iML8681 Application Notes

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1. IC Description

The iML8681 is a Two Terminal Current Controller (TTCC) for regulating the current flowing through an LED string according to the voltage established across the LED string.

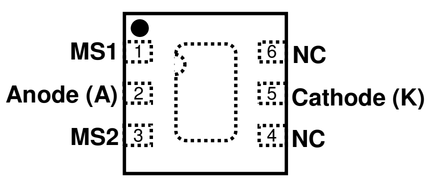
When the iML8681 is configured with an LED string in the application, the iML8681 can work as voltage controlled current source, current regulator, or cut-off, depending on the voltage across the device and its placement in the string. The typical application for the device is to power an LED string from an AC voltage source as in an LED light bulb.

No external components are needed saving PCB area and reducing total BOM cost. The device allows the designer flexibility in PCB layout to meet various shape requirements and constraints. It is especially suitable for replacing incandescent light bulb and linear type fluorescent lamp.

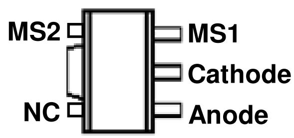
2. Features

- **System**
  - ✓ All solid state components
  - ✓ No electrolytic capacitor needed
  - ✓ Compact size
  - ✓ High Power Factor and Low Total Harmonic Distortion Performance
  - ✓ High efficiency
  - ✓ Flexible PCB layout style
- **Chip**
  - ✓ 80V input sustaining voltage.
  - ✓ Various bypass-current options available for different applications.
  - ✓ Can be parallel connected to increase the current drive capability.
  - ✓ Chip-on-board process available.
- **Applications**
  - ✓ AC LED lighting engine.
  - ✓ LED light bulb.
  - ✓ LED light tube.

