# EENG28070: Switched Mode Power Supply Design Laboratory.

# SMPS Group Worksheets for 2020.

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| Cohort | Group |  |
|  |  |  |

## Progress and Assessment

This worksheet will form part of the Group Assessment and the progress meetings with the Unit Organiser (during synchronous sessions). Results and the answers given to questions posed will be discussed at these meetings and verbal feedback given. This is does not replace recoding information individually in your laboratory books that is required for the Individual Blackboard test. You should work through the 6 tasks as a group (completing about one task per week) and discuss your individual results before collectively filling in the worksheet. This will require you to schedule at least one meeting per week within your group to discuss your findings.

The general requirements for each section of this worksheet are:

* Circuit diagram (with components clearly labelled on the circuit)
* Brief description of operation
* Waveforms to demonstrate working part of the system and comment on performance
* Choice of components and questions

Fill in this form as you do each task and the work will be assessed on a regular basis by the Unit Organiser once a task is completed. Worksheets should not be altered after assessment unless specifically instructed by the Unit Organiser. This document is not marked as such, but the information and discussion arising from it is used for the Group Mark. The final document will need to be uploaded to Blackboard at the end of the design exercise.

|  |  |  |
| --- | --- | --- |
| Task | Date completed | Brief comments by the Group on your understanding of the task |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |
| 4 |  |  |
| 5 |  |  |
| 6 |  |  |

## 1. Full-wave rectification of AC supply voltage (Section 4.1)

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| --- |
|  |
| Circuit diagram.  Here, the diagram has been included as guidance of what to do generally. Add comments. |
| Operation: Brief single paragraph description. |

|  |  |
| --- | --- |
| <Insert figure here> | <Insert figure here> |
| Input and output voltages with <?> capacitance | Graph of voltage sag versus capacitance |
| Comment on results: | |

|  |  |
| --- | --- |
| Questions: | |
| 1 | Why is AC voltage source peak set for 42.4V? |
|  | The input AC voltage source is required to produce 30Vrms. Therefore, the peak is 30 \* V = 42.4V |
| 2 | Choice of reservoir capacitor, C? |
|  | 4700uF |
| 3 | What is suitable value of effective SMPS resistance, Reff? |
|  | 26.3Ohm |
| 4 | Intended ripple voltage (with sawtooth approximation) |
|  | 3.3V |
| 5 | Actual ripple voltage? |
|  | ???? |

## 2. PWM generator (Section 4.2)

|  |
| --- |
| <Insert figure here> |
| Circuit diagram (add comments to diagram) |
| Operation: Brief single paragraph description. |

|  |
| --- |
| <Insert figure here> |
| Results figure: |
| Comment on results: |

|  |  |
| --- | --- |
| Questions: | |
| 1 | Why is the maximum Duty Cycle 50%? |
|  | The reason for this is that it will allow the oscillator to discharge the capacitor quickly ensuring that the sawtooth waveform has a nearly vertical edge after the ramp so that the duty cycle obtainable will approach 50% in practice 4046 |
| 2 | PWM frequency? |
|  | 100kHz |
| 3 | PWM timing components C and R? |
|  |  |
| 4 | With potentiometer set to 0.6, what is the Duty Cycle? |
|  | bigger |
| 5 | … & what would be the average voltage output from the PWM? |
|  |  |
| 6 | With only one power supply (15V), where could the 5V power rail be supplied from? |
|  | Use potentiometer |

## 3. Gate-drive circuit (Section 4.3)

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| --- |
| <Insert figure here> |
| Circuit diagram (add comments to diagram) |
| Operation: Brief (single paragraph) description. |

|  |
| --- |
| <Insert figures here> |
| Results figures: |
| Comment on results: |

|  |  |
| --- | --- |
| Questions: | |
| 1 | What inductance values should be used for both L2 and L3 given the number of turns recommended in the PowerPoints? |
|  |  |
| 2 | What is the use of the capacitor between the transistors and the toroid? |
|  |  |
| 3 | Why the ‘dot’ convention for the gate-drive transformer? |
|  |  |

