

ISL6420B
DESIGN CALCULATIONS
FOR THE
FIREMC-PIHAT (FIREMC-3.14)
3.3 VOLTS DC

REQUIRED REFERENCES:

INTERSIL ISL6420B DATASHEET <[HTTP://WWW.INTER-SIL.COM/EN/PRODUCTS/POWER-MANAGEMENT/SWITCHING-CONTROLLERS/SINGLE-OUTPUT---BUCK-CONTROLLERS/ISL6420B.HTML](http://www.intersil.com/en/products/power-management/switching-controllers/single-output---buck-controllers/isl6420b.html)>

ST MICROELECTRONICS STD86N3LH5 DATASHEET
<[HTTP://WWW.ST.COM/CONTENT/ST_COM/EN/PRODUCTS/POWER-TRANSISTORS/POWER-MOSFETS/N-CHANNEL-STRIPFET-12-V-TO-30-V/STD86N3LH5.HTML](http://www.st.com/content/st_com/en/products/power-transistors/power-mosfets/n-channel-stripfet-12-v-to-30-v/std86n3lh5.html)>

SCHELLE, D. ET AL: (2006, JUNE). BUCK-CONVERTER DESIGN DEMYSTIFIED. *POWER ELECTRONICS TECHNOLOGY*. RETRIEVED FROM [HTTP://POWEELECTRONICS.COM/DC-DC-CONVERTERS/BUCK-CONVERTER-DESIGN-DEMYSTIFIED](http://powerelectronics.com/dc-dc-converters/buck-converter-design-demystified)

$$V_{IN_{MIN}} = 11V$$

$$V_{OUT} = 3.3V$$

$$f_{SW} = 300kHz$$

$$T_{A_{MAX}} = 60^{\circ}C$$

$$V_{IN_{NOM}} = 12V$$

$$V_{OUT_{RIPPLE}} = 0.02 \cdot V_{OUT} = 0.066V$$

$$LIR = 0.3$$

$$\Delta V = 0.1V$$

$$V_{IN_{MAX}} = 13V$$

$$I_{OUT_{MAX}} = 4A$$

$$T_{J_{MAX}} = 115^{\circ}C$$

$$V_{IN_{RIPPLE}} = 0.075V$$

$$L = \frac{(V_{IN_{MAX}} - V_{OUT}) \cdot V_{OUT}}{V_{IN_{MAX}} \cdot f_{SW} \cdot LIR \cdot I_{OUT_{MAX}}}$$

$$L = 6.840\mu H$$

$$\text{CHOOSE } 6.8\mu H$$

$$\Delta I_L = LIR \cdot I_{OUT_{MAX}} = \frac{(V_{IN_{MAX}} - V_{OUT}) \cdot V_{OUT}}{V_{IN_{MAX}} \cdot f_{SW} \cdot L}$$

$$\Delta I_L = 1.2A$$

$$\Delta I_{L_{ACT}} = 1.21A$$

$$I_{OUT_{PK}} = I_{OUT_{MAX}} + \frac{\Delta I_{L_{ACT}}}{2}$$

$$I_{OUT_{PK}} = 4.604A$$

$$I_{L_{SAT}} > I_{OUT_{PK}} \cdot 1.2$$

$$I_{L_{SAT}} > 5.524A$$

$$C_O = \frac{L \cdot \left(I_{OUT_{MAX}} + \frac{\Delta I_{L_{ACT}}}{2} \right)^2}{(\Delta V + V_{OUT})^2 - V_{OUT}^2} = \frac{L \cdot I_{OUT_{PK}}^2}{(\Delta V + V_{OUT})^2 - V_{OUT}^2}$$

$$C_O = 215\mu F$$

$$C_{O_{ACT}} = C_O \cdot 1.2$$

$$C_{O_{ACT}} = 258\mu F$$

$$\text{CHOOSE } 3 \times 150\mu F = 450\mu F$$

$$V_{OUT_{CAP}} = \frac{1}{2 \cdot C_O} \cdot \frac{V_{IN_{MAX}} - V_{OUT}}{L} \cdot \left(\frac{V_{OUT}}{V_{IN_{MAX}}} \cdot \frac{1}{f_{SW}} \right)^2$$