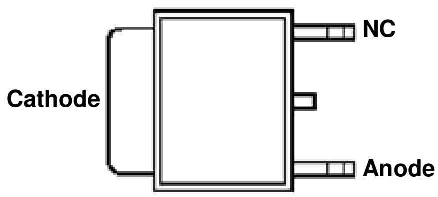
3. Package and Pin Diagrams



DFN 2mm×2mm

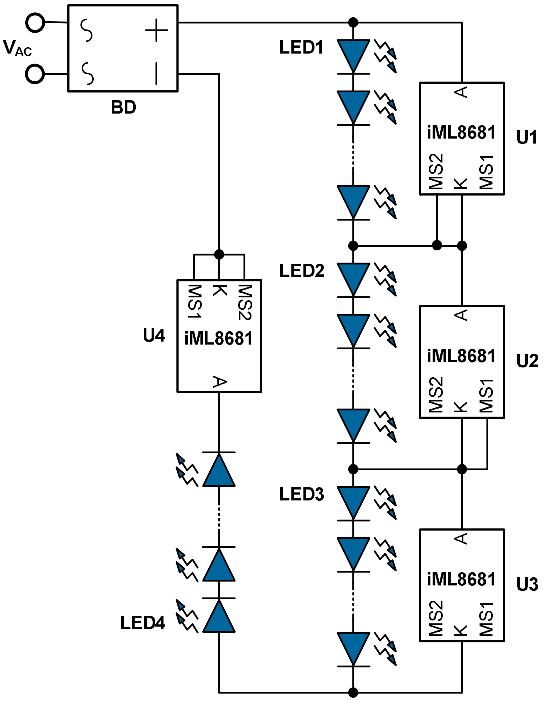


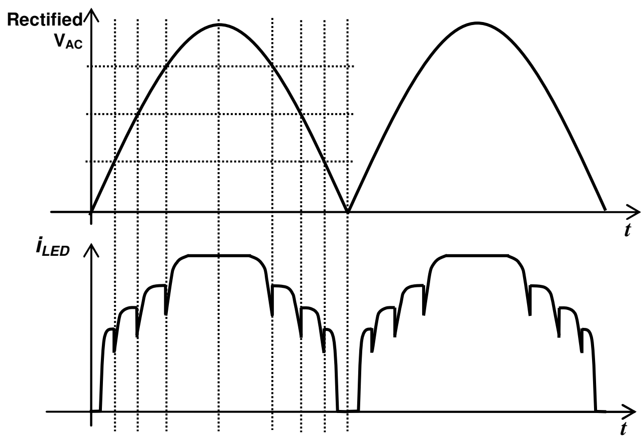
SOT-89-5L



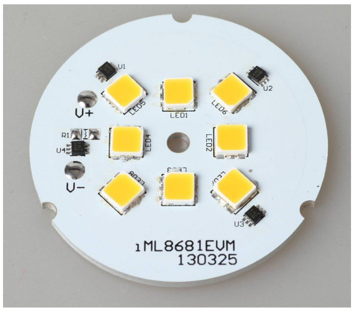
TO-252-2L

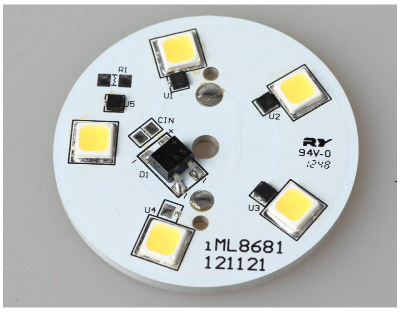
4. Typical Application Circuit and Waveforms

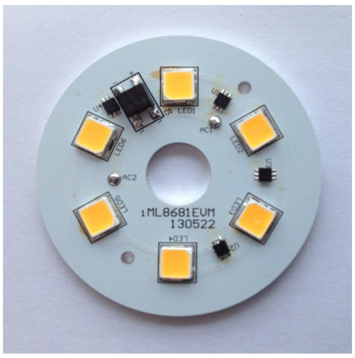




5. Evaluation Modules







6. Key Parameters by Order Number

Package Type: DFN – 2mm x 2mm – 6 Pin (Halogen Free)

Part Number	1st Line Marking	Target LED V_F In Each Segment	***Mode 0*** (MS2=L; MS1=L)			***Mode 1*** (MS2=L; MS1=H)			***Mode 2*** (MS2=H; MS1=L)			***Mode 3*** (MS2=H; MS1=H)		
			I_{PEAK} (mA)	$V_{ON,TH}$ (V)	$V_{OFF,TH}$ (V)	I_{PEAK} (mA)	$V_{ON,TH}$ (V)	$V_{OFF,TH}$ (V)	I_{PEAK} (mA)	$V_{ON,TH}$ (V)	$V_{OFF,TH}$ (V)	I_{PEAK} (mA)	$V_{ON,TH}$ (V)	$V_{OFF,TH}$ (V)
iML8681NL-K11	8K11		38			30.4			20.9			12.5		
iML8681NL-K21	8K21	65V LED	51	N/A	N/A	40.8	64	55	28.1	60.8	52.25	16.8	57.6	49.5
iML8681NL-K31	8K31		64			51.2			35.2			21.1		
iML8681NL-K41	8K41		44			35.2			24.2			14.5		
iML8681NL-K51	8K51		46			36.8			25.3			15.2		
iML8681NL-K61	8K61	52V LED	58	N/A	N/A	46.4	50.5	45.7	31.9	48.0	43.4	19.1	45.5	41.1
iML8681NL-K71	8K71		61			48.8			33.6			20.1		
iML8681NL-K81	8K81		73			58.4			40.2			24.1		
iML8681NL-K91	8K91		76			60.8			41.8			25.1		
iML8681NL-N11	8N11		71			56.8			39.1			23.4		
iML8681NL-N21	8N21		78			62.4			42.9			25.7		
iML8681NL-N31	8N31		86			68.8			47.3			28.4		
iML8681NL-N41	8N41	36V LED	95			76.0			52.3			31.4		
iML8681NL-N51	8N51		104	N/A	N/A	83.2	35.5	30.5	57.2	33.7	29.0	34.3	32.0	27.5
iML8681NL-N61	8N61	Or lower	114			91.2			62.7			37.6		
iML8681NL-N71	8N71		119			95.2			65.5			39.3		
iML8681NL-N81	8N81		130*			104.0			71.5			42.9		
iML8681NL-N91	8N91		143*			114.4			78.7			47.2		
iML8681NL-K12	8K12		38			30.4			20.9			12.5		
iML8681NL-K22	8K22	65V LED	51	N/A	N/A	40.8	62	53	28.1	58.9	50.35	16.8	55.8	47.7
iML8681NL-K32	8K32		64			51.2			35.2			21.1		
iML8681NL-K42	8K42		44			35.2			24.2			14.5		
iML8681NL-K52	8K52		46			36.8			25.3			15.2		
iML8681NL-K62	8K62	52V LED	58	N/A	N/A	46.4	49.1	44.2	31.9	46.6	42.0	19.1	44.2	39.8
iML8681NL-K72	8K72		61			48.8			33.6			20.1		
iML8681NL-K82	8K82		73			58.4			40.2			24.1		
iML8681NL-K92	8K92		76			60.8			41.8			25.1		
iML8681NL-N12	8N12		71			56.8			39.1			23.4		
iML8681NL-N22	8N22		78			62.4			42.9			25.7		
iML8681NL-N32	8N32		86			68.8			47.3			28.4		
iML8681NL-N42	8N42	36V LED	95			76.0			52.3			31.4		
iML8681NL-N52	8N52		104	N/A	N/A	83.2	34.5	29.5	57.2	32.8	28.0	34.3	31.1	26.6
iML8681NL-N62	8N62	Or lower	114			91.2			62.7			37.6		
iML8681NL-N72	8N72		119			95.2			65.5			39.3		
iML8681NL-N82	8N82		130*			104.0			71.5			42.9		
iML8681NL-N92	8N92		143*			114.4			78.7			47.2		

