite and I am choosing EE core.

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And then that is it the calculations are done and the results are displayed, you have the pushpull converter specifications then the designer variables.

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```
%Design of multi-output PUSH PULL CONVERTER

%SPECIFICATIONS
Vc=325; %nominal dc-link voltage
Vcmin=210; %minimum dc-link voltage
Vcmax=380; %maximum dc-link voltage
Vo=[15,-15]; %isolated multi output voltages
dvc=[0.15,0.15]; %peak to peak output voltage ripples
Io=[1,0.5]; %output currents

%DESIGNER'S VARIABLES
di=0.1*Io; %inductor current ripple
fs=40e3; %switching frequency
Bm=0.2; %flux density, T for transformer
Bml=0.25; %flux density, T for inductor
eff=0.8; %estimated efficiency
Dmax=0.45; %maximum duty cycle
J=3e6; %current density, A/m2
Kw=0.4; %window factor for transformer
Kwl=0.6; %window factor for inductor
Vd=1.0; %diode forward drop
muo=4*pi*1e-7; %muo - permeability of air
Ro=abs(Vo)/Io; %output load resistance

%POWER CALCULATIONS
Pos=sum((1.1*abs(Vo)+Vd).*Io);

%TURNS RATIO and DUTY RATIO
n=(1.1*abs(Vo)+Vd)/(2*Dmax*Vcmin);
Dmin=(Dmax*Vcmin)/Vcmax;

%PUSH PULL TRANSFORMER DESIGN
```

Command Window

| | |
|---|-----------|
| Primary VA | 32.81 |
| Secondary VA | 26.25 |
| Core | E25/13/07 |
| Number of windings in centre tapped primary, Np | 432 |
| Gauge of Np | SWG 35 |
| Number of windings in centre tapped secondary, Ns 1 | 40 |
| Gauge of Ns 1 | SWG 24 |
| Number of windings in centre tapped secondary, Ns 2 | 40 |
| Gauge of Ns 2 | SWG 27 |

POWER SWITCH RATINGS

| | |
|---------------------------------------|--------|
| Maximum continuous current, Icm, amps | 0.16 |
| Maximum off state voltage drop | 769.09 |

DIODE RATINGS

| | |
|--------------------------------------|-------|
| Blocking diode ratings for winding 1 | |
| winding1 Peak current, amps | 1.05 |
| winding1 Average current, amps | 0.53 |
| winding1 PIV, volts | 79.37 |
| Blocking diode ratings for winding 2 | |
| winding2 Peak current, amps | 0.53 |
| winding2 Average current, amps | 0.26 |
| winding2 PIV, volts | 79.37 |

INDUCTOR DESIGN

| | |
|---------------------------|-----------|
| Inductor value, mH | 0.94243 |
| Core | E25/09/06 |
| Number of windings | 99 |
| Gauge of inductance | SWG 22 |
| Airgap for inductance, mm | 0.52274 |
| Inductor value, mH | 1.88487 |
| Core | E28/18/05 |
| Number of windings | 128 |
| Gauge of inductance | SWG 25 |
| Airgap for inductance, mm | 0.33862 |

Then followed by the POWER SWITCH RATINGS diode ratings, inductor design.

(Refer Slide Time: 08:12)

```
%Design of multi-output PUSH PULL CONVERTER

%SPECIFICATIONS
Vc=325; %nominal dc-link voltage
Vcmin=210; %minimum dc-link voltage
Vcmax=380; %maximum dc-link voltage
Vo=[15,-15]; %isolated multi output voltages
dvc=[0.15,0.15]; %peak to peak output voltage ripples
Io=[1,0.5]; %output currents

%DESIGNER'S VARIABLES
di=0.1*Io; %inductor current ripple
fs=40e3; %switching frequency
Bm=0.2; %flux density, T for transformer
Bml=0.25; %flux density, T for inductor
eff=0.8; %estimated efficiency
Dmax=0.45; %maximum duty cycle
J=3e6; %current density, A/m2
Kw=0.4; %window factor for transformer
Kwl=0.6; %window factor for inductor
Vd=1.0; %diode forward drop
muo=4*pi*1e-7; %muo - permeability of air
Ro=abs(Vo)/Io; %output load resistance

