Design Guidelines for Buck Regulator using MP15X

Application Note

Prepared by Hommy Ding

June 07, 2012

ABSTRACT

This application note provides design guidelines for a buck regulator with current-mode control using MPS' MP15X series of regulators, including step-by-step instructions and experimental results using a design prototype.

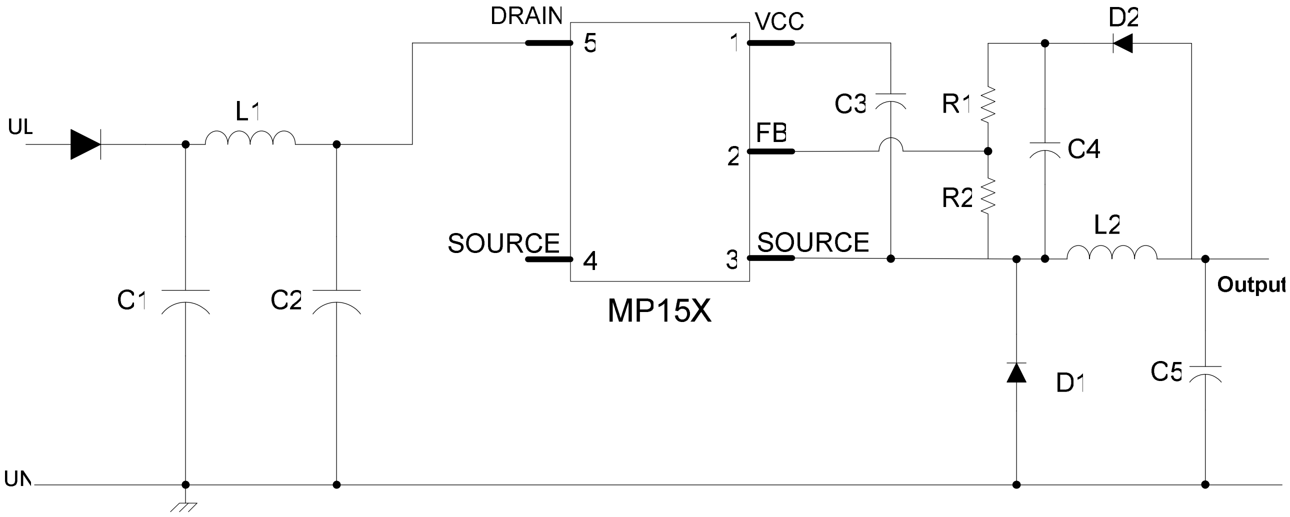

Figure 1: Typical Buck Regulator Using the MP15X

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AN INTRODUCTION TO THE MP15X

The MP15X is a series of primary-side regulators that provide accurate constant voltage (CV) regulation without an opto-coupler, and can support buck, buck-boost, and flyback topologies. Applications for the MP15X include home appliances, white goods, and consumer electronics. It has multiple integrated protection features, such as internal VCC under-voltage lockout (UVLO), overload protection (OLP), short-current protection (SCP), open-loop protection, and over-temperature protection, thus minimizing the number of external components. This application note also includes a step-by-step design procedure for a buck converter, which also applies to other various offline applications.

The MP15X is a fully-integrated switching regulator. Figure 2 shows the device's operation as a buck regulator (as per Figure 1) in CCM. The integrated MOSFET turns ON at the beginning of each cycle when the feedback voltage drops below the 2.5V reference voltage, which indicates insufficient output voltage. The internal MOSFET turns OFF when its current reaches the internal-peak–current limit. The freewheeling diode (D1) remains OFF until the inductor current charges the sampling capacitor (C4) to the output voltage. Then the sampling capacitor voltage follows the output voltage to sample and hold the output voltage to regulate the output voltage. The sampling capacitor voltage will decrease when the inductor current falls below the output current. When the feedback voltage falls below the 2.5V reference voltage, the internal switch turns ON to begin another switching cycle.

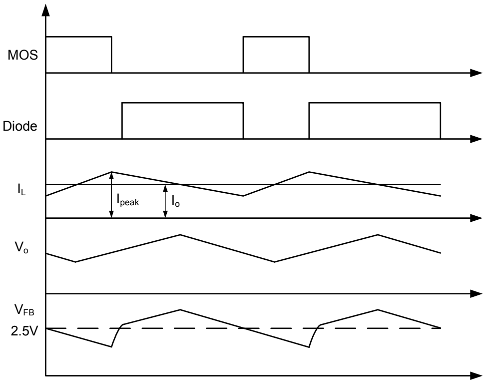


Figure 2: CCM Buck Converter Using the MP15X

By monitoring the sampled output voltage across C4 regulates the output voltage as per the following equation:

$$V_o = 2.5V \cdot \frac{R_1 + R_2}{R_2} \tag{1}$$

The MP15X features an internal error amplifier (EA) and ramp compensation (shown in Figure 3) to ensure accurate CV regulation.

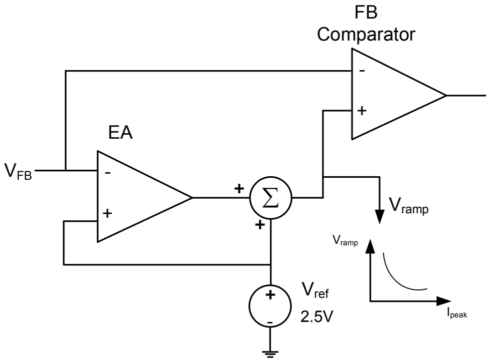


Figure 3: EA and Ramp Compensation

The MP15X samples the feedback voltage 6µs after the internal MOSFET turns OFF. The buck converter voltage ripple changes with the load condition. If the FB voltage equals the fixed voltage reference, the converter will have poor load regulation. Under this condition, the MP15X has an internal EA to change the FB comparator reference to achieve good output regulation. When the sampled voltage differs from the 2.5V reference, the EA contributes an error signal to the 2.5V reference voltage, thus changing the effective reference as shown in Figure 3. The EA's high DC gain minimizes the steady-state output voltage error. At the same time, an exponential voltage sinking source pulls down the reference voltage. The ramp compensation changes the FB comparator's reference voltage based on the load condition. This ramp compensation results in a kind of feed-forward compensation: As the load current increases, the sinking current decreases exponentially, which means the comparator reference increases slightly, resulting in better load regulation. Under maximum load condition, the compensation is about the 1mV/µs.

DESIGN PROCEDURE

Determine the Input and Output Specifications

-Input AC voltage range: $V_{ac(min)}$, $V_{ac(max)}$, for example 85VAC to 265VAC RMS

-DC bus voltage range: $V_{in(max)}$, $V_{in(min)}$

-Output: V_{out}, $I_{out(min)}$, $I_{out(max)}$, P_{out}

-Estimated efficiency: η. Estimates the power conversion efficiency to calculate the maximum input power. Generally, η is set to be 0.7.

