# ISL6420B

# Design Calculations

# for the

# FireMC-PiHat (FireMC-3.14)

**Required references:**


Intersil ISL6420B Datasheet < 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>

Schelle, D., et al: (2006, June). Buck-Converter Design Demystified. *Power Electronics Technology.* Retrieved from http://powerelectronics.com/dc-dc-converters/buck-converter-design-demystified

# ISL6420B DESIGN CALCULATIONS
FIREMC-3.14 PAGE 1

$V_{IN(MIN)} = 11V$ $\quad f_{SW} = 300\,000$
$V_{IN(NOM)} = 12V$ $\quad LIR = 0.30$
$V_{IN(MAX)} = 13V$ $\quad I_{OUT(MAX)} = 4A$
$V_{OUT} = 3V3$

$$L = \frac{(V_{IN(MAX)} - V_{OUT})\, V_{OUT}}{V_{IN(MAX)}\, f_{SW}\, LIR\, I_{OUT(MAX)}}$$

$= 6.84\,\mu H$ CHOOSE $6.8\,\mu H$

$$\Delta I_L = LIR\,(I_{OUT(MAX)}) = \frac{(V_{IN(MAX)} - V_{OUT})\, V_{OUT}}{V_{IN(MAX)}\, f_{SW}\, L}$$

$\approx 1.2A$

$$I_{OUT(PK)} = I_{OUT(MAX)} + \frac{\Delta I_L}{2}$$

$= 4 + 1.2$
$= 5.2A$ CHOOSE $I_{L(SAT)} > I_{OUT(PK)}(1.2) = 6.26A$

$$\Delta I_{L(ACT)} = \frac{(V_{IN(MAX)} - V_{OUT})\, V_{OUT}}{V_{IN(MAX)}\, f_{SW}\, L}$$

$= 1.21A$

$$C_O = \frac{L\left(I_{OUT(MAX)} + \frac{\Delta I_{L(ACT)}}{2}\right)^2}{(\Delta V + V_{OUT})^2 - V_{OUT}^2} \qquad \Delta V = 0.1V$$

$= 276\,\mu F$

$C_{O(ACT)} = C_O + 20\%$

$= 331\,\mu F$ CHOOSE $470\,\mu F$

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

=

$V_{OUT(ESR)} = \Delta I_L (ESR_{CO})$ $\quad V_{OUT(RIPPLE)} = 2\% = 0.06V$

$$ESR_{CO} = \frac{1}{\Delta I_L} \left( V_{OUT(RIPPLE)} - \frac{V_{IN(MAX)} - V_{OUT}}{2 C_O L} \left( \frac{V_{OUT}}{V_{IN(MAX)} f_{SW}} \right)^2 \right)$$

$= 0.0537\ \Omega$

$$I_{CIRMS} = I_{OUT(MAX)} \frac{\sqrt{V_{OUT}(V_{IN} - V_{OUT})}}{V_{IN}}$$

$= 1.79A$

$$C_I = \frac{10\mu F}{1A} (I_{CIRMS}) \text{ TO } \frac{22\mu F}{A} (I_{CIRMS})$$

$= 17.9\mu F$ TO $39.4\mu F$

CHOOSE $20\mu F$ TO $40\mu F$

$T_{J(MAX)} = 115°C$
$T_{A(MAX)} = 60°C$

$T_{J(RISE)} = T_{J(MAX)} - T_{A(MAX)}$

$= 55°C$

$P_{D(TOT)} = \frac{T_{J(RISE)}}{\Theta_{JA}}$ $\quad \Theta_{JA} = 52°C/W$

$= 1.06\ W$

$R_{DS(ON)[HOT]} = [1 + .005(T_{JHOT} - 25°)]\, R_{DS(ON)25}$

$R_{DS(ON)25} = \left(\frac{V_{IN(MIN)}}{V_{OUT}}\right)\left(\frac{1}{I_{OUT(MAX)}^2\left[1 + .005(T_{JHOT} - 25°)\right]}\right)(P_{DTOT})(.6)$

$R_{DS(ON)25} \leq .091\ \Omega$ $\quad$ STD86N3LH5 $R_{DS(ON)25} \leq .0065\ \Omega$

** ESTIMATE (REQUIRES LAB VERIFICATION) **

$P_{D(SW)} = \frac{C_{RSS}(V_{IN(MAX)})^2(f_{SW})(I_{OUT(MAX)})}{I_{GATE}}$ $\quad C_{RSS} = 38pF$, $I_{GATE} = .7A$

$= .0168\ W$

** END ESTIMATE **

$R_{DS(ON)[HOT]} = .00942\ \Omega$

$P_{D(RDS)} = \frac{V_{OUT}\, I_{OUT(MAX)}^2\, R_{DS(ON)[HOT]}}{V_{IN(MIN)}}$

$= .45264\ W$

$P_D = P_{D(RDS)} + P_{D(SW)}$ $\quad T_{J(RISE)[EST]} = P_D(\Theta_{JA})$

$= .547\ W$ $\quad = 28.44$

$T_J = 88.44°$

$I_{OC} > I_{OUT(PK)} + 20\%$

$I_{OC} \geq 6.26A$

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

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

$\approx 0.0902\Omega$

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

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

$= 5670\Omega$ CHOOSE $5.76k\Omega$

* SEE FIGURE 17 SHEET 17 OF ISL6420B DATASHEET FOR THE BELOW

$$f_{LC} = \frac{1}{2\pi\sqrt{L(C_O)}}$$

$= 2877 Hz$

$$f_{ESR} = \frac{1}{2\pi(ESR_{CO} C_O)}$$

$ESR_{CO(ACT)} = 0.05333$

$= 6632 Hz$

$$V_1 = \frac{V_2 R_4}{R1+R_4}$$

$V_2 = V_{OUT}$

$V_1 = 0.594 - 0.606$

$$R4 = \frac{V1\ R1}{V2 - V1}$$

$$R4 = \frac{0.594\,(10000)}{3.3 - 0.594} \qquad R4 = \frac{0.606\,(10000)}{3.3 - 0.606}$$

$$= 2195\ \Omega \qquad = 2250$$

CHOOSE $R4 = 2.21k$

$R1 = 10k$

$R2/R1 = 5.62$

$R2 = 56.2k$

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

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

$= 1.66\,nF$ CHOOSE $1600pF$

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

$$f_{LC} = \frac{1}{2\pi \left(R1 + \frac{1}{2\pi (f_{SW}/2) C3}\right) C3} \qquad R3 = \frac{1}{2\pi (f_{SW}/2) C3}$$

$$C3 = \frac{\frac{f_{sw}/2}{f_{LC}} - 1}{2\pi R1 (f_{sw}/2)}$$

$= 6.88\,nF$ CHOOSE $6800\,pF$

$$R3 = \frac{1}{2\pi (f_{sw}/2) C3}$$

$= 156$ CHOOSE $158\,\Omega$

$$f_{p1} = \frac{1}{2\pi (R2)\left(\frac{C1 (C2)}{C1+C2}\right)} = f_{ESR}$$

$$\frac{C1\,C2}{C1+C2} = \frac{1}{2\pi (R2)(f_{p1})}$$

$$C1\,C2 = \frac{C1+C2}{2\pi (R2)(f_{ESR})}$$

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

$= 582.46\,pF$ CHOOSE $560\,pF$