%POWER CALCULATIONS
Pos=sum((1.1*abs(Vo)+Vd).*Io);

%TURNS RATIO and DUTY RATIO
n=(1.1*abs(Vo)+Vd)/(2*Dmax*Vcmin);
Dmin=(Dmax*Vcmin)/Vcmax;

%PUSH PULL TRANSFORMER DESIGN
```

Command Window

INDUCTOR DESIGN

| | |
|------------------------------------|-----------|
| winding1 Inductance value, mH | 0.94243 |
| winding1 Core | E25/09/06 |
| winding1 Number of windings | 99 |
| winding1 Gauge of inductance | SWG 22 |
| winding1 Airgap for inductance, mm | 0.52274 |
| winding2 Inductance value, mH | 1.88487 |
| winding2 Core | E28/18/05 |
| winding2 Number of windings | 128 |
| winding2 Gauge of inductance | SWG 25 |
| winding2 Airgap for inductance, mm | 0.33862 |

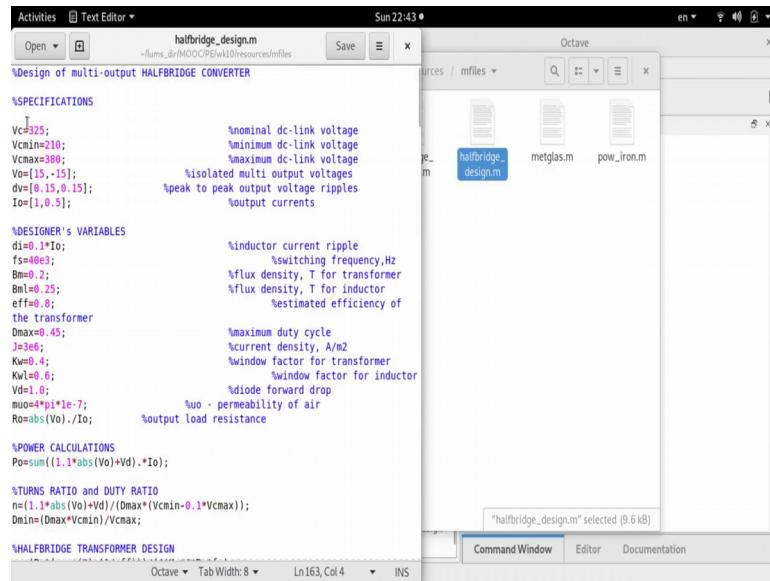
CAPACITOR FILTER RATINGS

| | |
|--------------------------------|----------|
| winding1 Capacitance value, uF | 10.41667 |
| winding1 Voltage rating, volts | 30.000 |
| winding1 ESR requirement, ohms | 1.20000 |
| winding2 Capacitance value, uF | 5.20833 |
| winding2 Voltage rating, volts | 30.000 |
| winding2 ESR requirement, ohms | 2.40000 |

Inductor design with its core, air gap all those things capacitor filter rating and everything that is needed for rigging up the converter.

So, the pushpull converter design is designed in this fashion, I will allow you to play around with this specification and look into the equations and try to get more insight into the multi output push pull converter mfile.

(Refer Slide Time: 08:44)



```
Activities | Text Editor | Sun 22:43 | en |
halbridge_design.m
- /home_darMOOCPE/wk10/resources/mfiles

%Design of multi-output HALFBRIDGE CONVERTER

%SPECIFICATIONS
Vc=325; %nominal dc-link voltage
Vcmin=210; %minimum dc-link voltage
Vcmax=380; %maximum dc-link voltage
Vo=[15,-15]; %isolated multi output voltages
dv=[0.15,0.15]; %peak to peak output voltage ripples
Io=[1,0.5]; %output currents