Then the maximum input power can be given as:

$$P_{in} = \frac{P_{out}}{\eta} \tag{2}$$

The MP15X can output power ≤3W. Normally, a half-wave rectifier supplies the DC input voltage when the output power is less than 2W, and a full-wave rectifier supplies the DC input voltage when the output power exceeds 2W. This application note describes the converter using a half-wave rectifier as an example. When using a half-wave rectifier, the DC input capacitor (C_{in}) is usually 3µF/W. Choose an input capacitor with a minimum DC voltage ≥70V; a very low DC input voltage will cause the MP15X to enter thermal shutdown. Figure 4 shows the typical DC bus voltage waveform using a half-wave rectifier.

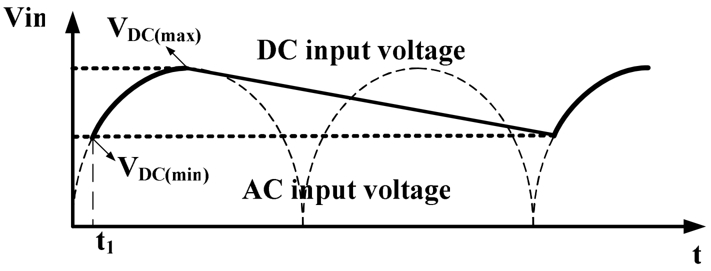


Figure 4: Input Voltage Waveform

From the waveform above, the AC input voltage V_{AC} and DC input voltage V_{DC} are then:

$$V_{AC}(V_{ac},t) = \sqrt{2} \cdot V_{ac} \cdot \sin(2 \cdot \pi \cdot f \cdot t), 2k\pi < 2\pi ft < (2k+1)\pi, k = 0,1,2... \quad (3)$$

$$V_{DC}(V_{ac},t) = \sqrt{2 \cdot V_{ac}{}^{2} - \frac{2 \cdot P_{in}}{C_{in}} \cdot (t - \frac{\pi}{2})} \quad (4)$$

When V_{AC}=V_{DC} (t_1), the DC input voltage reaches its minimum ($V_{DC(min)}$), calculated as:

$$V_{DC(min)} = V_{DC}(V_{ac(min)}, t_1) \quad (5)$$

Then, the minimum average DC input voltage ($V_{in(min)}$) is:

$$V_{in(min)} = \frac{\sqrt{2} \cdot V_{ac(min)} + V_{DC(min)}}{2} \quad (6)$$

The maximum average DC input voltage ($V_{in(max)}$) is then:

$$V_{in(max)} = \sqrt{2} \cdot V_{ac(max)} \quad (7)$$

IC Part Selection

The MP15X family includes three parts: MP150, MP155, and MP156. They each have different internal IC consumption values when the MOSFETs do no switch. This consumption value determines the no-load power consumption each part can achieve. Select an appropriate part initially based on the no-load power. Table 1 shows a brief selection guideline.

Table 1: MP15X Selection—No-Load Power Consumption

P/N	Internal IC Consumption (No Switching)	No-Load Power Loss 85VAC to 265VAC
MP150	300µA	≤ 150mW
MP155	250µA	≤ 100mW
MP156	165µA	≤ 30mW (7V ≤ V_O ≤ 30V)

The parts have different peak current limits and ON-state resistance. A part with a higher peak current limit and smaller ON-state resistance can deliver more power and higher output current. **Table 2** lists the parts according to their output power and current.

Table 2: MP15X Selection—Maximum Output Power, 85VAC to 265VAC

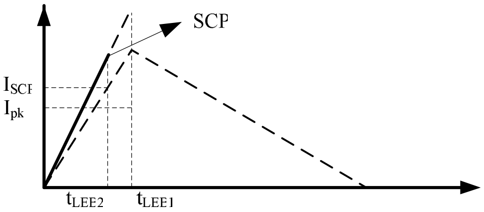
Part Number	Adapter
MP150	P_O≤2W, I_O≤200mA
MP155, MP156	P_O≤3W, I_O≤220mA

After selecting the converter's components design, calculate the IC loss and perform a thermal check to ensure that the converter functions within desired specifications using the selected part. If the OTP triggers with the rated output power, select a part with a higher power rating and recalculate the parameters based on the following design procedure.

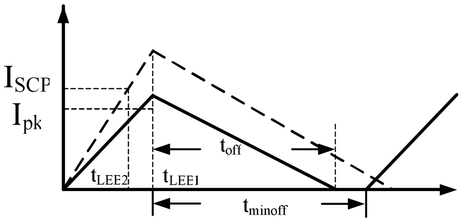
Inductor Design

The inductance determines the maximum converter output power, so selecting an inductor with the desired output power is very important. The MP15X's integrated MOSFET turns ON when the load causes the FB voltage to drop below 2.5V. Under heavy loads, the output drops very fast and the MOSFET turn-off time decreases. The operating frequency increases as the load increases. The MP15X has a minimum off-time limit that determines a maximum switching frequency, and limits the maximum power. The principle of inductor design is to choose an inductor with a maximum power limit bigger than the desired maximum output power. Calculate the maximum output power capability as per the following instructions:

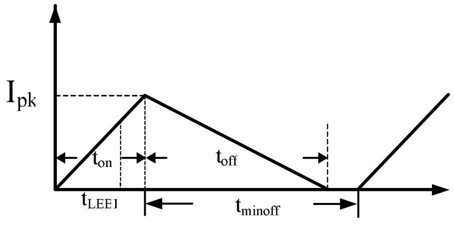
After determining the remaining converter parameters, different inductance values will lead to different operating modes. Figure 5 shows the different operating conditions when the converter outputs maximum power.



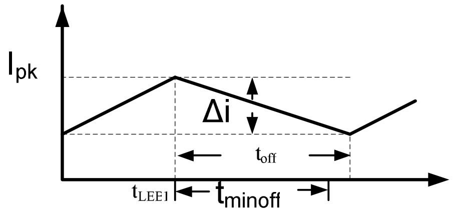
a. SCP



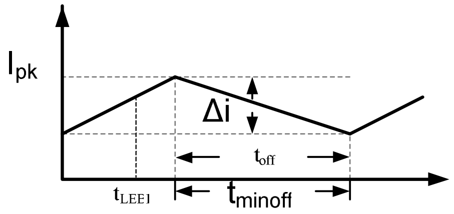
b. DCM, $I_p > I_{pk}$, $t_{off} < t_{minoff}$



c. DCM, $I_p = I_{pk}$, $t_{off} < t_{minoff}$



d. CCM, $I_p = I_{pk}$, $t_{off} > t_{minoff}$



e. CCM, $I_p = I_{pk}$, $t_{off} = t_{minoff}$

Figure 5: Maximum Power Under Different Conditions

Condition a: The converter inductor is very small (tens of µH), which makes the current slew rate very fast. Within the SCP's leading-edge blanking time (t_{LEB2}—avoids premature switching pulse termination due to the parasitic capacitance), the MOSFET current exceeds the SCP threshold. Then the SCP triggers and the converter cannot work normally. Avoid this condition.