$$V_{OUT_{ESR}} = \Delta I_{L_{ACT}} \cdot ESR_{C_O}$$

$$V_{OUT_{RIPPLE}} = V_{OUT_{CAP}} + V_{OUT_{ESR}} = \frac{1}{2 \cdot C_O} \cdot \frac{V_{IN_{MAX}} - V_{OUT}}{L} \cdot \left(\frac{V_{OUT}}{V_{IN_{MAX}}} \cdot \frac{1}{f_{SW}} \right)^2 + \Delta I_{L_{ACT}} \cdot ESR_{C_O}$$

$$ESR_{C_O} = \frac{1}{\Delta I_{L_{ACT}}} \cdot \left(V_{OUT_{RIPPLE}} - \frac{1}{2 \cdot C_O} \cdot \frac{V_{IN_{MAX}} - V_{OUT}}{L} \cdot \left(\frac{V_{OUT}}{V_{IN_{MAX}}} \cdot \frac{1}{f_{SW}} \right)^2 \right)$$

$$ESR_{C_O} \leq 0.054 \Omega$$

COMBINE CAPS IN PARALLEL TO SO EFFECTIVE ESR IS LESS THAN OR EQUAL TO THE ABOVE VALUE.

$$I_{C_{I_{RMS}}} = I_{OUT_{MAX}} \cdot \frac{\sqrt{V_{OUT} \cdot (V_{IN_{MIN}} - V_{OUT})}}{V_{IN_{MIN}}}$$

$$I_{C_{I_{RMS}}} = 1.833A$$

$$C_{IN_{MIN}} = \frac{I_{OUT_{MAX}} \cdot \frac{V_{OUT}}{V_{IN_{NOM}}} \cdot \left(1 - \frac{V_{OUT}}{V_{IN_{NOM}}} \right) \cdot 1000}{f_{SW} \cdot V_{IN_{RIPPLE}}}$$

$$C_{IN_{MIN}} = 35.44 \mu F$$

$$ESR_{C_{IN}} \leq \frac{V_{IN_{RIPPLE}}}{2 \cdot \sqrt{3} \cdot I_{C_{I_{RMS}}}}$$

$$ESR_{C_{IN}} \leq 0.012 \Omega$$

$$T_{J_{RISE}} = T_{J_{MAX}} - T_{A_{MAX}}$$

$$T_{J_{RISE}} = 55^{\circ}C$$

$$P_{D_{TOT}} = \frac{T_{J_{RISE}}}{\Theta_{JA}} \quad \Theta_{JA} \text{ FROM STD86N31H5 DATASHEET IS } 50^{\circ}C \text{ (R}_{thj-pcb} \text{ ON THE DATASHEET)}$$

$$P_{D_{TOT}} = 1.1W$$

$$R_{DS(ON)_{HOT}} = R_{DS(ON)_{25}} \cdot [1 + 0.005 \cdot (T_{J_{HOT}} - 25^{\circ}C)]$$

$$R_{DS(ON)_{25}} \leq \frac{V_{IN_{MIN}}}{V_{OUT}} \cdot \frac{1}{I_{OUT_{MAX}}^2 \cdot [1 + 0.005 \cdot (T_{J_{HOT}} - 25^{\circ}C)]} \cdot P_{D_{TOT}} \cdot 0.6$$

$$R_{DS(ON)_{25}} \leq 0.0948 \Omega \quad \text{STD86N31H5 } R_{DS(ON)_{25}} \leq 0.0065 \Omega \text{ (FROM DATASHEET)}$$

$$R_{DS(ON)_{HOT}} = 0.009425 \Omega \quad @ \quad R_{DS(ON)_{25}} = 0.0065$$

$$P_{D_{RDS}} = \frac{V_{OUT} \cdot I_{OUT_{MAX}}^2 \cdot R_{DS(ON)_{HOT}}}{V_{IN_{MIN}}}$$

$$P_{D_{RDS}} = 0.04524W$$

***** ESTIMATE (REQUIRES LAB VERIFICATION) *****

$$P_{DSW} = \frac{C_{RSS} \cdot V_{INMAX}^2 \cdot f_{SW} \cdot I_{OUTMAX}}{I_{GATE}} \quad \text{WHERE} \quad C_{RSS} = 58pF \quad \text{AND} \quad I_{GATE} = 0.7A$$

$$P_{DSW} = 0.0168W$$

$$P_D = P_{DRDS} + P_{DSW}$$

$$P_D = 0.06204W$$

$$T_{JRISEEST} = P_D \cdot \Theta_{JA}$$

$$T_{JRISEEST} = 3.1022^{\circ}C$$

$$T_{JEST} = T_{JRISEEST} + T_{AMAX}$$

$$T_{JEST} = 63.1022^{\circ}C$$

***** END ESTIMATE *****

THE FOLLOWING CALCULATIONS REQUIRE THE ISL6420B DATASHEET AS THE COMPONENT REFERENCES USED IN THE CALCULATIONS COME RIGHT FROM THE DATASHEET AND NOT THE FIREMC-PIHAT (FIREMC-3.14) DESIGN SCHEMATIC.

