Sanjaya Maniktala, 2013

Turns Ratio and Primary Inductance Calculator for LX7309 and IPS18

We will do this in several ways:

Example: Input 36V-57V, Output 12V 1A, f=150kHz using IPS18/LX7309

Duty cycle equation of Buck-Boost modified for Flyback: refected output voltage (V_{OR}) replaces output voltage (V_O)

$$V_{OR} = (\eta V_{IN}) \times \frac{D}{1-D}$$

Here η is estimated efficiency at the voltage V_{IN}

Set min Input V_{INMIN} $\quad V_{INMIN} = 36V$

Set expected efficiency at V_{INMIN} $\quad \eta_{MIN} = 0.75$

At this min voltage we must be at max duty cycle limit of controller and the reflected output voltage must be V_{OR}

$$V_{OR} = 36V \times 0.75 \times \frac{0.66}{1-0.66} = 52.4\ V$$

For LX7309 just set D_{MAX} = 0.44 instead of 0.66 as for IPS18 here...rest remains the same!

Set effective output (including 0.6V diode drop for non-synchronous topology) $\quad V_O$=12.6V

Turns ratio converts thereflected output voltage to actual output

$$n = \frac{N_P}{N_S} = \frac{V_{OR}}{V_O} = \frac{52.4}{12.6} = 4.16$$

Turns ratio required

In a Buck-Boost/Flyback, the center of ramp ("COR") of the current (on Secondary side in Flyback) is

$$I_{COR} \equiv \text{Average Inductor Current} = I_L = \frac{I_O}{1-D} \quad \text{(Buck-Boost)}$$

$$I_{COR\_SEC} = \frac{I_O}{1-D} \quad \text{(Flyback)}$$

So at minimum input condition we get

$$I_{COR\_SEC} = \frac{I_O}{1-D} = \frac{1A}{1-0.66} = 2.94\ A$$

Best operating condition (in CCM) is a current swing ΔI of about 0.3 to 0.4 at minimum input (about 0.4 to 0.45 at nominal operating). Let us set to 0.35 here

$$\Delta I = 0.35 \times I_{COR}$$

Turns Ratio and Primary Inductance Calculator for LX7309 and IPS18

There are actually two conditions here, for the Primary and Secondary sides in a Flyback, but they are related through turns ratio so we can use either the Secondary or Primary sides to do the calculations. Let us use the Primary side here.

From turns ratio we know that

$$\Delta I_{PRI} = 0.35 \times \frac{I_{COR\_SEC}}{n} = 0.35 \times \frac{2.94\,A}{4.16} = 0.247\ A$$

Now all we have to do is to find Primary Inductance using V=Ldi/dt

$$L_{PRI} = V_{INMIN} \times \frac{T_{ON}}{\Delta I_{PRI}} = \left(\eta \times V_{INMIN}\right) \times \frac{D / f}{\Delta I_{PRI}}$$

$$L_{PRI} = \left(0.75 \times 36V\right) \times \frac{0.66 / 150k}{0.247} = 481\mu H$$ ⬅

$$L_{PRI} = V_{OR} \times \frac{T_{OFF}}{\Delta I_{PRI}} = V_{OR} \times \frac{\left(1 - D_{MAX}\right) / f}{\Delta I_{PRI}}$$

$$L_{PRI} = V_{OR} \times \frac{T_{OFF}}{\Delta I_{PRI}} = 52.4 \times \frac{\left(1 - 0.66\right) / 150k}{0.247} = 481\mu H$$ ⬅