Condition b: Uses a larger inductor than Condition a. The internal MOSFET current is less than the SCP threshold within t_{LEB2}, so SCP does not trigger and the converter works normally. However, the small inductor value leads to a peak current that exceeds the peak current limit (I_{PK}) within I_{PK}'s leading-edge blanking time (t_{LEB1}). Then the peak current under this condition is:

$$I_p = \frac{(V_{in} - V_o)\cdot t_{LEB1}}{L} \tag{8}$$

And the maximum power is calculated as:

$$P_{max} = \frac{1}{2} L I_p^2 \frac{1}{t_{LEB1} + t_{minoff}} \tag{9}$$

Though the converter can work normally under this condition, the inductor is so small that the peak current is not controlled by the peak current limit under full load. Avoid this condition.

Condition c: The converter works in DCM at the maximum power output. The peak current limit and the inductor determine the turn-on time (t_{on}). The inductor current slew rate, which is bigger than t_{LEB1}, is then:

$$t_{on} = \frac{L \cdot I_{pk}}{V_{in} - V_o} \tag{10}$$

The converter reaches maximum power when the off-time equals the minimum off time (t_{minoff}). The maximum power is then:

$$P_{max} = \frac{1}{2} L I_{pk}^2 \frac{1}{t_{on} + t_{minoff}} \tag{11}$$

Condition d: The converter works in CCM the output reaches maximum power. t_{LEB1} determines the current ripple. This condition occurs at low output voltages.

$$\Delta i_{min} = \frac{V_{in} - V_o}{L} \cdot t_{LEB1} \tag{12}$$

Then the average output current is:

$$I_{o\_max} = I_{pk} - \frac{1}{2} \cdot \Delta i_{min} \tag{13}$$

So the maximum power under this condition is:

$$P_{max} = V_o \cdot I_{o\_max} \tag{14}$$

Condition e: This converter works in CCM when it reaches the maximum power. t_{minoff} determines the current ripple.

$$\Delta i_{min} = \frac{V_o}{L} \cdot t_{minoff} \tag{15}$$

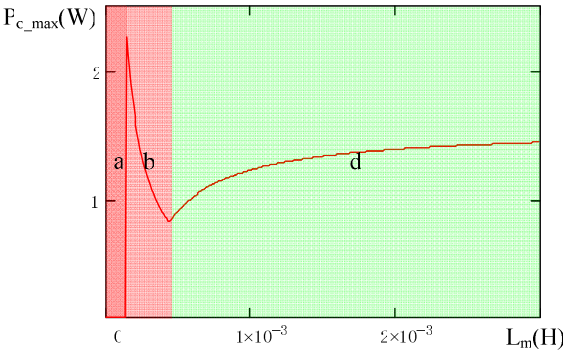
The average output current under this condition is:

$$I_{o\_max} = I_{pk} - \frac{1}{2} \cdot \Delta i_{min} \tag{16}$$

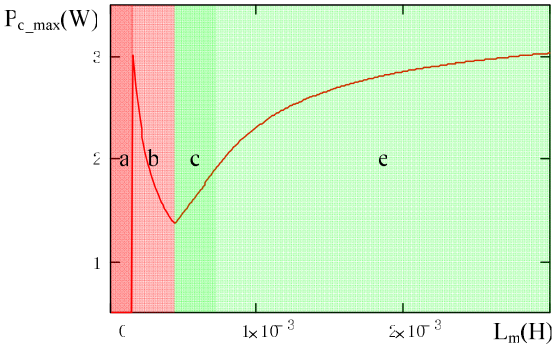
And the maximum power is then:

$$P_{max} = V_o \cdot I_{o\_max} \tag{17}$$

The operation mode where the converter outputs the maximum power changes with V_{in} and V_o. By analyzing different maximum power conditions, we get an inductor vs. maximum power curve. Figure 6 shows the curve for 5V and 12V (I_{pk} = 290mA, t_{minoff} = 18µs, V_{in} = 375VDC). The green zones provide the safest converter working regions.



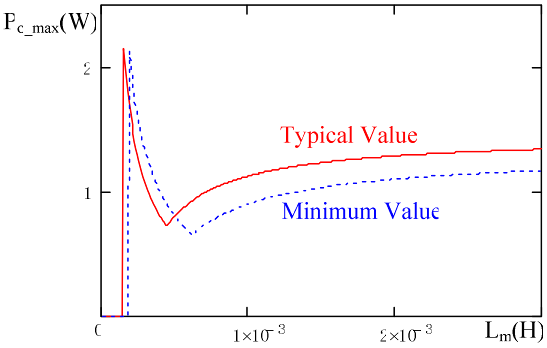
a) V_o = 5V



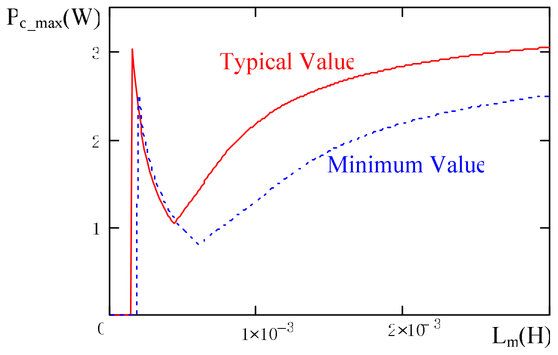
b) V_o = 12V

Figure 6: Inductor Value vs. Maximum Output Power

The peak current limit, minimum off time and the inductance affect the maximum power output: These parameters' tolerances affect the maximum output power capability. Normally, the peak current limit tolerance is ±10%, the minimum off time tolerance is ±17% and the inductance tolerance is ±20%. We can obtain a maximum value (P_{o_max}) and a minimum value (P_{o_min}) of maximum power considering the tolerance of the parameters. P_{o_min} is used to design the minimum inductance. So the converter we designed can output the required maximum output power considering the tolerance of the parameters. Figure 7 compares the minimum value and typical value of the maximum output power for 5V (a) and 12V (b).



a) V_o = 5V



b) V_o = 12V

Figure 7: Minimum Value of the Maximum Output Power

We can select a minimum inductance by calculating the maximum output power,

$$P_{o\_min}(L) \geq P_{out} \tag{18}$$

Accounting for costs, use a standard off-the-shelf inductor—use a standard inductor value greater than or equal to the calculated values.

Freewheeling Diode

Select a diode with a maximum reverse block voltage rating that exceeds the maximum input voltage. For universal voltage applications, use a diode with a 600V reverse block voltage. Determine the diode current rating from the RMS current as follows:

$$Irms_{DCM} = I_{pk} \cdot \sqrt{\frac{1}{3} \cdot 2\frac{I_o}{I_{pk}} \cdot (1 - \frac{V_o}{V_{in}})} \quad \text{for DCM} \tag{19}$$

$$Irms_{CCM} = \sqrt{(I_o^2 + \frac{\Delta i^2}{3}) \cdot (1 - \frac{V_o}{V_{in}})} \quad \text{for CCM} \tag{20}$$

Where Δi is the current ripple of inductor, and is equal to $2(I_{pk} - I_o)$.