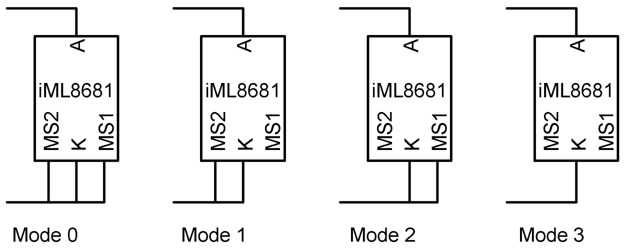
Note: When using the N81/N91 or N82/N92 options, using 2 pieces of K31/N11 or K32/N12, respectively, connected in parallel for U4 in place of a single N81/N91 or N82/N92 is recommended in order to improve the thermal dissipation (please refer to the Typical Application Circuit). Because U4 is always turned on and conducting high current during operation, the junction temperature may rise high enough to activate OTP in a single N81/N91 or N82/N92 chip used as U4. With proper thermal design, there is no thermal issue for U1, U2, or U3 using a single N81/N91 or N82/N92 chip.

7. Operation Theory

The iML8681 is a Two Terminal Current Controller (TTCC) that regulates the current flowing through an LED string according to the voltage established across the string. The typical application for the device is to power an LED string from an AC voltage source as in an LED light bulb or light tube.

The iML8681 has 4 functional pins -- Anode (A), Cathode (K), MS1, and MS2. In typical applications, the LED string is divided into several segments. The Anode pin is connected to the most positive terminal of the LED segment and the Cathode pin is connected to the most negative terminal. The MS1 and MS2 pins are used for device mode selection. One of four device modes (Mode 0 through Mode 3) is selected by connecting MS1 and/or MS2 to the Cathode (logic 0) or by leaving both pins open (internally pulled up to logic 1). The regulating current (I_{PEAK}), turn on voltage ($V_{ON,TH}$), and turn off voltage ($V_{OFF,TH}$) are different for each mode. Please refer to the diagram and the table in below. In Mode 0, the chip is connected to the LED string in series and acts as a constant current sink, regulating the current through the string. In Modes 1 through 3, the device, connected in parallel with a string segment, acts as a current shunt or bypass when the voltage across the segment, v_{AK}, is below the mode threshold.

The following explains the operation theory in detail. The MS1 and MS2 pins will not be shown in the applications drawings to simplify the drawings.