## 4. Completing the Main Transformer Primary Winding circuit (Section 4.4)

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| --- |
| <Insert figure here> |
| Circuit diagram (add comments to diagram) |
| Operation: Brief (single paragraph) description. |

|  |  |
| --- | --- |
| <Insert figures here> |  |
| Steady-stage responses. | |
| Comment on results:  For instance, the magnetising current level? | |

|  |  |
| --- | --- |
| Questions: | |
| 1 | What is the function of the MOSFETS and why are they operated in this particular mode? |
|  |  |
| 2 | What is the function of the free-wheeling diodes? |
|  |  |
| 3 | How is current flow in the Main Transformer Primary winding being monitored? |
|  |  |
| 4 | What is the inductance and number of turns for the Main Transformer primary winding using the B-H curve? |
|  |  |
| 5 | What is the inductance and number of turns for the Main Transformer primary winding using the ‘10% magnetising current rule’? |
|  |  |
| 6 | Which of the two calculations in 4 and 5 will you be using for your design and why? |
|  |  |
| 7 | How do you think you can calculate the saturation inductance and estimate its value? |
|  |  |
| 8 | By (artificially) reducing the saturation level, what effect does this have on the main transformer primary winding current and why is this a problem? |
|  |  |
| 9 | For the practical circuit, why might there be an issue with putting the scope probes directly across the main transformer primary winding to monitor its voltage? |

Heatsink requirements for active components.

|  |  |
| --- | --- |
| Questions: | |
| 1 | Rds(on) at the chosen junction temperature for the MOSFET? |
|  |  |
| 2 | What would be the power dissipated in each MOSFET with full load? |
|  |  |
| 3 | What heatsink is required from those listed in the data sheets? |
|  |  |

## 5. Secondary Circuit and 100KHz filter (Section 4.5)

|  |
| --- |
| <Insert figure here> |
| Circuit diagram (add comments to diagram) |
| Operation: Brief (single paragraph) description. |

|  |
| --- |
| <Insert figures here> |
| Transient Responses |
| <Insert figures here> |
| Steady-state Responses. |
| Comment on results: |

|  |  |
| --- | --- |
| Questions: | |
| 1 | How many turns are required for the secondary winding and what is its ‘leakage’ inductance? |
|  |  |
| 2 | What is the purpose of the diode pair (D1 & D2)? |
|  |  |
| 3 | Critical value of the of the filter inductance? |
|  |  |
| 4 | Minimum value of the filter capacitance to satisfy the ‘100kHz’ output voltage ripple specification (on its own)? |
|  |  |
| 5 | ESR (and hence the number of 100μF capacitors) required to satisfy the ‘100kHz’ output voltage ripple specification. |
|  |  |
| 6 | Which of the calculations in 5 and 6 do you need to employ in your design and why? |
|  |  |

## 6. Complete open loop SMPS circuit (Section 4.6)

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| --- |
| <Insert figure here> |
| Circuit diagram (add comments to diagram) |
| Comment on any component changes that have been made: |

|  |  |
| --- | --- |
| <Insert figures here> |  |
| Steady-state responses. | |
| <Insert figures here> |  |
| Example of ‘100Hz’ and ‘100KHz’ noise | |
|  | |
| Graph of Vout (across load resistor) versus Vin (at potentiometer). Plot step-by-step. | |
| Comment on results: | |

|  |  |
| --- | --- |
| Questions: | |
| 1 | Why in a practical circuit would there be a need to replace the current sensing resistor? |
|  |  |
| 2 | Regulation: How does the voltage change as the resistive load is switched from its lowest to highest values with the output voltage initially set for your design specification? Comment on the reasons for this. |
|  |  |
| 3 | Determine the maximum ‘100KHz’ ripple under full load condition (lowest output resistance). Does it meet your specification? If not, how might it be improved? |
|  |  |
| 4 | Determine the maximum ‘100Hz’ ripple under full load condition. Does it meet your specification? If not, how might it be improved? |
|  |  |
| 5 | Determine the maximum current in the Main Transformer primary winding |
|  |  |
| 6 | By exporting the primary winding current data into Matlab (proper), use numerical integration to determine the actual rms current in each MOSFET and hence a value for the MOSFET losses. How do these compare with Task 4 calculations using the ‘on’ time period only? |
|  |  |
| 7 | How do you determine the efficiency of the SMPS? What are these for both high and low resistor values? |
|  |  |