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lOMoARcPSD|4419572 Chapter 6 Solutions, Power Electronics (Hart) Electrónica de Potencia (Universidad de las Américas Puebla) StuDocu no está patrocinado ni avalado por ningún colegio o universidad. Descargado por David Ruiz () lOMoARcPSD|4419572 CHAPTER 6 SOLUTIONS 5/17/10 6-1) Po = Vo I o = Vo I s ; Ps = Vs I s h= Po Vo I o Vo = = Ps Vs I s Vs 6-2) Io = P 100 = = 3.33 A. Vo 30 a) Ps = Vs I o = (100)(3.33) = 333 W .; h = Po 100 = = 30% Ps 333 b) PQ = VCE I o = (70)(3.33) = 233 W . 1 yr.=8760 Hr.; W = (233)(8760)=2044 kW-Hr, c) e.g., @10 cents/kW-Hr, cost = $204.40/yr. 6-3) a) Vo = Vs D = (100)(0.6) = 60 V . b) Vo, rms = Vm D = (100) 0.6 = 77.5 V (see Example 2-4) Vo2,rms 77.52 c) P = = = 600 W . R 10 d) Results are not dependent on frequency. 6-4) a) Vo = Vs D = (24)(0.65) = 15.6 V . Vo 15.6 = = 1.56 A. R 10 V 15.6 1 DiL = o (1 - D)T = (1 - 0.65) = 2.18 A. -6 L 25(10) 100, 000 Di 2.18 I L ,max = I L + L = 1.56 + = 2.65 A. 2 2 Di 2.18 I L ,min = I L - L = 1.56 = 0.47 A. 2 2 b) I L = I R = Descargado por David Ruiz () lOMoARcPSD|4419572 Vo (1 - D) 15.6(1 - 0.65) = = 0.182 2 8LCf 8(25)(10)-6 (15)(10) -6 (100, 000)2 DVo or = 1.17% Vo c) DVo = 6-5) a) Vo = Vs D = 9 V . b) I L = 1.8 A.; DiL = 2.4 A. DiL = 3.0 A. 2 Di = I L - L = 0.6 A. 2 I L ,max = I L + I L ,min c) DVo = 0.44% Vo 6-6) a) D = Vo = 0.5 Vs b) I L = I R = Po 125 = = 5 A. Vo 25 DiL V = 1.25; DiL = 2.5 A. = o (1 - D)T 2 L V 25 1 = 50 m H . L = o (1 - D)T = (1 - .5) DiL 2.5 100, 000 I L ,max = 6.25 A. ⌧ c) D Vo 1- D = 5% = .005 = Vo 8LCf 2 C= 1- D 1 - .5 = = 25 m F . ⌧DVo ⌧ 2 8(.005)(50)(10) -6 (100, 000) 2 8 ⌧ ⌧Lf ⌧Vo ⌧ Descargado por David Ruiz () lOMoARcPSD|4419572 6-7) a) D = Vo 1.5 = = 0.25 Vs 6 V 1.5 b) average : I L = I R = o = = 0.5 A. R 3 2 rms : I L ,rms ⌧0.5625 / 2 ⌧ = 0.5 + ⌧ ⌧ = 0.526 A. 3 ⌧ ⌧ 2 DiL = 0.5625 ⌧1 1 - D ⌧ ⌧1 ⌧ 1 - .25 peak : I L ,max = Vo ⌧ + = 1.5 ⌧ + ⌧ ⌧= 0.781 A. -6 ⌧R 2 Lf ⌧ ⌧3 2(5)(10) (400,000) ⌧ ⌧1 1 - D ⌧ I L,min = Vo ⌧ ⌧= 0.219 A. ⌧R 2 Lf ⌧ c) Ps = Po ⌧ Vs I s = Vo I R ⌧ I s = Vo I R 1.5(0.5) = = 0.125 A. Vs 6 d) I D ,max = I L,max = 0.781 A. I D = I o - I s = 0.5 - 0.125 = 0.375 A. 6-8) Io = I L = D= Po 25 = = 1.25 A. Vo 30 Vo 20 = = 0.667 Vs 30 DiL 2 DiL = (I L - I L ,min)2 = (1.25 - 0.31)2 = 1.88 A. I L,min = (0.25)(1.25) = 0.31 A. = I L - Vo (1 - D)T L V 1 20 1 = 89 m H L = o (1 - D) = (1 - .667) DiL 40000 f 1.88 DiL = Descargado por David Ruiz () lOMoARcPSD|4419572 6-9) Lmin = D= (1 - D) R 2f Vo 20 20 ; Dmax = = 0.4; Dmin = = 0.33 Vs 50 60 IL = IR = Po 75 125 ; I R ,min = = 3.75 A.; I R ,max = 6.25 A. Vo 20 20 Vo 202 202 R = ; Rmax = = 5.33 W; Rmin = = 3.20 W P 75 125 (1 - Dmin) Rmax (1 - .33)(5.33) Lmin = = = 17.76 m H 2f 2(100, 000) 6-10) (1 - D)(R) 2f Lmin = f = 200 kHz Vo=5 V Vs, V D I, A. R, Ω Lmin, µH 10 0.5 0.5 10 12.5 10 0.5 1.0 5 0.5 10 6.25 16.7 (worst case, D = 1/3, R = 10) 1.0 5 8.33 15 15 1/3 1/3 L= Lmin 6-11) (1 - Dmin) Rmax 2f ⌧ 1⌧ 1- ⌧ (10) ⌧ 3⌧ ⌧ = = 16.67 m H (200 k) Example design: Descargado por David Ruiz () lOMoARcPSD|4419572 D= Vo 15 = = 0.3125 Vs 48 Let f = 100 kHz (for example) V ⌧ Let DiL = 40% of I L = 0.40 ⌧ o ⌧R L= C= 15 ⌧ ⌧ ⌧ ⌧= 0.40 ⌧8 ⌧= 0.75 A ⌧ ⌧ ⌧ (Vs - Vo) D (48 - 15) 0.3125 = = 137.5 m H (DiL) f (0.75) 100,000 1- D 1 - 0.3125 = = 12.5 m F ⌧DVo ⌧ 8 (150) 10-6 (0.005)100,000 8L ⌧ ⌧f ⌧Vo ⌧ Other values of L and C are valid if the inductor current is continuous with margin. 6-12) (Based on the example design in 6-11) Vmax, switch = Vs = 48 V Vmax, diode = Vs = 48 V Imax, switch = ILmax = 1.5 + 0.75/2 = 1.875 A Iavg, switch = Irms, switch Vo Io 15 (1.875) = = 0.586A Vs 48 1 = T DT i (t)d t = 1.06 A (numerically) ⌧ 2 L 0 Imax,diode = ILmax = 1.875 A Iavg,diode =IL- Iavg,switch = 1.875 – 0.586 = 1.289 A T Irms,diode = 1 i 2L (t)d t = 1.56 A (numerically) T DT ⌧ 6-13) Example design: Descargado por David Ruiz () lOMoARcPSD|4419572 D= Vo 15 = = 0.625 Vs 24 Let f = 400 kHz (for example) Let DiL = 40% of I L = 0.40 (2) = 0.8 A L= C= (Vs - Vo) D = (24 - 15) 0.625 = 17.6 m H (0.8) 400,000 (DiL) f 1- D 1 - 0.625 = = 1.67 m F ⌧DVo ⌧ 8 (17.6) 10-6 (0.01)400,000 8L ⌧ ⌧f ⌧Vo ⌧ 6-14) Example design: D= Vo 12 = = 0.667 Vs 18 Let f = 200 kHz (for example) I L = Io = Po 10W = = 0.833 A Vo 12V Let DiL = 40% of I L = 0.40 (0.833) = 0.333 A L= C= (Vs - Vo) D = (18 - 12) 0.667 = 60 m H (DiL) f (0.333) 200,000 1- D 1 - 0.667 = = 3.5 m F 0.1 ⌧ ⌧DVo ⌧ -6 ⌧ 200,000 8L ⌧ ⌧f 8 (60) 10 ⌧ ⌧ ⌧12 ⌧ ⌧Vo ⌧ Other values of L and C are valid if the inductor current is continuous with margin. Descargado por David Ruiz () lOMoARcPSD|4419572 6-15) n = 1 ⌧ V1 = 30.27 Using ac circuit analysis, Vo1 = 0.048 V = 2(0.048) = 0.096 V p - p 0.096 0.096 = = 0.48% Vo 20 DVo = 0.469% Vo Using Eq. 6 -16, The output voltage is mainly the dc term and the first ac term. 6-16) a) rC = 0.5 W, DiL = 2.88 A = DiC DVo ,ESR = DiC rC = 2.88(0.5) = 1.44 V . DVo 1.44 = = 8% 18 Vo b) DVo ⌧0.5% Vo DVo ⌧DVo ,ESR = DiC rC ⌧ rC = rC = 50(10) -6 C ⌧ C= DVo 0.005(18) = = 0.031 W DiC 2.88 50(10) -6 50(10) -6 = = 1600 m F . rC 0.031 6-17) Descargado por David Ruiz () lOMoARcPSD|4419572 20 Vs = = 50 V . 