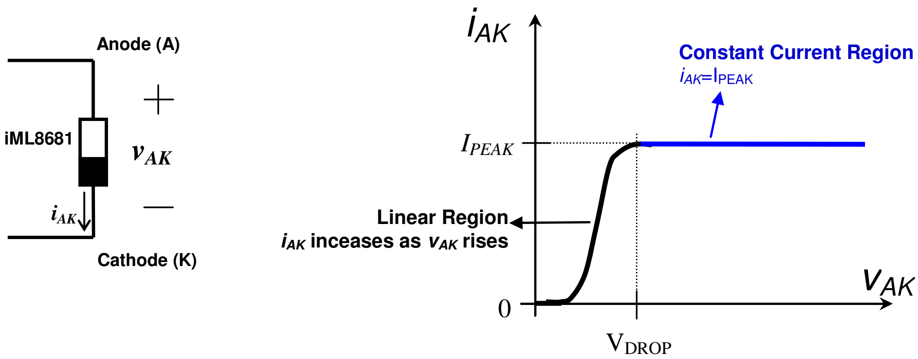


MS1 and MS2 Pins Connection for Each Mode

Mode	MS2	MS1	I_{PEAK}	$V_{ON,TH}$ / $V_{OFF,TH}$
3	1	1	33%	89%/76%
2	1	0	55%	94%/80%
1	0	1	80%	98%/85%
0	0	0	100%	N/A

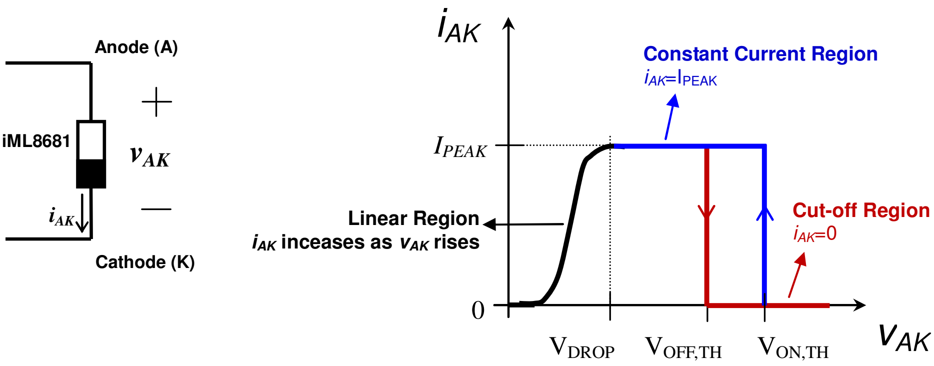
Current and On/Off Voltage Thresholds for Each Mode

The *i-v* curve of the iML8681 operating in Mode 0 is shown in below. There are two operating regions – the linear region and the constant current (saturation) region. When the voltage across the Anode pin (A) and the Cathode pin (K), v_{AK}, is lower than the dropout voltage (V_{DROP}), the conduction current, i_{AK}, increases as v_{AK} rises. When v_{AK} rises beyond V_{DROP}, the chip enters the constant current region and i_{AK} will be kept at predetermined level, I_{PEAK}, as v_{AK} increases. Power dissipation is most important when operating in Mode 0. Use the exposed thermal pad to increase power dissipation. Soldering the thermal pad of the part to a copper foil on the PCB will improve thermal conductivity.



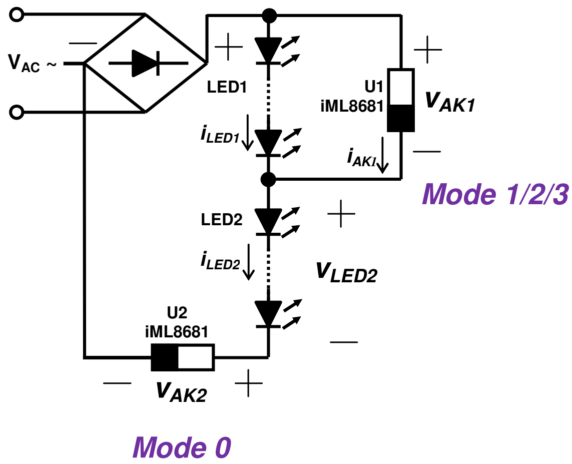
i-v Curve of the iML8681 Operating in Mode 0