The reverse recovery of freewheeling diode affects the efficiency and the circuit operation, so use an ultrafast diode. For DCM, select a diode with a reverse recovery time of less than 75ns, such as EGC10JH from ZOWIE. For CCM, select an ultrafast diode with a reverse recovery time of less than 35ns, such as UGC10JH.

Output Capacitor Design

The output capacitor maintains the DC output voltage. Estimate the output voltage ripple as:

$$V_{DCM\_ripple} = \frac{I_o}{f_s C_o} \cdot \left(\frac{I_{pk} - I_o}{I_{pk}} \right)^2 + I_{pk} \cdot R_{ESR} \text{ for DCM} \tag{21}$$

$$V_{CCM\_ripple} = \frac{\Delta i}{8 f_s C_o} + \Delta i \cdot R_{ESR} \text{ for CCM} \tag{22}$$

Where f_s is switching frequency, and R_{ESR} is ESR of output capacitor.

To lower the output voltage ripple, use ceramic, tantalum or low-ESR electrolytic capacitors.

Dummy Load Selection

The output requires a dummy load to maintain the load regulation under no-load condition. This can ensure sufficient inductor energy to charge the sample-and-hold capacitor to detect the output voltage. Most applications can use a 3mA dummy load, and this load can be adjusted according the regulation. Increasing the dummy load adversely affects the efficiency and no-load consumption. If the user does not care about no-load regulation, use a Zener diode.

Feedback Circuit

a. Sample Diode Selection

The diode should have the same or higher voltage rating as the freewheeling diode. The current through the diode is very small, so use fast and slow diodes such as FR10X and 1N400X. However, the sample diode and freewheeling diode should have the same forward voltage drop for better regulation.

b. Feedback Resistors

The MP15X provides accurate constant voltage (CV) regulation, and the resistor divider determines the output voltage as:

$$V_o = 2.5V \times \frac{R_1 + R_2}{R_2} \tag{23}$$

Choose appropriate R1 and R2 to maintain the FB voltage at 2.5V. R2 is typically between 5kΩ and 10kΩ.

c. Sample and Hold Capacitor

The feedback capacitor provides sample-and-hold function. Design this capacitor for good output voltage regulation. Figure 8 shows the detailed operation waveforms under DCM. Figure 2 shows the detailed operation waveforms under CCM.

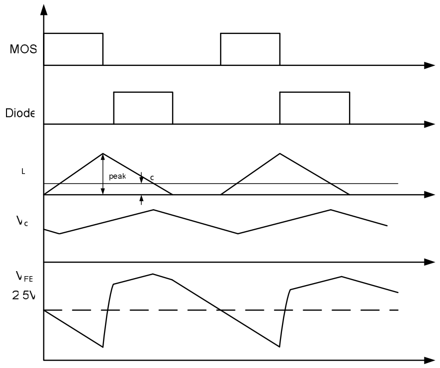


Figure 8: Detailed Operation in DCM

When the MOSFET turns off and the freewheeling diode turns on, if the feedback capacitor voltage is less than the output voltage, the inductor charges the capacitor until the feedback capacitor voltage equals the output voltage. This makes the feedback capacitor (C4) sample the output voltage. But if the feedback capacitor voltage exceeds the output voltage, the capacitor is only discharged by the feedback resistors. So The feedback capacitor’s discharge rate should exceed that of the output capacitor by the load Then the voltage of feedback capacitor cannot exceed the output voltage. Otherwise the converter may work abnormally.

In CCM, when the feedback capacitor’s discharge rate exceeds that of the output capacitor, the feedback capacitor’s voltage will equal the output voltage. In DCM, when the freewheeling diode turns off and the converter works in the discontinuous area, the feedback capacitor’s voltage remains below output voltage. This results in a higher output voltage than the rated output voltage under light load and result in loose output voltage regulation.

From the previous analysis, we can find that a fast feedback capacitor discharge rate causes poor light-load regulation, and a slow discharge rate affects circuit operation.

To estimate the capacitance:

$$\frac{1}{2}\frac{V_o}{R_1+R_2}\cdot\frac{C_o}{I_o} \le C_{FB} \le \frac{V_o}{R_1+R_2}\cdot\frac{C_o}{I_o}. \tag{24}$$

Where C_o is the output capacitance.

We can obtain a rough value of the feedback capacitance, and then choose an appropriate value for practical applications.

Thermal Check

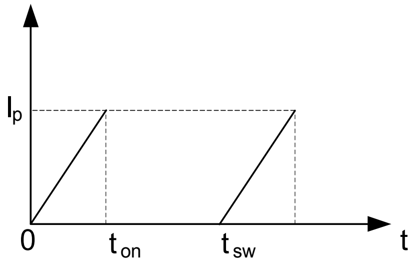
The MP15X has an internal OTP function that triggers when the IC junction temperature increases to 150°C. The part will not resume function unless the Vcc voltage drops below 2.4V. The part temperature increases as the output power increases, thus perform a thermal check and choose an appropriate part after designing the converter.

To ensure a stated margin, the maximum junction thermal shutdown temperature is T_b (normally 125°C). Let T_a represent the maximum ambient temperature for normal MP15X applications. The maximum temperature rise (ΔT) is then T_b - T_a. Given that the junction-to-ambient thermal resistance θ_{JA} is 100°C/W, the maximum IC power loss is:

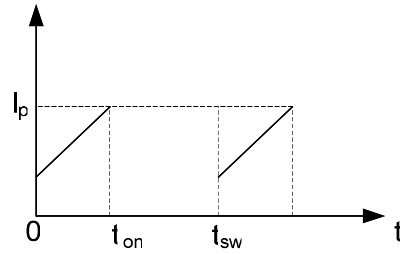
$$P_{max\_loss} = \frac{T_b - T_a}{\theta_{JA}} \tag{25}$$

Two factors contribute to the MP15X's power loss: power loss of the Integrated MOSFET, and internal IC consumption. The power loss of the integrated MOSFET can be divided into conduction loss and switching loss. The internal IC consumption includes the MOSFET driving loss.

Figure 9 shows the MOSFET current under DCM and CCM.



