**Component Selection and Controller**

In this part of the report, selected components, purposes and outcomes will be discussed. Basically, to design a system with an analog controller, we firstly selected the controller and then arranged other components, such as transformer design, output capacitor selection, output diode selection, switch selection, etc.

In this final report, we will review the selected components, moreover we will discuss the changed components compared with Simulation Report. If we make an overview, the output diode, D-Z snubber and connectors have changed. Moreover, to protect our board and output from high voltages, we have placed a TVS diode into our project.

1. **Controller**

While selecting the controller, the main aim was to have a wide input voltage range(220V-400V) and to operate at 100W operation. To simulate the closed-loop design easily, products of Analog Devices have been investigated. In these ranges, we have ended up with LT8316 and LT3752 controllers; however, LT3752 is an active clamp forward controller and accepts only 100V input maximum, however when LT8316 is examined, it has a wide operating input voltage range from 16V to 600V, and datasheet specifies that the controller can operate up to 100W. And when we investigate the configuration, the switch is connected externally, and the controller is operated by taking output voltage and current as feedback, which means if we arrange these external components for 100W operation, we could easily use that controller. So, we have decided to use LT8316 as the controller.

The main advantage of LT8316 is, the voltage feedback of the output voltage is taken from a tertiary winding, which means that in closed-loop control we do not need any optocoupler or other kind of isolation, which is a cost-effective solution. Moreover, we will only place the third winding into the transformer core with a very thin cable due to the high impedance of sense pins, so we will save space compared with the optocoupler isolation case. In addition, optocouplers are very sensitive components, and generally, they need a 3.3V or 5V supply; however, we do not need any power IC, thanks to tertiary winding. The feedback resistor selection will be discussed in the feedback resistor part. We are able to use the tertiary winding as a solution of LT8316, which is boundary mode operation. In this mode, the output voltage is sampled from the tertiary winding, when the secondary current is almost zero. The falling voltage is detected by DCM pin by sensing dV/dT and sampled from FB pin. With the boundary operation, the output diode voltage drops to zero in every cycle, so parasitic resistive voltage drops do not cause load regulation errors. Moreover, with the boundary operation, we can select a smaller transformer compared with CCM.

The other feature of the controller is current, so power limitation. The sense pin of the controller accepts 100mV maximum, and when the sense resistor voltage reaches that value, the controller limits the duty cycle to prevent the circuit. The sense resistor selection will be discussed in the "6.2. Discrete Component Selection" section.

In short, an example application of the selected controller LT8316 is shown in Figure 7, one can find the example application of LT8316. In this figure, all mentioned pin connections can also be seen, and this application example is a good guide for this project.

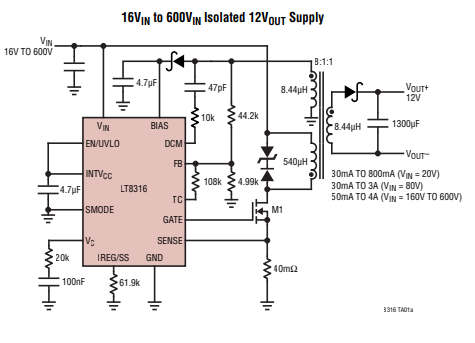


Figure 7 Typical Application of LT8316

Another safety function of the LT8316, the EN/UVLO pin. This pin is compared with 1.22V internally, so if the voltage of this pin is lower than 1.22V, the converter will not operate for safety purposes. So, in this project, we have a 220V-400V input range, and we can arrange a high impedance voltage divider for that pin so that under a critical voltage, the controller does not operate. The protector resistor selection will be discussed in the UVLO Resistor part.

1. **Discrete Component Selection**
2. **Feedback Resistor Selection:**

The feedback pin compares the output voltage with a 1.22V comparator, and to have a 12V output, we must divide the 12V into 1.22V; however, we have a small output, compared with the input voltage, so we need to consider the output diode forward voltage drop. The formulation in the datasheet is given as Equation 29.

|  |  |
| --- | --- |
|  | (29) |

In this case, the output diode has a 0.95V forward voltage drop, the output voltage is 12V, and , tertiary to secondary turns ratio, is 1. So that, the ratio between the feedback resistors becomes 9.6147. In this case, we can use as 48.1KΩ and as 5KΩ. However, when the detailed simulation is investigated, it is observed that with 47KΩ and 5KΩ resistors we obtain better output voltage. This may be a consequence of the inner reference voltage or the diode forward voltage drop. So, we will use 47KΩ and 5KΩ feedback resistors.

