“DESIGN OF HIGH VOLTAGE GAIN, VARIABLE OUTPUT DC-DC CONVERTER FOR HI-REL APPLICATIONS”

*Mid Semester Review*

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*By*

RISHIT THAKKAR (19EC413)

*Under the guidance of*

*Mr. NANDHA KUMAR (SAC, ISRO)*

*DR. DARSHANKUMAR DALWADI (BVM)*

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Birla Vishvakarma Mahavidyalaya (Engineering College)

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# Abstract

Multiple systems on-board a satellite require a translator or rotational motion. This has traditionally been accomplished by mechanical motors and related mechanical systems. However, these mechanisms are bulky. In view of reducing the overall mass of such systems, satellites are largely shifting to a piezo-actuated approach. Examples of these systems are optical Fast steering mirrors. These actuators are typically require large controllable bias voltages (150-200V) with low noise. Traditionally, in order to control this bias voltage, a fixed output converter is used in tandem with a linear regulator high voltage operational amplifier. This project focuses on developing a variable output DC-DC converter. This involves comparing various available topologies for dc-to-dc converters that fits into the requirements of the system that are stated in table 1. Further, the most suitable controllable converter topology will be designed and developed into hardware. The hardware will then be tested on various conditions for high reliability applications.

|  |  |
| --- | --- |
| **Parameter** | **Value** |
| Nominal input voltage | 12Vdc ± 20% |
| Output voltage | 10Vdc-150Vdc |
| Maximum output power | 2W |
| Size | 40mmX 60mm |

Table 1

# Methodology

1. As per the requirement of the system, shortlisting of various available dc-dc converter configurations and controllers will be done.
2. Appropriate calculations for parameters and component selection will be done accordingly.
3. The designed converter will be simulated using MATLAB SIMULINK and verification of the calculated values will be done.
4. Primarily, the converter will be tested by creating a temporary circuit on breadboard.
5. Control of the converter will be simulated, tested and DC output (10Vdc-150Vdc) will be mapped with the control value.
6. Appropriate ICs will be chosen, simulated, and tested in open-loop.
7. A Printed Circuit Board will be designed to accommodate all the components and the converter will be tested in closed loop.

The Input Voltage Range is from 9.6Vdc to 14.4Vdc, and the corresponding output voltage range required is 10Vdc to 150Vdc.

For Extreme cases:

1) From 9.6Vdc to 150Vdc:- We can use a Boost Converter.

2) From 14.4Vdc to 10Vdc:- We have to use a Buck Converter.

For getting the extreme conversions, we will use a Flyback Converter Topology (Coupled Inductor).

# //(//To be changed)Constrains

The main constrains while choosing the type of converter to be used are:

* Number of switches: With increase in number of switches; the control circuit requirement increases and the design gets more complex. Also, cost, space required, weight, and losses increases.
* Isolation between input and output: The input and output needs to be separated to prevent any fault and noise signal from getting injected to the input side i.e. the DC bus. This safe guard other equipment connected to the same DC bus.
* Maximum output power: To supply enough power to the devices connected to the output of the converter and ensure satisfactory operation of the connected devices and converter.
* Number of transformers: The design becomes more complex with increase in number of transformers. Also, the cost, size, and losses increases.
* Value of output capacitor: Converters which require large capacitors for filtering the outputs are not preferred since they are bulky, costly, and lead to increased charging current during startup.
* Multiple output capability: The converter itself requires multiple inputs to run its control circuit consisting the gate driver and feedback circuitry. Hence, multiple outputs are preferred to ensure an independent system.

# A Comparison

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Converter | Isolation | Switches | Windings | Outputs | Remarks |
| Buck | No | 1 | 0 | Single | - |
| Push-pull | Yes | 2 | 3 | Multiple | * Problem of flux imbalance. * Very high voltage stress (2.4Vdc) on transistor. |
| Single-Ended Forward | Yes | 1 | 3 | Multiple | * Above output powers of 200W the primary input current becomes too large. * Very high voltage stress (2.4Vdc) on transistor. |
| Double-Ended Forward | Yes | 2 | 2 | Multiple | * Lower voltage stress as compared to previous topologies. |
| Flyback | Yes | 1 | 2 | Multiple | * Large Output Filter Capacitor * High Ripple Current * Large Output Voltage Spikes |

Table 2 Comparison of various available topologies

# Forward Converter

# 

# Calculations

# Simulation of the Converter in Open Loop Configuration

# Results

# Simulation of the control IC in Open Loop

# Results

The simulation is run for 1ms and the results were recorded. The green colored plot in Figure 15 shows the

# Testing of the control IC in Open Loop

Figure 17 Testing of UC1825 in open loop

# Results

# Testing of the converter in Open Loop:

# Future Work

# References