%DESIGNER'S VARIABLES
di=0.1*Io; %inductor current ripple
fs=40e3; %switching frequency,Hz
Bm=0.2; %flux density, T for transformer
Bml=0.25; %flux density, T for inductor
eff=0.8; %estimated efficiency of
the transformer
Dmax=0.45; %maximum duty cycle
J=3e6; %current density, A/m2
Kw=0.4; %window factor for transformer
Kwl=0.6; %window factor for inductor
Vd=1.0; %diode forward drop
muo=pi*1e-7; %mu - permeability of air
Ro=abs(Vo)./Io; %output load resistance

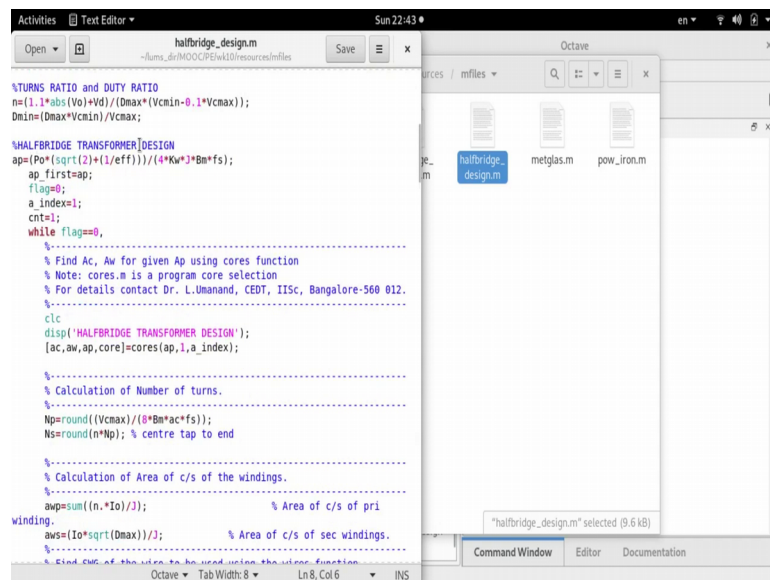
%POWER CALCULATIONS
Po=sum((1.1*abs(Vo)+Vd).*Io);

%TURNS RATIO and DUTY RATIO
n=(1.1*abs(Vo)+Vd)/(Dmax*(Vcmin-0.1*Vcmax));
Dmin=(Dmax*Vcmin)/Vcmax;

%HALFBRIDGE TRANSFORMER DESIGN
```

Likewise, I have the half bridge design m file, you can look into that also. I have kept the same specifications and so, that you can compare. Slightly I have changed the output specs, but otherwise I have essentially kept the same simplification.

(Refer Slide Time: 09:06)



```
Activities | Text Editor | Sun 22:43 | en |
halbridge_design.m
- /home_darMOOCPE/wk10/resources/mfiles

%TURNS RATIO and DUTY RATIO
n=(1.1*abs(Vo)+Vd)/(Dmax*(Vcmin-0.1*Vcmax));
Dmin=(Dmax*Vcmin)/Vcmax;

%HALFBRIDGE TRANSFORMER DESIGN
ap=(Po*(sqrt(2)*(1/eff)))/(4*Kw*Bm*fs);
ap_first=ap;
flag=0;
a_index=1;
cnt=1;
while flag==0
%-----
% Find Ac, Aw for given Ap using cores function
% Note: cores.m is a program core selection
% For details contact Dr. L.Umanand, CEDT, IISc, Bangalore-560 012.
%-----
clc
disp('HALFBRIDGE TRANSFORMER DESIGN');
[ac,aw,ap,core]=cores(ap,1,a_index);

%-----
% Calculation of Number of turns.
Np=round((Vcmax)/(8*Bm*ac*fs));
Ns=round(Np); % centre tap to end

%-----
% Calculation of Area of c/s of the windings.
awp=sum((n.*Io)/J); % Area of c/s of pri
winding
aws=(Io*sqrt(Dmax))/J; % Area of c/s of sec windings.
%-----
% Find cmc of the wire to be used using the wire function
```

Here also everything is same except for the half bridge transformer design, the area product which this equation will change just like as I have listed shortly a while back.

(Refer Slide Time: 09:24)