DCM



CCM

Figure 9: MOSFET Current Under DCM and CCM

Calculate the duty cycle as:

$$D_{DCM} = \frac{2I_o}{I_{pk}} \cdot \frac{V_o}{V_{in}} \text{ for DCM} \tag{26}$$

$$D_{CCM} = \frac{V_o}{V_{in}} \text{ for CCM} \tag{27}$$

Estimate the MOSFET RMS current as:

$$I_{MOS\_DCM} = I_{pk} \cdot \sqrt{\frac{D_{DCM}}{3}} \text{ for DCM} \tag{28}$$

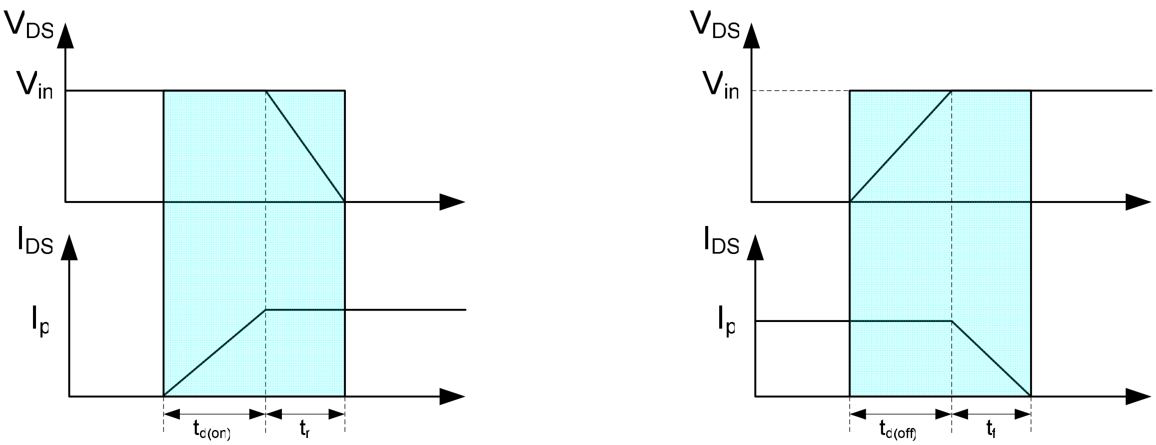
$$I_{MOS\_CCM} = \sqrt{(I_o^2 + \frac{\Delta i^2}{3}) \cdot D_{CCM}} \text{ for CCM} \tag{29}$$

The MOSFET conduction loss is then:

$$P_{MOS\_con} = I_{MOS}{}^2 \cdot R_{ds\_on} \tag{30}$$

When the converter operates in DCM, the MOSFET turns on at zero current. The MOSFET turn-on power loss is very small and can be ignored. So for DCM mode, calculate the turn-off loss.

However, CCM requires calculations for both turn-on and turn-off losses. The integrated MOSFET's turn-on and turn-off times are very small (~50ns), so use the simplified model shown in Figure 10[1] to calculate the power loss during turn on and turn.off



a) Turn On **b) Turn Off**

Figure 10: MOSFET Switching Process

The MOSFET switching loss is then:

$$P_{MOSFET\_on} = \frac{1}{2} \cdot V_{in} \cdot I_p \cdot (t_{d(on)} + t_r) \cdot f_s \tag{31}$$

$$P_{MOSFET\_off} = \frac{1}{2} \cdot V_{in} \cdot I_p \cdot (t_{d(off)} + t_f) \cdot f_s \tag{32}$$

Where $t_{d(on)}$ is the turn-on delay time, t_r is the rise time, $t_{d(off)}$ is the turn-off delay time, and t_f is the fall time. Internal IC consumption power loss can be calculated as:

$$P_{IC} = V_{in} \cdot I_{CC} \tag{33}$$

Where I_{CC} is the operation current under a full load.

Normally conduction loss is the primary contributor to IC power loss, and the lower the input voltage, the greater the conduction loss. So we only need to do a thermal check when V_{in} equals V_{inmin}.

Auxiliary VCC Supply

MP155 and MP156 have a function of auxiliary Vcc supply. When the output voltage exceeds VCC (typically 5.5V), we can use an auxiliary VCC supply by connecting a diode and a resistor between C3 and C4 as shown in Figure 11.

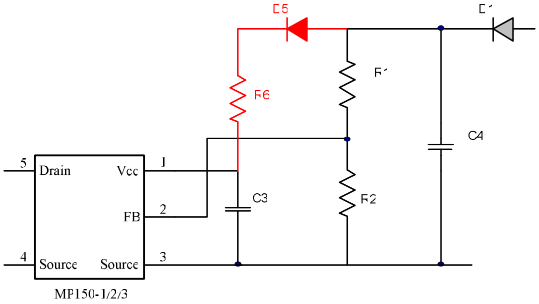


Figure 11: Auxiliary VCC Supply

Then VCC can be clamped to 5.8V, and the internal regulator is forced off at all times. This can eliminate IC power consumption due to charging the VCC capacitor from the Drain pin. We can lower the no-load consumption through an auxiliary VCC supply. As this can cause additional power loss, and select an appropriate resistor value as per:

$$R_6 \approx \frac{V_o - 5.8V}{I_C} \tag{34}$$

IC power consumption (No switching) is different for different parts. For instance, the MP155 requires 250µA. In addition, we recommend adding a 1N4148 diode. When the output voltage is 12V under these conditions, use a 25kΩ resistor.