The generic *i-v* curve of the iML8681 operating in Modes 1 through 3 is shown in below. There are three operation regions; the linear region, the constant current region, and the cut-off region. When the voltage across the Anode pin (A) and the Cathode pin (K), v_{AK}, is lower than the dropout voltage, V_{DROP}, the conduction current, i_{AK}, increases as v_{AK} rises. When v_{AK} rises beyond V_{DROP}, the chip enters constant current region and i_{AK} will be kept at predetermined level, I_{PEAK}. When v_{AK} rises beyond $V_{OFF,TH}$, the chip enters the cut-off region and i_{AK} drops to 0. When v_{AK} drops below $V_{ON,TH}$, the chip enters the constant current region again and i_{AK} increases to I_{PEAK}.



i-v Curve of the iML8681 Operating in Modes 1 through 3

To control the current flowing through the LED string, the iML8681 can be connected to LED string either in series or in parallel. Please refer to the 2-stage driving scheme as an example, shown below. The LED string is divided into 2 segments, LED1 and LED2, connected in series. The iML8681 chip U1 is connected in parallel with LED1 and chip U2 connected in series with the LED string. A rectified AC source is applied to the LED string network, as shown in the figure, below. U1 is operated in Mode 1, 2 or 3, and U2 is operated in Mode 0 with a higher current setting, I_{PEAK2}, than U1.

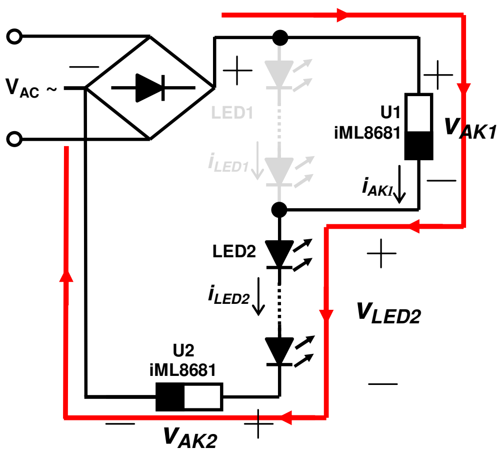


2-stage Driving Scheme

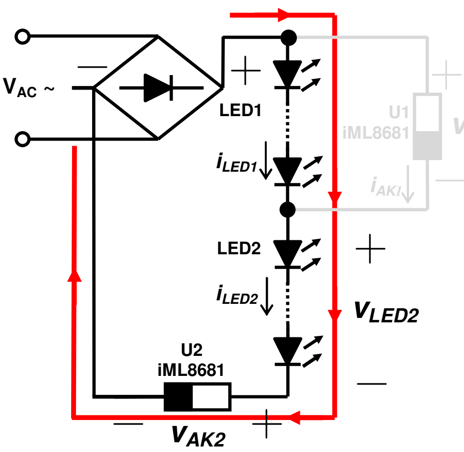
The operation of the 2-stage driving scheme is explained with the circuit and waveforms shown below. For illustration purposes, one rectified V_{AC} cycle is divided into 8 periods, t_0 to t_7.

During the period t_0, as V_{AC} ramps up, the system is working at stage 1, and U1 is ON. The current flows through U1, LED2, and U2, and increases as the rectified V_{AC} rises. During t_1, the system is still working at stage 1. When the rectified V_{AC} rises to V_{DROP}, the current is clamped at I_{PEAK1} by U1, and V_{AK1} keeps rising. During t_2, V_{AK1} rises above $V_{OFF,TH}$ and the system enters stage 2. U1 turns off and the current flows through LED1, LED2 and U2. The current increases again until it is clamped at I_{PEAK2} by U2 during t_3.