```
fprintf(id, '\t%s\t %s\t %5.2f\n', ['winding', num2str(i)], 'Average current, amps', Idav(i));
fprintf(id, '\t%s\t %s\t %5.2f\n', ['winding', num2str(i)], 'PIV, volts', Vbrm(i));
end

fprintf(id, '\n\n%s\n\n', 'INDUCTOR DESIGN');
for i=1:length(L),
fprintf(id, '\t%s\t %s\t %10.5f\n', ['winding', num2str(i)], 'Inductance value, mH', L(i)*1e3);
fprintf(id, '\t%s\t %s\t %s\n', ['winding', num2str(i)], 'Core', coreL(i,:));
fprintf(id, '\t%s\t %s\t %5d\n', ['winding', num2str(i)], 'Number of windings', NL(i));
fprintf(id, '\t%s\t %s\t %s\n', ['winding', num2str(i)], 'Gauge of inductance', SWGL(i,:));
fprintf(id, '\t%s\t %s\t %10.5f\n', ['winding', num2str(i)], 'Airgap for inductance, mm', Llg(i)*1e3);
end

fprintf(id, '\n\n', 'CAPACITOR FILTER RATINGS');
for i=1:length(C),
fprintf(id, '\t%s\t %s\t %10.5f\n', ['winding', num2str(i)], 'Capacitance value, uF', C(i)*1e6);
fprintf(id, '\t%s\t %s\t %5.2f\n', ['winding', num2str(i)], 'Voltage rating, volts', Vcr(i));
fprintf(id, '\t%s\t %s\t %10.5f\n', ['winding', num2str(i)], 'ESR requirement, ohms', Esr(i));
end

fprintf(id, '\n\n', 'FLUX WALKING CAPACITOR RATINGS');
fprintf(id, '\t%s\t %10.5f\n', 'Capacitance value, uF', Cw*1e6);
fprintf(id, '\t%s\t %5.2f\n', 'Voltage rating, volts', Vfc);
```

So, you can execute this design like I did for the pushpull and try to find out the design values.

(Refer Slide Time: 09:25)

```
HALFBRIDGE CONVERTER SPECIFICATIONS
Output Power, W 28.25
Input DC voltage, volts 325.00
Minimum DC input voltage, volts 210.00
Maximum DC input voltage, volts 380.00
Output voltage, volts Vo1 15.00
Output voltage, volts Vo2 -15.00
Output voltage ripple, volts ripple1 0.15
Output voltage ripple, volts ripple2 0.15
Output current, amps Io1 1.00
Output current, amps Io2 0.50
Inductor current ripple, amps ripple1 0.10
Inductor current ripple, amps ripple2 0.05

DESIGNER VARIABLES
Switching frequency, KHz 40.00
Bm for transformer, Tesla 0.20
Bm for inductors, Tesla 0.25
Estimated efficiency of transformer, % 80.00
Maximum Duty cycle, Dmax 0.45
Minimum Duty cycle calculated, Dmin 0.25
Window factor for transformer, Kw 0.48
Window factor for inductor 0.60
Secondary side blocking diode drops, volts 1.00

HALFBRIDGE TRANSFORMER
less (f)orward, (b)ack, (q)uit
```

I will just run it through half bridge converter design, it goes in the same fashion I will choose Ferrite E CORES again Ferrite EE CORE Ferrite for the inductor Ferrite inductors. So, you can you will get the mm design values, you can read through the values later on and here in the case of the half bridge I am also calculating the flux working capacitor ratings for so, that if you want to use the flux walking prepare

prevention using capacitors you can use it, for small powers this is really fine. In a similar way I have also with me here the full bridge design mfile.

So, very very similar except for the area product. The area product in the case of the half bridge and the full bridge are same. So, even those equations remain the same. You just have to run full bridge and do the same process of selecting the core, selecting the shape and go through the process of selecting the core for the inductor shape, inductor 2 shape and then you get the results.

So, just walk through the design values, you will probably get a hang of the numbers for the a typical design of this specification. So, I will allow you to play around with the specs and get try to get more insight into the design of the converters using this mfile as a template.