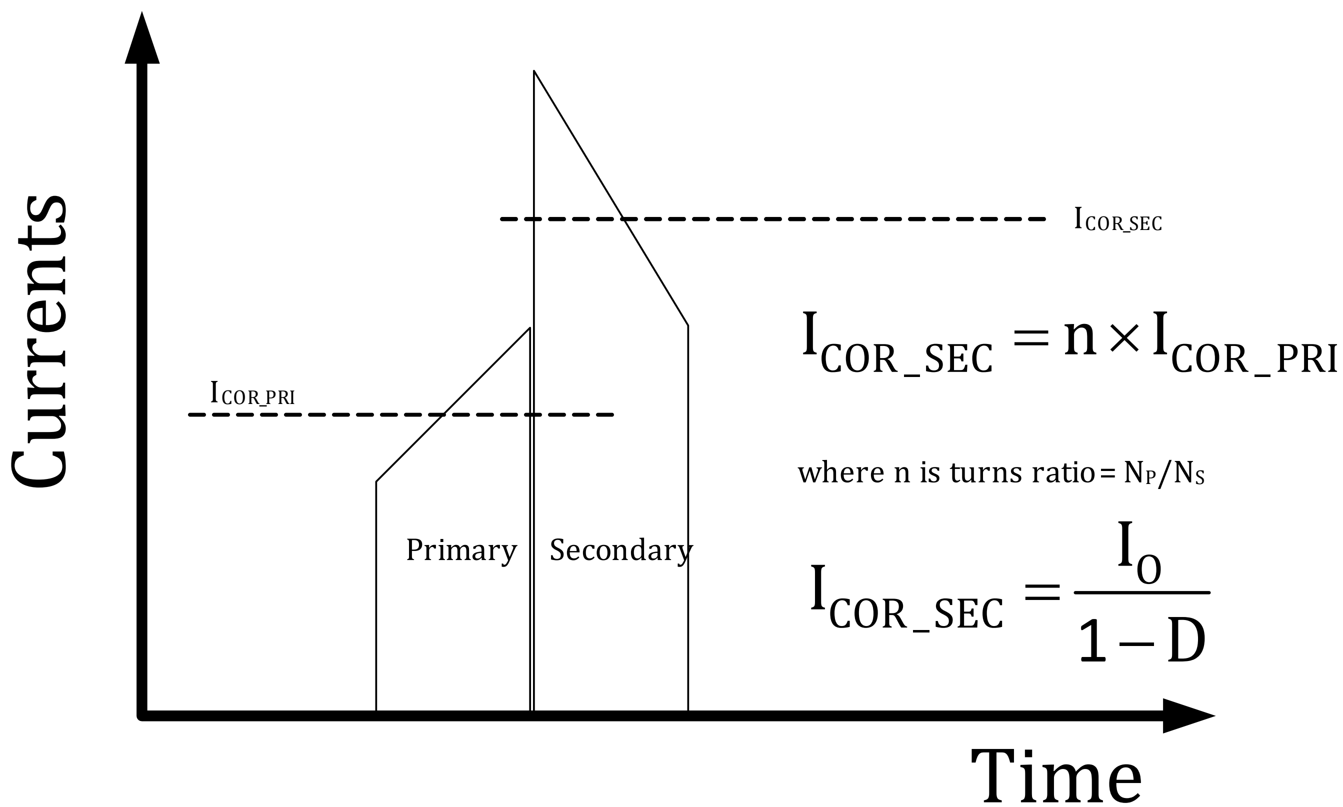
One-step Solution (using equation for Buck-Boost):

$$L_{SEC} = \frac{V_O}{I_O \times r \times f} \times \left(1 - D\right)^2 \quad \mu H$$

$$\frac{(12 + 0.6)}{1A \times 0.35 \times 150k} \times \left(1 - 0.66\right)^2 = 27.7\mu H$$

Reflecting this to get Primary Side Inductance

$$L_{PRI} = n^2 \times L_{SEC} = 4.16^2 \times 27.7\mu H = 480\mu H$$ ⬅


Currents
I_{COR_SEC}
I_{COR_PRI}
$I_{COR\_SEC} = n \times I_{COR\_PRI}$
where n is turns ratio = N_P/N_S
$I_{COR\_SEC} = \frac{I_O}{1-D}$
Primary
Secondary
Time