1 - D 1 - .6 Vs 20 b) I L = = = 10 A. 2 (1 - D) R (1 - .6) 2 (12.5) Vs V DT 20 20(.6) / (200,000) I max = + s = + = 13 A. 2 2 (1 - D) R 2L (1 - .6) (12.5) 2(10)(10) -6 Vs V DT I min = - s = 7.0 A. 2 (1 - D) R 2L DVo D 0.6 c) = = = 0.6% Vo RCf 12.5(40)(10) -6 (200,000) a) Vo = d) ID = Io = Vo 50 = = 4.0 A. R 12.5 6-18) Inductor current: (see Example 2-8) 2 I L, rms 2 ⌧DI / 2 ⌧ ⌧4.61/ 2 ⌧ = I + ⌧ L ⌧ = 102 + ⌧ ⌧ = 10.09 A. ⌧ 3 ⌧ ⌧ 3 ⌧ 2 L Capacitor current: (define t=0 at peak current) Descargado por David Ruiz () lOMoARcPSD|4419572 1/2 I C ,rms 10 m s 25 m s ⌧ 1 ⌧ ⌧ ⌧ 5 2 2 (4.61(10) t 8.3) dt (4) dt =⌧ + + = 4.97 A. ⌧ ⌧ ⌧ -6 ⌧⌧ ⌧ ⌧ 25(10) ⌧ ⌧ 0 10 s m ⌧ ⌧ ⌧ ⌧ 6-19) Vo = Vs V 5 ⌧ D = 1 - s = 1 - = 0.667 1- D Vo 15 Vo2 152 = =9 W 25 25 Vs 5 IL = = = 5 A. 2 (1 - D) R (1 - .667) 2 (9) I L ,min = 0.5(5) = 2.5 A. ⌧ DI L = 5 A. R= DI L = Vs DT 5(.667) / 300 = = 2.22 m H 5 DI L From Eq. 6 - 27, C = D 0.667 = = 24.7 m F . ⌧ Vo ⌧ 9(.01)(300, 000) R⌧ D ⌧f ⌧ Vo ⌧ Descargado por David Ruiz () lOMoARcPSD|4419572 6-20) Example design: D =1- R= Vs 12 = 1 - = 0.333 Vo 18 Vo2 182 = = 16.2 W P 20 Vs IL = (1- D) 2 = R 12 (1 - .333) 2 16.2 = 1.67 A Let f = 200 kHz Let DiL = 40% of I L = 0.4 (1.67) = 0.667 A L= 12 (0.333) Vs D = = 30 m H (DiL) f (0.667)200,000 (Lmin C= for continuous current = 6 m H) D ⌧DV R⌧ o ⌧Vo ⌧ ⌧f ⌧ = 0.333 = 20.6 m F 16.2 (0.005) 200,000 6-21) Using C = 48 m F , R = 50 W, ton = 0.6T = 0.6 = 24 m s 25000 vo (t) = Vo ,max e - t / RC vo (24 m s) = Vo ,max e -24/[(50)(48)] = Vo ,max (0.99005) Vo ,max - vo (24 m s) = DVo = Vo ,max - 0.99005Vo ,max ⌧0.01Vo,max DVo = 0.01 = 1% Vo Descargado por David Ruiz () lOMoARcPSD|4419572 6-22) 6-23) ⌧D ⌧ ⌧ 0.6 ⌧ = -12 ⌧ = -18 V . a) Vo = -Vs ⌧ ⌧ 1- D ⌧ 1 - 0.6 ⌧ ⌧ ⌧ ⌧ Vs D 12(.6) = = 4.5 A. b) Eq. 6 - 31: I L = 2 R (1 - D) (10)(1 - .6) 2 Vs D V DT 12(.6) / 200, 000 I L ,max = = s = 4.5 + = 6.3 A. 2 R (1 - D) 2L 2(10)(10) -6 Vs D V DT I L ,min = - s = 2.7 A. 2 R (1 - D) 2L DVo 0.6 D = = c) = 0.015 = 1.5% Vo RCf 10(20)(10)-6 (200, 000) Descargado por David Ruiz () lOMoARcPSD|4419572 6-24) Inductor current: (see Example 2-8) 2 I L,rms 2 ⌧DI / 2 ⌧ ⌧3.6 / 2 ⌧ = I + ⌧ L ⌧ = 4.52 + ⌧ ⌧ = 4.62 A. ⌧ 3 ⌧ ⌧ 3 ⌧ 2 L Capacitor current: For convenience, redefine t = 0 at the peak current. The current is then expressed as ( ) iC (t) = 4.5 - 1.8 106 t A for 2 m s < t < 5m s = -1.8 A T I rms = 1 2 i (t) dt T⌧ 0 for 0 < t < 2m s T= 1 1 = = 5 (10-6) = 5m s f 200, 000 1/2 I C , rms 5m s ⌧ 1 ⌧2 m s ⌧ ⌧ 2 -6 2 ⌧ ⌧ =⌧ 4.5 1.8 10 dt + (1.8) dt ⌧ = 2.30 A. ⌧ ⌧ ( ) -6 ⌧⌧ ⌧ ⌧ ⌧ ⌧ 5(10) ⌧ ⌧ m 0 2 s ⌧ ⌧ ⌧ ⌧ Descargado por David Ruiz () lOMoARcPSD|4419572 6-25) a) From Eq. 6-48, D = Vo 36 = = 0.6 Vs + Vo 24 + 36 Vs D 24(.6) = = 9 A. ⌧ I L ,min = 0.4(9) = 3.6 A. 2 R (1 - D) 10(1 - .6) 2 DI L = 2(9 - 3.6) = 10.8 A. IL = From Eq. 6-28, L = Vs DT 24(.6) = = 13.3 m H DI L 10.8(100, 000) b) From Eq. 6-36, C = D 0.6 = = 120m F ⌧DVo ⌧ 10(0.005)(100,000) R ⌧ ⌧f ⌧Vo ⌧ 6-26) Example design: Vo Using Eq. (6-48), D= Using Eq. (6-49), IL = R= Vs + Vo = 50 = 0.556 40 + 50 P 75 = = 3.375 A. Vs D 40 (0.556) Vo2 502 = = 33.3 W P 75 Letting f = 100 kHz (designer's choice), (1 - D) 2 R (1 - 0.556) 2 33.3 Lmin = = = 32.9 m H 2f 2 (100, 000) Choose L at least 25% larger than L min (41 m H). A common practice is to select L such that Di L = 40% of I L = 0.40 (3.375) = 1.35 A. Using Eq. (6-45), L= 40 (0.556) Vs D = = 165 m H DiL f 1.35 (100, 000) Using Eq. (6-54), C= D ⌧DV ⌧ R ⌧ o ⌧f ⌧Vo ⌧ = 0.556 = 16.7 m F 33.3 (0.01) (100, 000) Descargado por David Ruiz () lOMoARcPSD|4419572 6-27) Example design: Using Eq. (6-48), and D = D= Vo Vs + Vo , D= 15 = 0.556 for the 12-V source, 12 + 15 15 = 0.455 for the 18-V source. 18 + 15 Using Lmin = (1 - D) 2 R 2f , the worst case is for D = 0.455 for the 18-V source. (1 - 0.455) 2 15 Letting f = 100 kHz (designer's choice), Lmin = = 22.3 m H 2 (100, 000) Choose L at least 25% larger than L min (28 m H). Alternatively, a common practice is to select L such that Di L = 40% of I L . Il = Vo2 152 = = 1.83 A Vs RD 18 (15) (0.455) DiL = 0.40 (1.83) = 0.73 A. Using Eq. (6-45), L= 18 (0.455) Vs D = = 112 m H (100 m H will be fine) DiL f 0.73 (100, 000) Using Eq. (6-54), C= C= D ⌧DV ⌧ R ⌧ o ⌧f ⌧Vo ⌧ , so base C on D = 0.556, (12-V source): 0.556 = 37 m F 15 (0.01) (100, 000) Descargado por David Ruiz () lOMoARcPSD|4419572 6-28) Using the equations Vo D= R= Vs + Vo Vo2 P Lmin = IL = C= (1- D) 2 R 2f P Vs D D ⌧DV R⌧ o ⌧Vo ⌧ ⌧f ⌧ and using f = 100 kHz (designer's choice), results are shown in the table. Vs, (V) 10 10 14 14 P (W) 10 15 10 15 D 0.545 0.545 0.462 0.462 R (Ω) 14.4 9.6 14.4 9.6 Lmin (µH) 14.9 9.9 20.9 13.9 IL (A) 1.83 2.75 1.55 2.32 C (µF) 37.9 56.8 32.1 48.1 The value of L should be based on Vs = 14 V and P = 10 W, where Lmin = 20.9 µH. Select the