SIDDHARTH INSTITUTE OF ENGINEERING AND TECHNOLOGY (AUTONOMOUS), PUTTUR

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QUESTION BANK (DESCRIPTIVE)

Subject with Code : SWITCHED MODE POWER CONVERTERS (25EE2101)

Course & Branch: M. Tech –POWER ELECTRONICS

Year & Semester: I - M. Tech. & I-Semester **Regulation:** R25

UNIT I

FUNDAMENTAL SWITCHING REGULATORS –BUCK AND BOOST TOPOLOGIES:

1.	(a)	Explain the basic operation of a Buck switching regulator with the help of a neat circuit diagram and waveform.	**[L2][CO1]**	**5M**
	(b)	A Buck converter steps down 24 V to 12 V at a load current of 2 A. Determine the duty cycle, average inductive current, and peak-to-peak inductive current for a switching frequency of 25 kHz with L = 200 μH.	**[L3][CO1]**	**5M**
2.	(a)	Illustrate and describe the significant current waveform of a Buck regulator operating in continuous conduction mode (CCM).	**[L2][CO1]**	**5M**
	(b)	For a Buck converter operating from 15 V to 5 V, supplying 2 A at 50 kHz, design the output filter inductive and capacitor to limit inductive current ripple to 30% and output voltage ripple to 1%.	**[L4][CO1]**	**5M**
3.	(a)	Discuss the major factors affecting buck regulator efficiency. Explain conduction and switching losses	**[L3][CO1]**	**5M**
	(b)	A Buck regulator has an input of 20 V, output of 10 V, and output current of 5 A. If the diode drop is 0.7 V and transistor saturation voltage is 0.3 V, calculate the efficiency.	**[L4][CO1]**	**5M**
4.		Derive the efficiency expression of a Buck converter considering switching and conduction losses.	**[L4][CO1]**	**10M**
5.	(a)	For a boost converter, derive the relation between output voltage and duty cycle in continuous conduction mode (CCM). State assumptions made.	**[L2][CO1]**	**5M**
	(b)	A Boost converter with an input of 5 V provides 12 V at 0.5 A. The converter operates at 100 kHz with an inductor of 150 μH. Determine the inductor current ripple and verify if it operates in continuous mode.	**[L3][CO1]**	**5M**
6.		With neat circuit and waveform diagrams, analyze the steady-state operation of a Boost converter in: (a) Continuous mode, and (b) Discontinuous mode. Derive the voltage conversion ratio for both cases.	**[L4][CO1]**	**10M**
7.		A Boost converter is designed to provide 20 V at 1.5 A from a 10 V source. The converter operates at 50 kHz with an inductor of 150 μH. (a) Calculate the duty ratio, inductor current ripple, and average inductor current. (b) Determine whether the converter operates in continuous or discontinuous conduction mode.	**[L3][CO1]**	**10M**
8.	(a)	Explain the boundary between Continuous Conduction Mode (CCM) and Discontinuous Conduction Mode (DCM) in a Buck converter. Derive the condition for the critical inductance.	**[L4][CO1]**	**5M**
	(b)	A Buck converter steps down from 18 V to 9 V delivering 3 A. It operates at 40 kHz. If the minimum inductor value required to maintain CCM is used,	**[L3][CO1]**	**5M**

		determine: (i) the ripple current, (ii) the minimum value of inductance that ensures CCM.		
9.		explain techniques used to improve the light-load efficiency of Buck and Boost converters. Discuss the operating principles of these methods and their impact on switching losses, converter performance, and Electromagnetic Interference.	**[L4][CO1]**	**10M**
10.		Compare Buck and Boost converter topologies with respect to the following aspects: i. Operating principle ii. Voltage conversion ratio iii. Inductor and capacitor current waveforms iv. Switching stresses on semiconductor devices v. Efficiency considerations and Behavior in continuous conduction mode (CCM) and discontinuous conduction mode (DCM)	**[L2][CO1]**	**10M**

UNIT II

PUSH-PULL AND FORWARD CONVERTER TOPOLOGIES:

