**Component Selection and Controller**

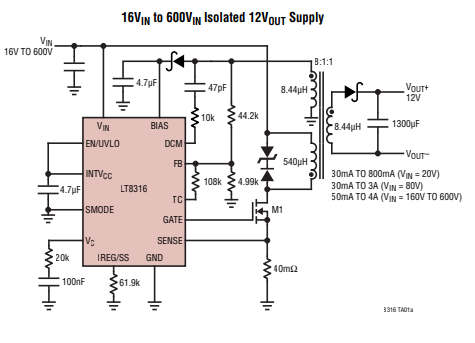
In this part of the report, we will discuss selected components, purposes and outcomes. Basically, to desing a system with an analog controller, we firstly selected our controller and then arranged other components, such as transformer design, output capacitor selection, output diode selection, switch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

1. **Controller**

While selecting the controller, our main aim was to have wide input voltage range(220V-400V), and to operate at 100W operation. To simulate our closed loop design easily, we have investigated products of Analog Devices. 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 we look LT8316, 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 operating by taking output voltage and current as feedback, which means if we arrange this external components for 100W operation, we could easily use that controllers. So, we have decided to use LT8316 as our 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 opto-coupler or other kind of isolation, which is a cost-effective solution. Moreover, we will only place the third winding into out transformer core with a very thin cable due to high impedance of sense pins, so we will save space compared with opto-coupler isolation case. In addition, opto-couplers are very sensitive components, and generally they need 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 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 sencondary 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 are able to select a smaller transformer compared with CCM.

The other feature of the controller is, the current, so power limitation. The sense pin of the controller accepts 100mV maximum, and when the sense resistor voltage reaches that value, controller limits the duty cycle to prevent the circuit. The sense resistor selection will be discussed in sense resistor part. In figure 1, one can find the example application of LT8316.



**Figure 1:** Typical Application of LT8316

An other safety funtion 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 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 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 input voltage, so we need to consider the output diode forward voltage drop. The formulation in the datasheet is given as equation-1,

Equation-1

In this case, our output diode has 0.95V forward voltage drop, output voltage is 12V and , tertiary to secondary turns ratio, is 1. So that, the ratio between the feedback resistors become 9.6147. In this case, we can use as 48.1Kohm and as 5Kohm. However, when we look detailed simulation, we will see that with 47Kohm and 5Kohm 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 47Kohm and 5Kohm feedback resistors.

1. **Sense Resistor Selection:** As we discussed in controller part, we need to select a proper sense resistor to set maximum output current. LT8316 datasheet specifies the sense resistor formulation as seen in equation-2,

Equation-2

When we look 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 17.5mohm, however to stay in safe zone we will select a 10mohm sense resistor.

**Link:** <https://www.digikey.com/en/products/detail/bourns-inc/CFG0612-FX-R010ELF/9924211>

1. **UVLO Resistor:** As we specified in controller part, the UVLO pin compares the pin voltage with 1.22V, and cuts the operation below that value. Our projects specifies 220V-400V input voltage, so if we select 200V as cut-off voltage, we need to divide that voltage to 1.22V. Equation-3 shows the UVLO voltage division,

Equation-3

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

1. **MOSFET Selection:** As we will see in our detailed simulation part, our MOSFET sees 450V and 6A maximum, so we are needed to select a MOSFET for that criteria. In this manner we have selected an N-Channel MOSFET with 550V and 7.6A ratings, because as the case temperature increases, the maximum drain current decreases. The MOSFET is Infineon Technologies IPD50R500CEAUMA1.

**Link:** <https://www.digikey.com/en/products/detail/infineon-technologies/IPD50R500CEAUMA1/6599409>

1. **Output Diode Selection:** As we will see in our detailed simulation part, our output diode sees maximum 110V reverse voltage and 22A peak forward current, so we have selected 170V, 30A STMicroelectronics STPS30170DJF-TR. The power-flat packaging will help us to dissipate heat.

**Link:**<https://www.digikey.com/en/products/detail/stmicroelectronics/STPS30170DJF-TR/2209783>

1. **Tertiary Diode Selection:** The diode is placed before the BIAS pin of the controller, as seen in figure-1. This diode sees the same reverse voltage with output diode, however the current does not exceed 100mA, so we have selected 150V, 1A STMicroelectronics STPS1150A. The main functionality of this diode is, it is a Schottky diode, so there is not a reverse recovery instance.

**Link:** <https://www.digikey.com/en/products/detail/stmicroelectronics/STPS1150A/1039597>

1. **Output Capacitor Selection:** As we will see in our 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 maximum 25mohm, 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 higher ripple current, and connected four of them parallel, to achieve 20A ripple, because we have selected 330uF, 16V, ripple @100kHz: 5A, ESR: 14mOhm KEMET A750KK337M1CAAE014. By this way, we have decreased the ESR, too.

**Link:** <https://www.digikey.com/en/products/detail/kemet/A750KK337M1CAAE014/6196330>

1. **D-Z Snubber Selection:** As we can see in figure-1, and as seen in datasheet, the manufacturer proposes a D-Z snubber upper side of the switch, to prevent the switch and the circuit from voltage spikes. When we investigate the demo-board of the controller, the diode sees 400V maximum, and each of the zener seed 90V, moreover both zener diodes are same and has a resistance of 60ohm. So we have selected a 450V, fast recovery, ON Semiconductor ES1H diode and 100V, 1W, Vishay SML4764A-E3/61 zener diode. While selecting these components, we are tried to stay similar with demo-board.

**Diode Link:** <https://www.digikey.com/en/products/detail/on-semiconductor/ES1H/1642578>

**Zener Link:** <https://www.digikey.com/en/products/detail/vishay-general-semiconductor-diodes-division/SML4764A-E3-61/3104257>

1. **Connector:** In this project, we will use a two input screw terminal which is capable up to 600V. For both input and output we will use same connector which is Phoenix Contact’s 1714971 model.

**Link:** <https://www.digikey.com/en/products/detail/phoenix-contact/1714971/260639>

In this part of the report, we have discussed all of critical components that are critical for our project to work in the desired requirements range. We have selected all of the components by considering 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. This components are needed for our 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 will be done after that part.