DESIGN FLOW

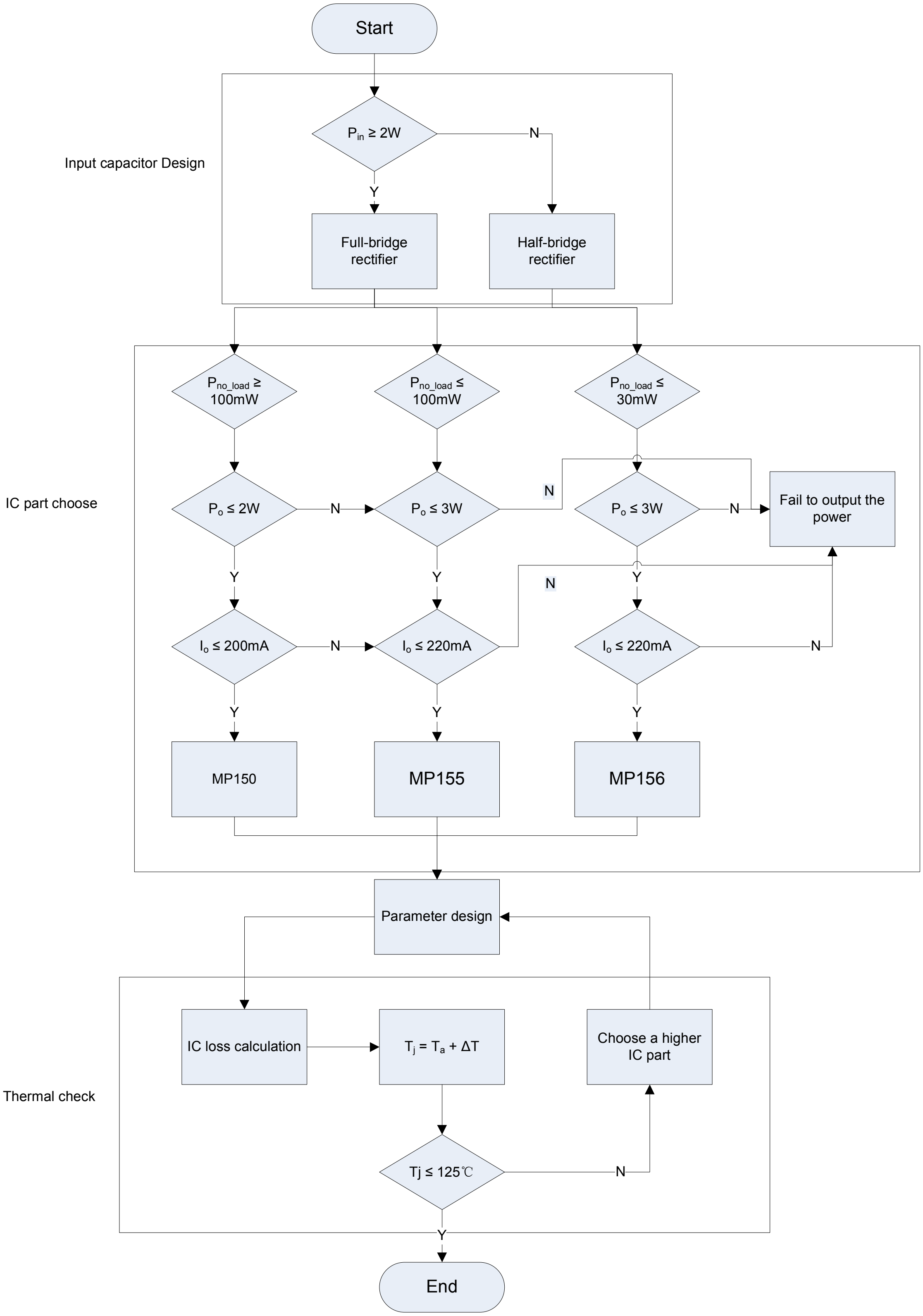


Figure 12: Design Flow for the MP15X

DESIGN SUMMARY

- MPS' design tool makes designing with the MP15X easier. The tools can calculate all key parameters to build a reliable design with excellent performance.
- Figure 13 shows a detailed buck converter reference design for the MP155. The inductor value is the most important component for this converter. Poor inductor selection may not deliver the desired rated power.
- Choose a sample-and-hold capacitor with an appropriate value to achieve good regulation. Determine a dummy load to regulate the voltage under no-load condition. However, very large dummy loads will deteriorate the efficiency and increase no-load consumption.
- Perform a thermal check after designing the parameters, especially for applications with high ambient temperatures.

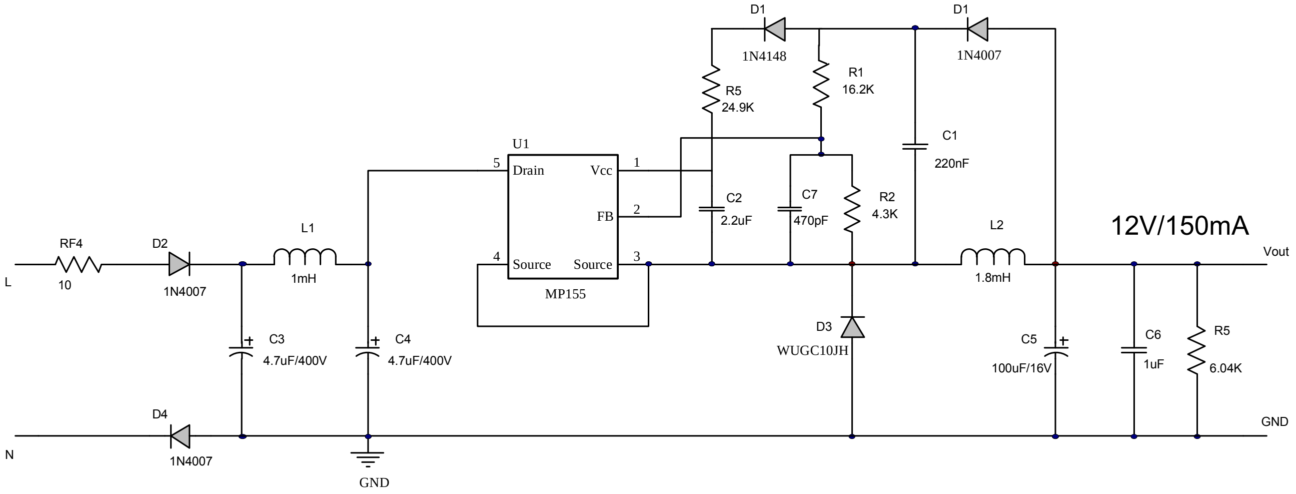
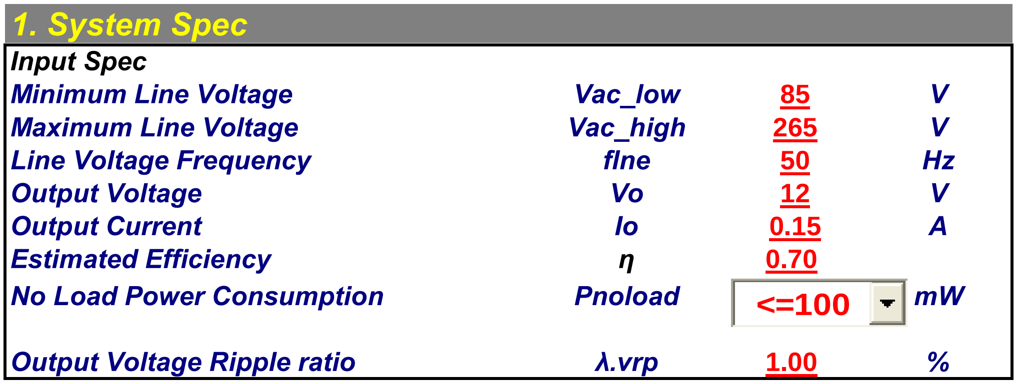


Figure 13: Buck Converter Application Using the MP155

EXAMPLE VERIFICATION

The following is a buck converter using the MP155 as a design example that has been built and tested (Input: 85VAC to 265VAC; Output: 12V/0.15A). MPS' design tool can calculate the values of key components. The following describes the design procedure using MPS' design tool:

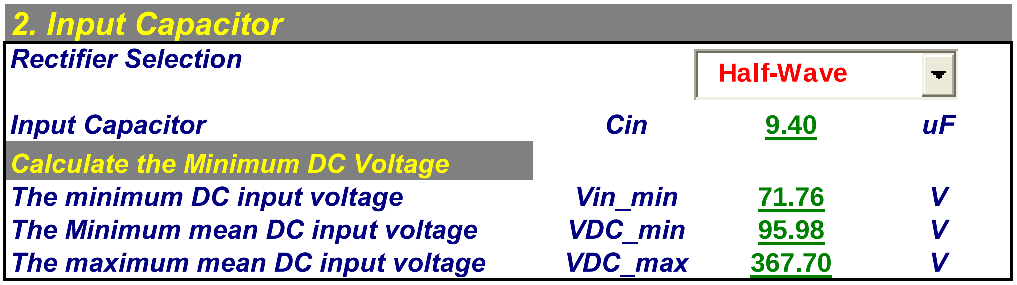
1. Input the system specifications, including input voltage, output requirements, efficiency and etc.