1. **Sense Resistor Selection:**

As discussed in the controller part, a proper sense resistor should be selected to set the maximum output current. LT8316 datasheet specifies the sense resistor formulation as Equation 30.

|  |  |
| --- | --- |
|  | (30) |

When we look at the detailed simulation part, the duty cycle changes between 0.1 and 0.2, and the primary to secondary turns ratio is detected as 26:6 in magnetic design part, so we find the maximum value of sense resistor as 17.5mΩ, however, to stay in the safe zone we will select a 10mΩ sense resistor. [1] This resistor selection means that, the output current will be disabled and the MOSFET will be in OFF position **after 10A current, which is an overcurrent protection.**

1. **UVLO Resistor:**

As specified in the controller part, the UVLO pin compares the pin voltage with 1.22V and cuts the operation below that value. The project specifies 220V-400V input voltage, so if 200V is selected as cut-off voltage, we need to divide that voltage to 1.22V. Equation 31 shows the UVLO voltage division.

|  |  |
| --- | --- |
|  | (31) |

In this equation, if we select as 1.5MΩ, we need to select as 9.2KΩ, so we will use these values in our circuit.

1. **MOSFET Selection:**

As seen in the detailed simulation part, MOSFET sees 450V and 6A maximum, so we are needed to select a MOSFET for that criteria. In this manner, N-Channel MOSFET with 550V and 7.6A ratings have been selected, because as the case temperature increases, the maximum drain current decreases. The MOSFET is Infineon Technologies IPD50R500CEAUMA1. [2]

1. **Output Diode Selection:**

As seen in the detailed simulation part, the output diode sees a maximum 110V reverse voltage and 22A peak (8.33A average) forward current. In Simulation Report, we have selected a diode whose ratings are 170V and 30A, however when we make thermal analysis, the temperature rise was very high. In order to stay in safe zone and operate without any coolers, we have selected a diode with 150V reverse voltage and 3A average current, Comchip Technology CDBB3150-HF. When we make thermal analysis, by using five parallel diodes, we can use them without any coolers.

1. **Tertiary Diode Selection:**

The diode is placed before the BIAS pin of the controller, as can be seen in Figure 7. This diode sees the same reverse voltage as the output diode; however; the current does not exceed 100mA, so we have selected 150V, 1A Vishay ES1CHE3\_A/H. The main functionality of this diode is, it is a Schottky diode, so there is not a reverse recovery instance. [4]

1. **Output Capacitor Selection:**

As seen in the detailed simulation part, the output capacitor has nearly 20A current ripple, so in order to stay in %4 voltage ripple criteria, the equivalent ESR must be a maximum 24mΩ, and the ripple current of the capacitor, specified in the datasheet, should be minimum 20A. In this manner, we have used Aluminum-Polymer capacitors because this type has a higher ripple current, and connected four of them parallel, to achieve 20A ripple, because we have selected 330uF, 16V, ripple @100kHz: 5A, ESR: 14mΩ KEMET A750KK337M1CAAE014. [5] In this way, we have decreased the ESR, too.

1. **RCD Snubber Selection:**

As seen in Figure 7, and as seen in the datasheet, the manufacturer proposes a D-Z snubber upper side of the switch, to prevent the switch and the circuit from voltage spikes. However, when we include leakage inductance and make simulation, the D-Z snubber could not helped and the voltage overshoot was up to 750V, so we have determined to add RCD snubber to compensate voltage overshoots. The resistance and capacitance voltages are determined from simulation, where the capacitor is 0.1uF 200V and the resistor is 5.6kohm and its rating is selected for worst case which is 3.5W. The diode sees nearly 400V, so the selected diode is Vishay S1J-E3/61T with 600V, 1A ratings.

1. **TVS Diode**

In this project, one of the bonuses is the overvoltage protection. In order to protect our circuit from overvoltage cases, we have placed a TVS diode between input and ground. By this way, after 400V, the TVS diode will be active, and the input voltage will be clamped into 400V. In this manner, we have selected Eaton Electronics SMBJE400CA 400V TVS diode.

1. **Connectors:**

In the project, we will use two inputs screw terminals. For input terminal, we will use TE Connectivity 282858-2 with 600V 24A ratings, and for output terminal we will use Würth 691103110002 with 125V 12A ratings. The purpose of the connector changing is the new connectors are smaller and cheaper.

In this part of the report, we have discussed all of the critical components that are critical for our project to work in the desired requirements range. Moreover, we have discussed the changed components and their purposes. We have selected all of the components by considering the minimum and maximum requirements, inputs, and outputs. While designing our schematic, there will be some consumables, which are some capacitors, resistors, or diodes that the controller or other components are needed as by-pass, noise filtering, etc. These components are needed for the project to work correctly; however, they are not critical to discuss. The Bill of Materials will be taken from the Altium Designer, and the budget calculation is shown at the end of the "Hardware Design" section.