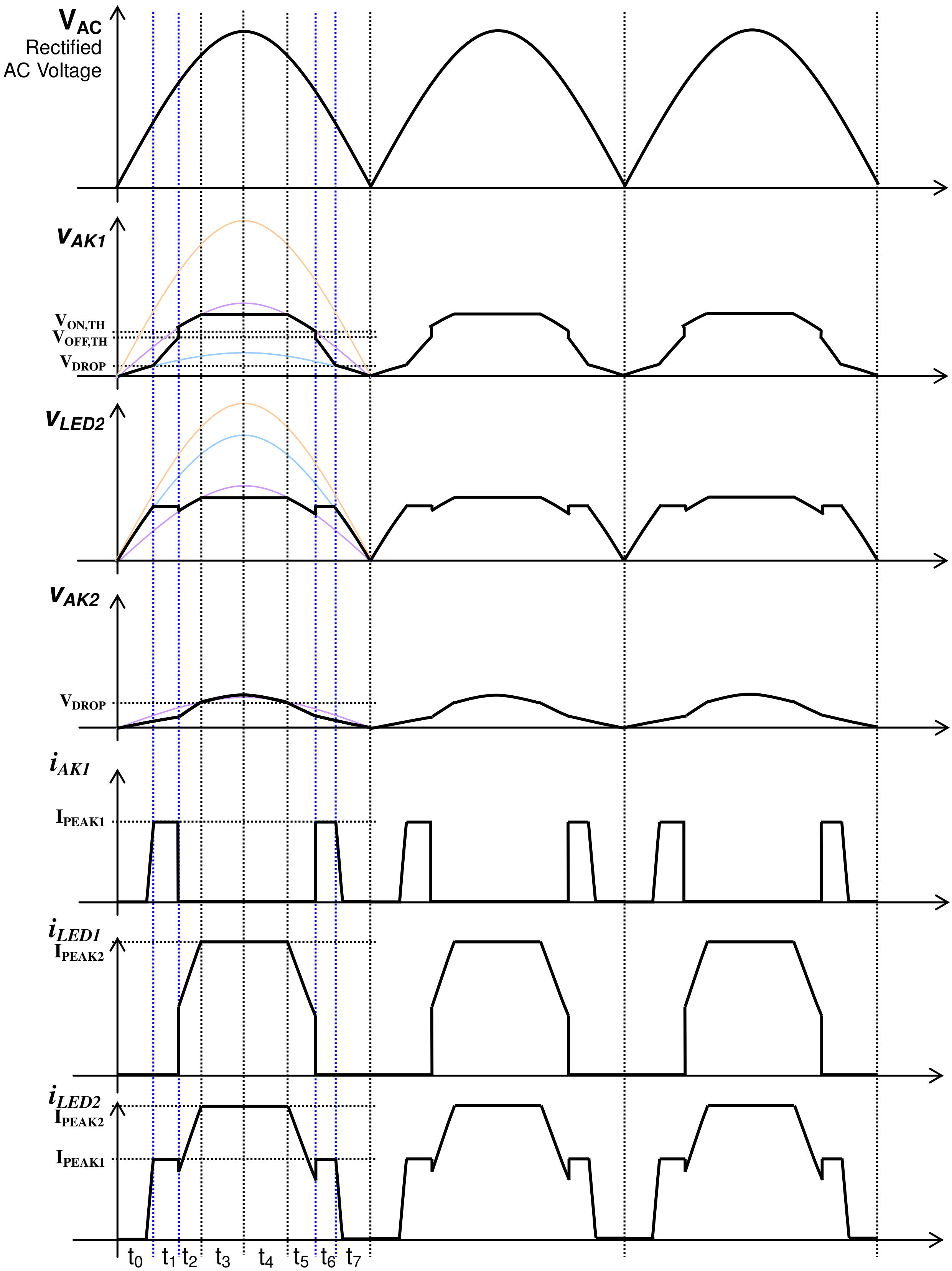
As V_{AC} ramps down, the current is still clamped at I_{PEAK2} by U2 during t_4. In the period of t_5, the current starts to decrease when V_{AK2} drops below V_{DROP} of U2. During t_6, V_{AK1} drops below $V_{ON,TH}$, and U1 is turned on again. The system re-enters stage 1. The current is clamped at I_{PEAK1} by U1. During t_7, V_{AK2} drops below V_{DROP} of U1 and the current decreases to 0. The system operation repeats for each rectified V_{AC} cycle.