1. System Spec

Input Spec			
Minimum Line Voltage	Vac_low	85	V
Maximum Line Voltage	Vac_high	265	V
Line Voltage Frequency	flne	50	Hz
Output Voltage	Vo	12	V
Output Current	Io	0.15	A
Estimated Efficiency	η	0.70	
No Load Power Consumption	Pnoload	<=100	mW
Output Voltage Ripple ratio	λ.vrp	1.00	%

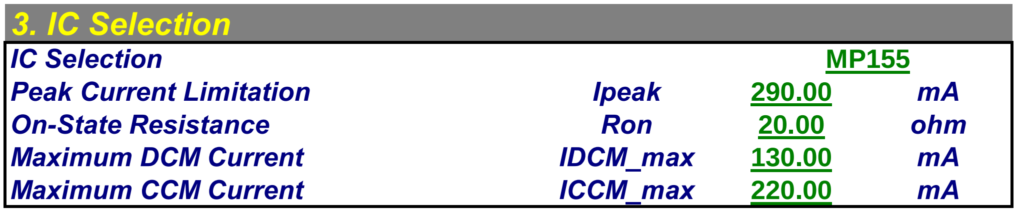
2. After determining the specifications, select the input rectifier topology. Use a half-wave rectifier for output power less than 2W. This example (1.8W, 12V 0.15A) uses the half-wave rectifier topology. The tool can then calculate the minimum input capacitance and obtain the input DC voltage.



2. Input Capacitor

Rectifier Selection		Half-Wave	
Input Capacitor	Cin	9.40	uF
Calculate the Minimum DC Voltage			
The minimum DC input voltage	Vin_min	71.76	V
The Minimum mean DC input voltage	VDC_min	95.98	V
The maximum mean DC input voltage	VDC_max	367.70	V

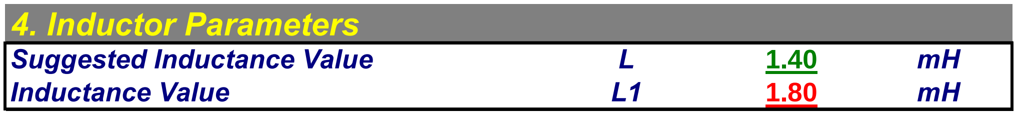
3. The tool will recommend an IC part for the user according the output specifications. However, the tool will notify the user if the output specification exceeds the capability of the MP15X.



3. IC Selection

IC Selection		MP155	
Peak Current Limitation	Ipeak	290.00	mA
On-State Resistance	Ron	20.00	ohm
Maximum DCM Current	IDCM_max	130.00	mA
Maximum CCM Current	ICCM_max	220.00	mA

4. The tool will suggest and inductance value based on an analysis of the inductor design. The user can choose a standard off-the-shelf inductor, but must choose a value greater than or equal to the suggested value.



4. Inductor Parameters

Suggested Inductance Value	L	1.40	mH
Inductance Value	L1	1.80	mH

5. The tool will suggest an output capacitor value based on the output voltage ripple and capacitor ESR, and recommend a dummy load value. The tool will calculate the resistor value based on the output voltage. The user can also adjust the value according the regulation and no-load consumption.

5 Output Design

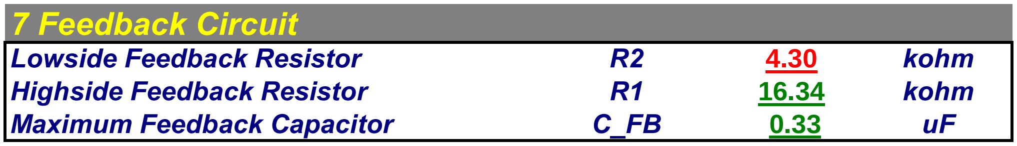
Output Cap ESR	Cesr	0.30	ohm
Output Cap	Cout	100.00	uF
Output Dummy Load	Rdummy	6.00	kohm

6. The user must choose a diode with a maximum DC blocking voltage higher than the maximum DC input voltage. For typical applications, use a 600V/1A diode.

6 Output Diode Voltage

Output Voltage of Output Diode	V_d	374.77	V

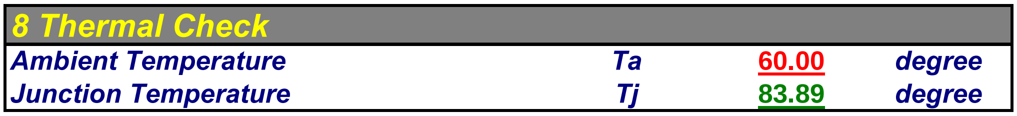
7. With the analysis of the feedback circuit, the tool can calculate the feedback resistors and the sample capacitor given an R2 value.



7 Feedback Circuit

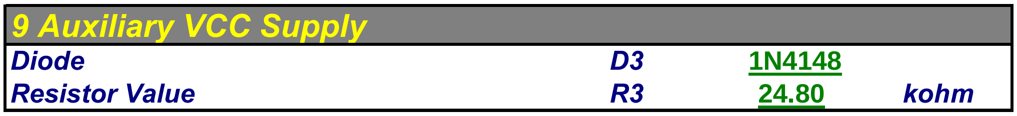
Lowside Feedback Resistor	R2	4.30	kohm
Highside Feedback Resistor	R1	16.34	kohm
Maximum Feedback Capacitor	C_FB	0.33	uF

8. At the end of the design process, the tool will calculate the junction temperature of MP15X according the power loss of IC part and ambient temperature. If the temperature exceeds 125°C, the tool will notify the user to lower the output specification or choose a part with a higher power rating.



8 Thermal Check			
Ambient Temperature	Ta	60.00	degree
Junction Temperature	Tj	83.89	degree

9. When the output voltage exceeds VCC (Typical value is 5.5V), add an auxiliary VCC supply by connecting a diode and a resistor to decrease the no-load power consumption. The tool will recommend a 1N4148 diode and calculate a resistor value.