1.		Explain the operation of a Push-Pull converter with essential circuit diagrams and waveforms and Discuss switching sequence, transformer action, flux symmetry, and output rectification/filtering.	[L2][CO2]	10M
2.	(a)	Describe the concept of master–slave outputs in Push-Pull converters and Explain how multiple secondary windings affect load regulation.	[L4][CO2]	5M
	(b)	A Push-Pull converter provides two outputs: 5 V/3 A and 12 V/1 A, input voltage = 36 V, duty cycle = 0.45. Design the secondary turns required for each output.	[L3][CO2]	5M
3.	(a)	Explain the causes of transformer core saturation in Push-Pull converters and Discuss how unequal switching, device mismatches, and improper reset conditions contribute to saturation, and describe techniques used to avoid these issues.	[L4][CO2]	5M
	(b)	A Push-Pull converter applies +18 V across one half of the primary for 22 μs and –18 V across the other half for 18 μs. Primary turns Np = 24. Calculate: (i) The volt-second difference between the two halves (ii) The percentage imbalance (iii) Comment on whether this imbalance can drive the core toward saturation.	[L3][CO2]	5M
4.		Derive the primary and secondary RMS current expressions in a Push–Pull converter, clearly explaining the assumed waveforms, conduction intervals of each switch, transformer utilization factor (TUF), and how these parameters influence transformer design.	[L4][CO2]	10M
5.	(a)	Explain the basic operation of a Forward converter with neat waveforms and Discuss role of magnetizing current, freewheeling path, and reset winding.	[L2][CO2]	5M
	(b)	A forward converter has: Vin = 24 V, Np:Ns = 1:0.5, duty cycle = 0.4, Load = 10 Ω. Determine: (i) Output voltage	[L3][CO2]	5M

		(ii) Average inductor current		
6.		Explain the complete operation of a Forward converter with key waveforms and Discuss magnetizing current, reset winding action, and freewheeling interval.	[L2][CO2]	10M
7.		Discuss transformer design relations in a Forward converter, including volt-second balance, core reset, and duty-cycle limitation.	[L4][CO2]	10M
8.		A Forward converter uses a demagnetizing (reset) winding equal to the primary turns. Given: Input voltage, $V_{in} = 48\ V$, Duty cycle, $D = 0.45$, Leakage inductance, $L_{\ell} = 2\mu H$, MOSFET current change rate, $\frac{di}{dt} = 20\ A/\mu s$. Calculate the expected voltage spike across the MOSFET due to leakage inductance (neglect snubber).	[L3][CO2]	10M
9.	(a)	Explain the role of synchronous rectification in Push-Pull and Forward converters and Discuss efficiency improvements at low output voltages.	[L4][CO2]	5M
	(b)	Derive the expression for the minimum required inductance in a Forward converter to maintain continuous conduction mode (CCM).	[L4][CO2]	5M
10.	(a)	Explain the secondary load freewheeling diode operation and expected inductor current waveforms in a Forward converter (show waveforms for the switching interval and freewheel interval).	[L2][CO2]	5M
	(b)	A Push-Pull converter has: Vin = 24 V, Np = 18 turns, Ns = 3 turns, Duty cycle = 0.40, Load = 4 Ω. Calculate: (i) Output voltage (ii) Ripple current in the output inductor (assume L = 50 μH, fs = 40 kHz)	[L3][CO2]	5M

UNIT III

HALF AND FULL BRIDGE CONVERTER TOPOLOGIES :

1.	(a)	Explain the sequence of switching and midpoint voltage formation in a Half-Bridge converter and Discuss how the two series capacitors maintain voltage balance.	**[L2][CO3]**	5M
	(b)	A Half-Bridge converter operates from 350 V DC. Output required = 28 V, duty cycle = 0.42. Determine the ideal transformer turns ratio and the primary applied volt-seconds during the ON interval.	**[L3][CO3]**	5M
2.	(a)	Describe the function and design constraints of the blocking capacitor in Half-Bridge converters. Why is its DC bias stability essential?	**[L2][CO3]**	5M
	(b)	A blocking capacitor of 1 μF is used. The load draws 5 A, the switching frequency is 50 kHz. Calculate the voltage ripple across the blocking capacitor.	**[L3][CO3]**	5M
3.		Explain leakage inductance problems in Half-Bridge converters and discuss how it causes switch voltage spikes, distorts current waveforms, and necessitates snubber/clamp circuits.	**[L4][CO3]**	**10M**
4.		Derive the output inductor and capacitor design equations for a Half-Bridge converter and show how duty cycle and input voltage determine ripple and CCM operation.	**[L4][CO3]**	**10M**
5.	(a)	Explain the basic operation of a Full-Bridge converter and discuss how all four switches contribute to transferring power to the transformer.	**[L2][CO3]**	5M
	(b)	A Full-Bridge converter operates with: Input = 300 V, Duty = 0.48, Transformer ratio = 8:2 Find the secondary voltage during the active interval and maximum ideal	**[L3][CO3]**	5M

