Thermal Calculations

In this part of the report, the thermal analysis of the design is displayed. The main losses in the design are caused by the semiconductor devices. The most significant losses occur in a semiconductor while it is in conduction mode or it is switching. One can find the approximate total loss by adding the conduction loss and switching loss as shown in Equation 4.1.

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*Equation 4.1*

The conduction losses can be calculated by two methods as shown in Equation 4.2 and Equation 4.3. In the first method, one can use the forward voltage drop of the semiconductor () to calculate the power dissipation. Another possible method is to use the on-resistance value () indicated in the datasheet.

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*Equation 4.2*

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*Equation 4.3*

Switching losses can be calculated as shown in Equation 4.4 by using the turn on energy () and turn off energy () dissipated while the diode is switching . If these parameters are not indicated in the datasheet, the switching loss can be estimated by using the turn on delay time () and turn of delay time () as displayed in Equation 4.5.

*Equation 4.4*

*Equation 4.5*

For the rectifier block, two single phase bridge rectifiers (KBPC3510) are combined to construct a three phase full bridge rectifier. The switching energy or delay times are not indicated in the datasheet of the component. The maximum is indicated as 1.1V in the datasheet. In maximum load case, the average current passing on one diode is 11 A when the diode is in conduction mode. One diode’s duty cycle is 1/6. There are 4 diodes that is working in one rectifier while only 2 diodes are working in the other.

The diode used in buck converter is DHG30I600PA.The diode’s conduction loss depends on both on-current and duty cycle. The maximum current is 11 A but the conduction loss is low because the duty cycle is 0.1 at that current. Thus, the maximum conduction loss occurs when duty cycle is 0.5 and the current is approximately 6A. Since the switching energy dissipation is not indicated in the datasheet, the Equation 4.5 is used to calculate switching loss. The switching loss is maximum when the duty cycle of the switch is maximum (0.9) since the current is maximum (0.44W). However, the conduction loss is more dominant than switching loss for this application in general. Thus, the worst case is calculated for 0.5 duty cycle.

In IGBT, the maximum switching loss and conduction loss occur when duty cycle is 0.9. The calculations are displayed below.

To find the maximum thermal resistance of the heatsink, the following two equations are used.

*Equation 7*

*Equation 8*

For rectifiers;

For diode (buck converter);

For IGBT;

In the implementation phase, we used a huge heatsink (thermal resistance is unknown but it is very low) and connected all of these semiconductor devices to this heatsink. Moreover, we used a fan to improve our thermal parameters.