value of L at least 25% larger than Lmin (26.1 µF). Using another common criterion of ΔiL = 40% of IL, again for 14 V and 10 W, L = 104 µH. The value of C is 56.8 µF for the worst case of Vs = 10 V and P = 10 W. Descargado por David Ruiz () lOMoARcPSD|4419572 6-29) ⌧D ⌧ ⌧ 0.6 ⌧ Vo = -Vs ⌧ = -12 ⌧ = -18 V . ⌧ 1- D ⌧ 1 - 0.6 ⌧ ⌧ ⌧ ⌧ P V 2 R 27 I L2 = o = o = = 1.5 A. -Vo -Vo 18 I L1 = Po 27 = = 2.25 A. Vs 12 DiL1 = Vs D 12(.6) = = = 0.14 A. -6 Lf 200 (10) (250,000) DiL 2 = Vs D = 0.29 A. L2 f 6-30) D= 1 1 = = 0.333 V 20 1- s 1Vo -10 I L 2 = I o = 1 A. Vo ⌧10 ⌧ I L2 = ⌧ ⌧ (1) = 0.5 A. Vs ⌧20 ⌧ VD VD 20(0.333) DiL1 = s ⌧ L1 = s = = 1.33 mH L1 f DiL1 f 0.10(.5)(100,000) I L1 = DiL 2 = Vs D VD 20(0.333) ⌧ L2 = s = = 0.667 mH L2 f DiL 2 f 0.10(1)(100,000) Descargado por David Ruiz () lOMoARcPSD|4419572 6-31) Example design: Vo D -30 == = -1.2 ⌧ D = 0.5455 Vs 1 - D 25 Po 60 I L 2 ===⌧ D==2.0==⌧; -Vo 30 iL 2 0.4(2.0) 0.4 A L2 Vs D DiL 2 f P 60 I L1 ===s⌧D==2.4 ==⌧; Vs 25 iL1 0.4(2.4) 0.48 A L1 Vs D DiL1 f Let f = 100 kHz (designer's choice). 1- D 1 - 0.5455 = = 1.67 m F C2 ⌧ 2 -6 ⌧DVo ⌧ 0.01 8 341 10 100,000 2 ( ) ( ) 8L2 f ⌧ ⌧ ⌧Vo ⌧ ((VC1 = Vs - Vo = 25 - (-30) = 55 V)) ⌧ DvC1 = 0.05 (55) = 2.75 V 2 Using R = Vo2 / P = (-30) / 60 = 15 W, 30 (0.5455) VD = = 3.97 m F C1 ⌧ o Rf DvC1 15 (100,000) 2.75 Descargado por David Ruiz () 25 (0.5445) 0.4 (100,000) 25 (0.5445) 0.48 (100,000) 341 m F 284 m F lOMoARcPSD|4419572 6-32) D= Vo 12 = = 0.706 Vo + Vs 12 + 5 I L1 = Vo 2 122 = = 7.2A Vs R 5(4) Di L1 = Vs D (5)(0.706) = = 3.53A L1f 10(10)-6 (100,000) I L1,max = 7.2 + 3.53 = 8.96A 2 I L1,min = 7.2 - 3.53 = 5.44A 2 I L2 = Vo 12 = = 3A R 4 Di L1 = Vs D (5)(0.706) = = 1.765A L2f 20(10)-6 (100,000) I L2,max = 3 + 1.765 = 3.88A 2 I L2,min = 3 - 1.765 = 2.12A 2 Descargado por David Ruiz () lOMoARcPSD|4419572 6-33) Vo = Vs D 3.3(.7) = = 7.7V 1 - D 1 - .7 I L1 = Vo 2 7.7 2 = = 3.6A Vs R 3.3(5) Di L1 = Vs D (3.3)(0.7) = = 1.925A L1f 4(10)-6 (300,000) I L1,max = 3.6 + 1.925 = 4.56A 2 I L1,min = 3.6 - 1.925 = 2.64A 2 I L2 = Vo 7.7 = = 1.54A R 5 Di L1 = Vs D (3.3)(0.7) = = 0.77A L 2 f 10(10)-6 (300,000) I L2,max = 1.54 + 0.77 = 1.925A 2 I L2,min = 1.54 - 0.77 = 1.155A 2 DVC1 = DVC2 = Vo D (7.7)(.7) = = 0.0719V RCf 5(50)(10) -6 (300,000) 6-34) Equation (6-69) for the average voltage across the capacitor C1 applies: VC1 = Vs . When the switch is closed, the voltage across L2 for the interval DT is v L2 = v C1 Assuming that the voltage across C1 remains