		output voltage.		
6.		Describe the transformer magnetic design procedure for a Full-Bridge converter, including flux swing, primary turns, core selection, and current stresses. Compare it briefly with Half-Bridge design.	**[L4][CO3]**	**10M**
7.	(a)	Explain the purpose of adding a primary-side blocking capacitor in some Full-Bridge converter designs. Discuss its impact on volt-second balance.	**[L2][CO3]**	5M
	(b)	A Full-Bridge converter primary applies +140 V for 16 μs and –140 V for 14 μs. Calculate: (i) Volt-second imbalance (ii) Percentage imbalance (iii) Comment on the risk of core saturation.	**[L4][CO3]**	5M
8.		Compare Half-Bridge and Full-Bridge converters in terms of operating principle, transformer utilization, switch stress, duty-cycle limits, and power/efficiency suitability.	**[L4][CO3]**	**10M**
9.		A Half-Bridge converter delivers 300 W at an output voltage of 24 V. The converter operates from an input voltage of 320 V at a switching frequency of 40 kHz. The output filter consists of an inductor of 75 μH and a capacitor of 680 μF. The high-frequency transformer used in the converter has a turns ratio of 10:3. Determine the following performance parameters of the converter: (a) the inductor ripple current, (b) the output voltage ripple, (c) the primary RMS current, and (d) the minimum capacitor ESR required to maintain the voltage ripple within 1% of the output voltage.	**[L3][CO4]**	**10M**
10.	(a)	Explain the output filter design of a Full-Bridge converter and Discuss inductor ripple, capacitor ripple, and diode recovery effects.	**[L2][CO4]**	5M
	(b)	A Full-Bridge converter with Vin = 250 V, duty = 0.40, Ns/Np = 1/5 supplies a 5 Ω load. Determine: (i) Output voltage (ii) Average diode current Assume ideal operation.	**[L3][CO4]**	5M

UNIT IV

FLYBACK CONVERTER TOPOLOGIES :

1.		Explain the basic operation of a Discontinuous-Mode (DCM) Flyback converter with detailed waveforms and energy transfer mechanism.	[L2][CO4]	**10M**
2.	(a)	Derive the expression for output voltage of a DCM Flyback converter in terms of input voltage, duty cycle, load, and transformer turns ratio.	[L3][CO4]	5M
	(b)	A DCM flyback converter operates from 24 V input, delivers 5 V at 2 A, with Np : Ns = 1 : 4 and D = 0.33. Calculate the peak primary current and energy stored in magnetizing inductance.	[L3][CO4]	5M
3.		Discuss the complete sequential design procedure of a DCM Flyback converter including selection of Lm, turns ratio, switch rating, diode rating, and output capacitor sizing. Provide necessary mathematical relations.	[L4][CO4]	**10M**
4.	(a)	Explain disadvantages of DCM Flyback converters such as high RMS current, poor utilization of the transformer core, and high ripple.	[L1][CO4]	5M
	(b)	A DCM flyback converter delivers 20 W at 15 V. If the switching frequency	[L3][CO4]	5M