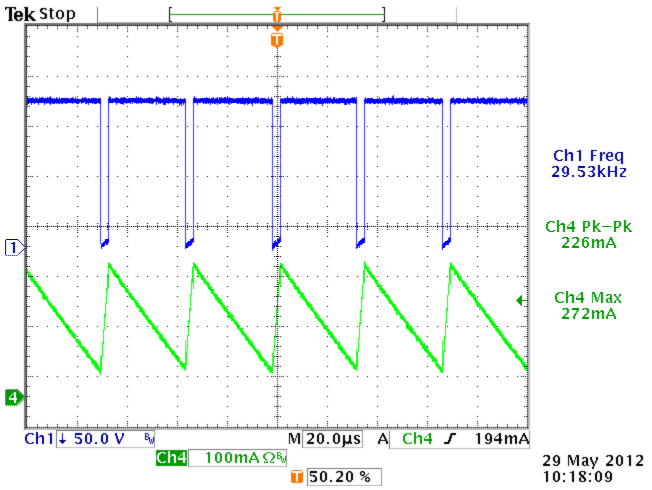


9 Auxiliary VCC Supply			
Diode	D3	1N4148	
Resistor Value	R3	24.80	kohm

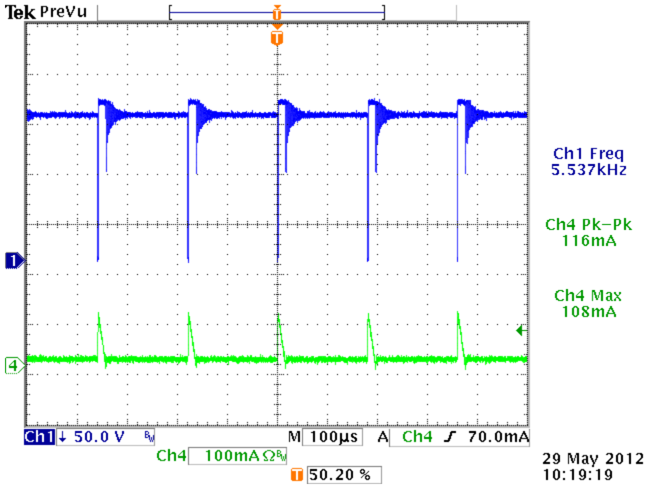
Figure 14 shows the drain-source voltage waveform (V_{ds}) and inductor current (I_L) under full load and no load. The MP155 has a frequency foldback feature. At the light-load or no-load conditions, the output drops very slowly. This increases the MOSFET turn-on time. The frequency decreases as the load decreases. At the same time, the peak current limit starts to decrease from 0.3A as the OFF-time increases.

Figure 15 and Figure 16 show the measured efficiency versus load and no load consumption at different input voltage. A Buck converter based on MP155 has a high efficiency above 75% under full load conditions. The addition of the auxiliary VCC supply, the no load consumption is about 70mW with 2mA dummy load.

Figure 17 and Figure 18 show the load regulation and line regulation. The MP155 has an internal EA and ramp compensation that improve the regulation. The load regulation is about ±3.4%.



a) Full load



b) No load

Figure 14: V_{ds} and I_L Waveforms (115VAC)

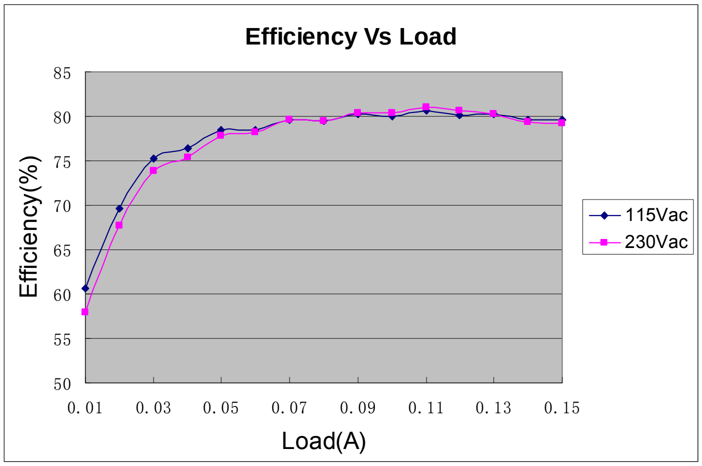


Figure 15: Efficiency

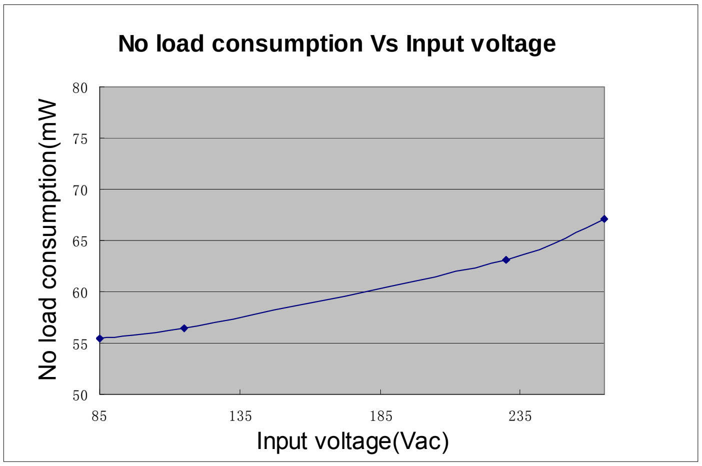


Figure 16: No-Load Consumption

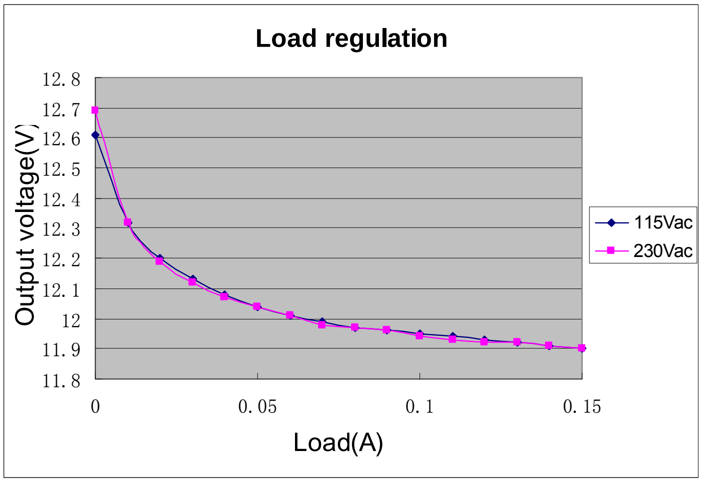


Figure 17: Load Regulation

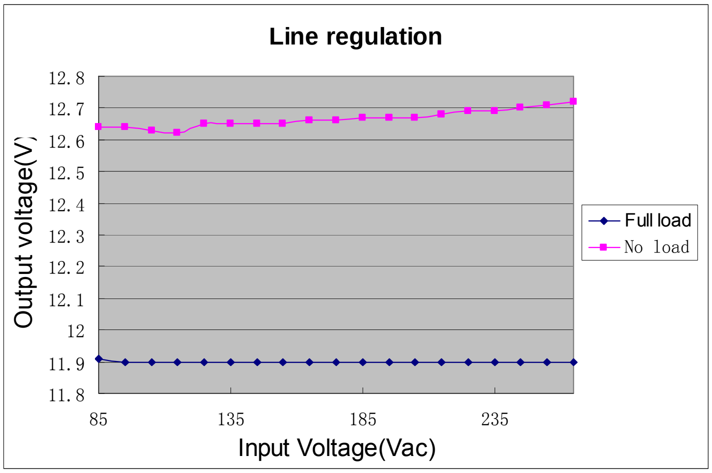


Figure 18: Line Regulation

REFERENCES:

[1] Weixun Lin, “Technology of Modern Power Electronics” Zhejiang University Book Concern, 2002-07.