$$I_{OC} > I_{LSAT}$$

$$I_{OC} > 5.524A$$

$$I_{OC} = 5.6A$$

$$I_{OC} = \frac{I_{OCSET} \cdot R_{OCSET}}{R_{DS(ON)MAX}}$$

$$R_{DS(ON)90} \approx 1.375 \cdot R_{DS(ON)25}$$

$$R_{DS(ON)90} \approx 0.008936\Omega$$

$$R_{DS(ON)90} = R_{DS(ON)MAX}$$

$$R_{OCSET} = \frac{I_{OC} \cdot R_{DS(ON)90}}{I_{OCSET}} \quad \text{WHERE} \quad I_{OCSET} = 100\mu A \quad 0.0001A$$

$$R_{OCSET} = 500.5\Omega \quad \text{CHOOSE} \quad 499\Omega$$

$$f_{LC} = \frac{1}{2 \cdot \pi \cdot \sqrt{L \cdot C_O}} \quad \text{WHERE} \quad C_O = 450\mu F \quad \text{AND} \quad L = 6.8\mu H$$

$$f_{LC} = 2877kHz$$

$$f_{ESR} = \frac{1}{2 \cdot \pi \cdot ESR_{CO(ACT)} \cdot C_O} \quad \text{WHERE} \quad ESR_{CO(ACT)} = 0.0533\Omega$$

$$f_{ESR} = 6636kHz$$

$$V_{FB} = V_{OUT} \cdot \frac{R4}{R1 + R4} \quad \text{WHERE} \quad V_{FB} = V_{REF} = 0.6V \quad \text{AND} \quad R1 = 10k\Omega$$

$$R4 = \frac{V_{FB} \cdot R1}{V_{OUT} - V_{FB}}$$

$$R4 = 2.222k\Omega \quad \text{CHOOSE} \quad 2.21k\Omega$$

$$\frac{R2}{R1} = 5.62$$

$$R2 = 5.62 \cdot R1$$

$$R2 = 56.2k\Omega$$

$$f_{Z1} = 0.75 \cdot f_{LC} = \frac{1}{2 \cdot \pi \cdot R2 \cdot C1}$$

$$C1 = \frac{1}{2 \cdot \pi \cdot R2 \cdot 0.75 \cdot f_{LC}}$$

$$C1 = 1.312nF \quad \text{CHOOSE} \quad 1300pF$$

$$f_{Z2} = f_{LC} = \frac{1}{2 \cdot \pi \cdot (R1 + R3) \cdot C3}$$

$$f_{Z2} = \frac{1}{2 \cdot \pi \cdot \left(R1 + \left(\frac{1}{2 \cdot \pi \cdot \left(\frac{f_{SW}}{2} \right) \cdot C3} \right) \right) \cdot C3}$$

$$C3 = \frac{\frac{f_{SW}}{2} - 1}{\frac{2 \cdot f_{LC}}{2 \cdot \pi \cdot R1 \cdot f_{SW}}}$$

$$C3 = 5.426nF \quad \text{CHOOSE} \quad 5600pF$$

$$f_{P2} = \frac{f_{SW}}{2} = \frac{1}{2 \cdot \pi \cdot R3 \cdot C3}$$

$$R3 = \frac{1}{2 \cdot \pi \cdot \frac{f_{SW}}{2} \cdot C3}$$

$$R3 = 195.56\Omega \quad \text{CHOOSE} \quad 196\Omega$$

$$f_{P1} = f_{ESR} = \frac{1}{2 \cdot \pi \cdot R2 \cdot \frac{C1 \cdot C2}{C1 + C2}}$$

$$C2 = \frac{C1}{(f_{ESR} \cdot 2 \cdot \pi \cdot R2 \cdot C1) - 1}$$

$$C2 = 63.245pF$$

CHOOSE

62pF