		is 40 kHz and magnetizing inductance is 180 μH, compute the boundary current to avoid CCM.		
5.	(a)	Describe the operation of Continuous Conduction Mode (CCM) Flyback converters with magnetizing current waveforms.	[L2][CO4]	5M
	(b)	For a CCM flyback operating from 18–36 V input, delivering 12 V, 5 A output, with Np : Ns = 3 : 1 and D = 0.4 at Vin(min), calculate the average and peak magnetizing currents.	[L3][CO4]	5M
6.		Explain the DCM–CCM transition in flyback converters and derive the boundary condition expression relating Lm, switching frequency, and load. Include waveform-based explanation.	[L4][CO4]	**10M**
7.		Compare DCM and CCM flyback converters with respect to transformer design, current stress, voltage stress, EMI, efficiency, and dynamic response. Use numerical examples for justification.	[L4][CO4]	**10M**
8.	(a)	Explain the impact of leakage inductance on flyback converter performance and list methods to minimize it.	[L2][CO5]	5M
	(b)	A flyback converter with Llk = 2 μH and primary current peak = 4 A is switched off at 80 kHz. Calculate the leakage energy and propose a suitable snubber/clamp topology with justification.	[L3][CO5]	5M
9.	(a)	Derive the expression for voltage stress on MOSFET and output diode in a flyback converter operating in CCM.	[L3][CO5]	5M
	(b)	A CCM flyback operates from 100 V input, turns ratio 2:1, and output voltage 20 V. Compute MOSFET peak voltage and diode peak reverse voltage.	[L3][CO5]	5M
10.	(a)	A 60 W universal input flyback (90–265 V AC) uses Lm = 600 μH. Determine the minimum and maximum magnetizing current in CCM operation at full load.	[L3][CO5]	5M
	(b)	Explain how transformer core design of gaped core, flux swing, AL value affects performance in fly-back converters and specify criteria for selecting the air gap.	[L2][CO5]	5M

UNIT V

VOLTAGE-FED AND CURRENT- FED TOPOLOGIES:

1.		Explain voltage-fed and current-fed topologies with neat block diagrams and switching waveforms. Compare their operational characteristics.	[L2][CO5]	**10M**
2.	(a)	Define the deficiencies of voltage-fed PWM full-bridge converters for circulating current, transformer saturation, cross-conduction.	[L1][CO5]	5M
	(b)	A PWM full-bridge converter operates from a 300 V DC bus at duty cycle 0.48.Calculate the effective primary voltage applied during the active interval.	[L3][CO5]	5M
3.		Explain the basic operation of the buck voltage-fed full-bridge converter and illustrate switching sequence, voltage waveforms, and transformer excitation.	**[L2]**[CO5]	**10M**
4.	(a)	List the advantages and drawbacks of a buck voltage-fed full-bridge topology with respect to switch stress, transformer utilization, and EMI.	[L1][CO5]	5M
	(b)	A buck voltage-fed full-bridge has input = 220 V and produces a 55 V output at 8 A with 92% efficiency. Calculate input current and input power.	[L3][CO5]	5M
5.	(a)	Describe the operation of a buck current-fed full-bridge topology and explain the importance of the input inductor in shaping current.	**[L2][CO6]**	5M

	(b)	A current-fed bridge uses an input choke of 2 mH. If average current = 9 A and ripple = 1.4 A peak-to-peak, compute maximum and minimum inductor currents.	**[L3][CO6]**	5M
6.		Explain the flyback current-fed push–pull converter topology, detailing flux reset, switching sequence, transformer operation, and advantages over conventional push–pull designs.	**[L2][CO6]**	**10M**
7.		Compare voltage-fed and current-fed bridge converters in terms of switching losses, transformer design, device stress, control complexity, and fault tolerance. Include analytical reasoning.	[L4]**[CO6]**	**10M**
8.	(a)	State transformer design constraints in voltage-fed full-bridge topologies, focusing on flux balance, magnetizing current, and leakage effects.	[L1]**[CO6]**	5M
	(b)	A full-bridge converter applies 280 V to a transformer primary with turns ratio 3:1. Calculate the secondary voltage and reflected primary current for a 10 A secondary load.	[L3]**[CO6]**	5M
9.	(a)	Derive the expression for MOSFET voltage stress in a current-fed full-bridge converter considering leakage inductance and transformer turns ratio.	[L3]**[CO6]**	5M
	(b)	A current-fed full-bridge input inductor carries peak current of 7.5 A; transformer turns ratio is 2:1.Calculate the peak secondary current.	[L3]**[CO6]**	5M
10.		Discuss design considerations for selecting the input inductor, transformer turns ratio, switch ratings, and snubber components in high-power current-fed converters. Include equations where relevant.	[L4]**[CO6]**	**10M**

Prepared By: Dr. M. PRIYA

ASSOCIATE PROFESSOR

Dept of EEE

SIETK