constant at its average value of Vs vL2 = VC1 = Vs (switch closed) When the switch is open in the interval (1 - D)T, vL2 = -Vo (switch open) Descargado por David Ruiz () lOMoARcPSD|4419572 Since the average voltage across an inductor is zero for periodic operation, (v L2, sw closed) (DT) + (v L2, sw open) (1 - D) T = 0 Vs (DT) - Vo (1 - D) T = 0 resulting in ⌧D ⌧ Vo = Vs ⌧ ⌧ 1- D ⌧ ⌧ 6-35) I L1 = Is = Vo 2 62 = = 1.2A Vs R (15)(2) D= Vo 6 = = 0.286 Vo + Vs 6 + 15 L1 = Vs D (15)(0.286) = = 35.7mH (Di L1)f 0.4(1.2)250,000 I L2 = I o = L2 = Vo 6 = = 3A R 2 Vs D (15)(0.286) = = 14.3mH (Di L2)f 0.4(3)250,000 VC2 = Vo = 6 DVC2 = DVo = Vo D RC 2f or C2 = 0.286 D = = 28.6mF ⌧DVo ⌧ 2(.02)250,000 R⌧ ⌧ f ⌧Vo ⌧ C1 = C2 = 28.6mF Descargado por David Ruiz () lOMoARcPSD|4419572 6-36) D= Vo 2.7 = = 0.231 Vo + Vs 2.7 + 9 R= 2.7 = 2.7W 1 I L1 = Vo 2 2.72 = = 0.30A Vs R 9(2.7) L1 = Vs D 9(0.231) = = 57.7mH (Di L1) f 0.4(0.30)300,000 I L2 = I o = 1A L2 = Vs D 9(0.231) = = 14.2mH (Di L2) f 0.4(1)300,000 6-37) DiC = I L ,max = 2.7 A. DVO , ESR = DiC rC = (2.7)(0.6) = 1.62 V . DVO , ESR VO = 1.62 = 0.054 = 5.4% 30 Worst case : DVO = DVO ,C + DVO , ESR = 0.3 + 1.63 = 1.92 V . = 6.4% 6-38) Switch closed : vL = Vs - VQ Switch open : vL = VO - VD avg (vL) = 0 : (Vs - VQ) DT + (VO - VD)(1 - D)T = 0 ⌧D ⌧ \ VO = VD - (Vs - VQ) ⌧ ⌧ 1- D ⌧ ⌧ Descargado por David Ruiz () lOMoARcPSD|4419572 6-39) (1 - D) R L 2 f 97.5(10) -6 (2)(40000) ⌧ Rmax = = = 12.5 W 2f 1- D 1 - .375 b) For R=20Ω, current is discontinuous: a) Lmin - ⌧ ⌧ 2D Vo = Vs ⌧ ⌧ 8L 2 ⌧D + D + RT ⌧ \ 18 ⌧Vo ⌧21.4 V . ⌧ ⌧ ⌧ ⌧ 2(0.375) ⌧= 48 ⌧ ⌧ ⌧ 8(97.5)(10) -6 2 ⌧ ⌧0.375 + (0.375) + ⌧ ⌧ 20 / 40000 ⌧ ⌧ ⌧= 21.4 V . ⌧ ⌧ ⌧ (1 - D) R (1 - 0.375)(20) = = 6.25 2 2 6.25 6.25 Increase Lf min : e.g ., Lmin = = 157 m H or f min = = 64.1 kHz 40000 97.5 mH c) Lf min = 6-40) 2 Lf 2(120)(10) -6 (25000) a) Rmax = = = 62.5 W for continuous current D(1 - D) 2 0.6(1-).6) 2 b) For R=100Ω, the current is discontinuous: ⌧ 2 D 2 RT ⌧ 1+ 1+ ⌧ ⌧ L ⌧ ⌧ Vo = Vs ⌧ ⌧ 2 ⌧ ⌧ ⌧ ⌧ ⌧ 2(.6) 2 (100) / 25000 1+ 1+ ⌧ 120(10) -6 Vo = 12 ⌧ ⌧ 2 ⌧ ⌧ ⌧ \ 30 ⌧Vo ⌧36 for 25 ⌧R ⌧100 c) Lf min = 4.8 ⌧ L > ⌧ ⌧ ⌧= 36 V . ⌧ ⌧ ⌧ ⌧ 4.8 4.8 = 192 m H or f > = 40 kHz. 25000 120(10)-6 Descargado por David Ruiz () lOMoARcPSD|4419572 6-41) Discontinuous current for the buck-boost converter: Let DT be the time that the switch is closed and D1T be the time that the switch is open and the current in the inductor is positive. For a lossless converter, the