## **Analytical Calculations**

In this part, analytical calculations of the flyback converter are made for the nonideal case. According to the research, the duty cycle of the flyback converter should be lower than 0.5. Since the increase in duty cycle rises the energy storage duration, the duty cycle is proportional to core size. Therefore, considering the core size, and voltage stress on switch and diode, we have decided the turn ratio(Np/Ns) as 1 so that the duty cycle is changing between %29-%45.

The controller operates flyback in continuous current mode. All calculations are made assuming continuous current operation. We have taken boundary mode results as the limit values for continuous conduction. Therefore, continuous current mode formulas are utilized for boundary condition calculations.

* Duty cycle calculation,

When ,

When ,

The maximum required inductance can be calculated as follows [1],

[1] Texas Instruments, “LM34XX how to design flyback converter with LM3481 boost ... - ti.com.” [Online]. Available: https://www.ti.com/lit/an/snva761a/snva761a.pdf. [Accessed: 09-May-2022].

Setting the magnetizing inductor current as:

where,

• KL is the fraction chosen, we have chosen KL as 2 in order to set boundary operation.

* (nonideal case)

Then, minimum magnetizing inductance is determined when Vin=48V,

* Calculation of maximum voltages on diode and MOSFET,

Generally in applications, rated voltage of MOSFETs are chosen as 1.7 multiplication of maximum voltage while 1.5 multiple of maximum value in diodes,

* Output capacitance calculation,

# Magnetic Design

## **Core selection**

Since minimum magnetizing inductance is found as 25.3µH, magnetizing inductance is chosen as,

* According to the selected magnetizing inductance value, peak currents of primary and secondary are calculated,

@ Vin=24V

@ Vin=48V

After those calculations and some attempts to creating transformer, we have decided to use **0P43434EC.** Magnetic properties and size of this core are suitable for our application.

Properties of 0P43434EC**,**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Effective crosssectional area Ae (mm2) | Maximum Magnetic Flux density (T) | AL-value with the air gap (nH/N^2) |
| **0P43434EC** | **97.1** | **0.47** | **2933** |

Since AL value of this core is high for energy storage, we have decided to add air gap to the core. Air gap length is determined by choosing magnetic flux density.

* **Choose Bac,max=0.2T** which is below the saturation point of the cores we are investigating (0.47T). Also, maximum magnetic flux density is obtained when Vin=24V.

Then,

* Air gap calculation,

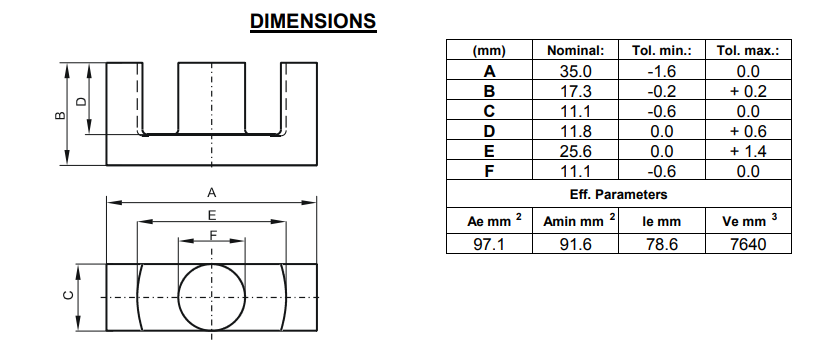
## Cable Selection

For the worst case, @24V

Choose,

We have decided to use 7 parallel connected 25AWG instead of one AWG copper for primary, and 7 parallel connected 5AWG cable instead of one copper cable. Since cables with a larger cross-section have a smaller maximum frequency for 100% skin depth, we have decided to multiple cables that have enough maximum frequency for 100% skin depth instead of one cable. The maximum frequency for 100% skin depths is 85kHz for 26 AWG.This selection makes AC and DC resistances the same since we operate with 100% skin depth.

* Calculation of fill factor,



Core loss;

In order to obtain core loss, firstly, change in magnetic flux is calculates as follows,

Diagram

Description automatically generated

As seen from the graph, @70kHz and , core loss density is approximetely equal to 40mW/cm^3. Then,

Copper loss,

* For primary winding, length of copper cable,

Primary cable of 25 AWG has 106.17Ω per km,

Since we connect 7 cable in parallel,

* For secondary winding, resistance is the same with primary copper losses since we have used the same AWG with equal amount.
* Calculation of copper losses,
* Primary copper losses,
* Secondary copper losses,
* Total copper losses,
* Total losses,