output power is the same as the input power. ⌧I D ⌧ Ps = Vs I s = Vs ⌧max ⌧ ⌧ 2 ⌧ V DT I max = s L 2 2 V DT Ps = s 2L 2 V Po = o R 2 2 Vs D T Vo2 = 2L R Vo RT =D Vs 2L 6-42) When switches “1” are closed, C1 and C2 are connected in series, each having Vs/2 volts. When the “1” switches are opened and the “2” switches are closed, Vo = Vs of the source plus Vs/2 of C1, making Vo = 1.5Vs. 6-43) Descargado por David Ruiz () lOMoARcPSD|4419572 20W p(t) for the MOSFET 10W 0W (1.000m,405.19m) Average P = 405 mW -10W 0.990ms W(M1) 0.992ms AVG(W(M1)) 0.994ms 0.996ms Time Descargado por David Ruiz () 0.998ms 1.000ms lOMoARcPSD|4419572 6-44) Simulate the buck converter of Example 6-1 using PSpice. (a) Use an ideal switch and ideal diode. Determine the output ripple voltage. Compare your PSpice results with the analytic results in Example 6-1. (b) Determine the steady-state output voltage and voltage ripple using a switch with an on resistance of 2 Ω and the default diode model Using Ron =0.01 for the switch and n=0.01 for the diode, the p-p ripple voltage is 93.83 mV. 93.83/20 = 0.469%, agreeing precisely with the analytical results. With Ron = 2 ohms, the p-p ripple is 90 mV, with a reduced average value. Descargado por David Ruiz () lOMoARcPSD|4419572 6-45) Note that for each converter topology, the average voltage across each inductor is zero, and the average current in each capacitor is zero. Buck Converter: Show from Eqs. (6-9) and (6-17) Vo = Vs D and Is D Io = From the averaged circuit of Fig. 6.33b, I L = Io = i c Vap = Vs and and ⌧ Is = Dic Io = ⌧ Vo = DVap Is D Vo = DVs Boost Converter: Show from Eqs. (6-27) and (6-28) that Vo = Vs 1- D Io = Is (1 - D) and From the averaged circuit of Fig. 6.33c, DVap = Vs - Vo and Io = -ic + Dic = ic (D - 1) Vap = - Vo and ⌧ Is = -ic Vo = ⌧ Descargado por David Ruiz () Vs 1- D I o = Is (1 - D) lOMoARcPSD|4419572 Buck-Boost Converter: Show from Eqs. (6-47) and (6-49) and preceding equations that ⌧D ⌧ Vo = -Vs ⌧ 1- D ⌧ ⌧ ⌧ and Is = I L D From the averaged circuit of Fig. 6.33d, I L = ic and ⌧ Is = Di c Vap = Vs - Vo and Is = I L D Vo = -DVap ⌧ ⌧D ⌧ Vo = -Vs ⌧ 1- D ⌧ ⌧ ⌧ Ćuk Converter: Show from Eqs. (6-59) and (6-61) that IL1 D = I L2 1 - D ⌧D ⌧ Vo = -Vs ⌧ 1- D ⌧ ⌧ ⌧ and From the averaged circuit, Vap = Vs - Vo and DVap = -Vo i c = Di c + I L2 and I L1 = Di c ⌧ ⌧ ⌧D ⌧ Vo = -Vs ⌧ 1- D ⌧ ⌧ ⌧ I L1 D = I L2 1 - D Descargado por David Ruiz ()

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