Stage 1: U1 and U2 are ON



Stage 2: U1 is OFF and U2 is ON



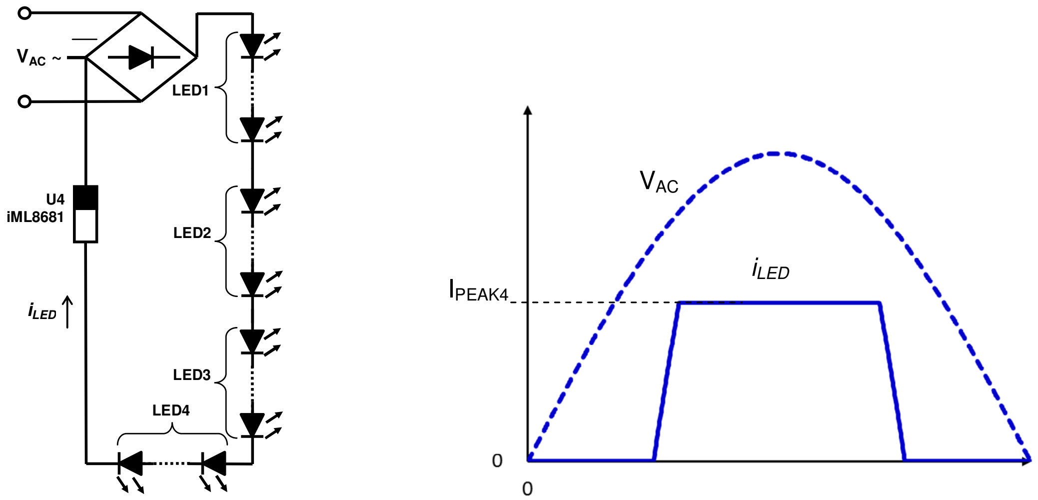
Driving Waveforms of 2-stage Driving Scheme

8. Application Information

8.1 Selection of Driving Scheme

There are 4 typical driving schemes for the iML8681. Stages 1 - 4 use 1 - 4 pieces of iML8681. The power factor (PF) and efficiency increase and the total harmonic distortion (THD) decreases with each additional stage used. The driving scheme is very flexible, so the user can optimize cost and performance. The following describes the driving scheme stages.

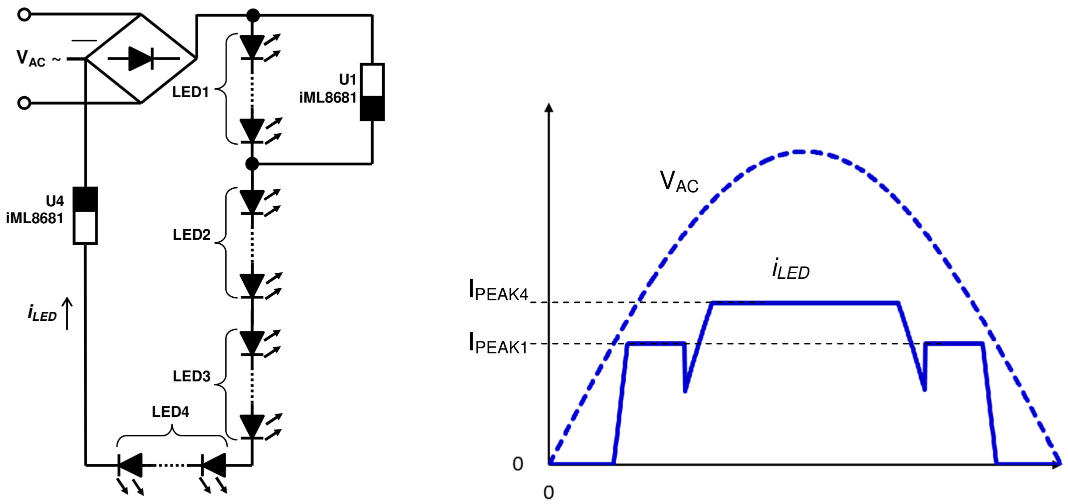
A. Single-Stage Driving Scheme



Single-stage Driving Scheme and Corresponding Waveform

In the single-stage driving scheme, only one iML8681 chip (U4) is utilized as a constant current regulator to drive the entire LED string. The current flowing through the LED string is clamped at I_{PEAK4}, the current setting of U4, when V_{AC} is higher than the cut-in voltage of the LED string.

B. 2-Stage Driving Scheme

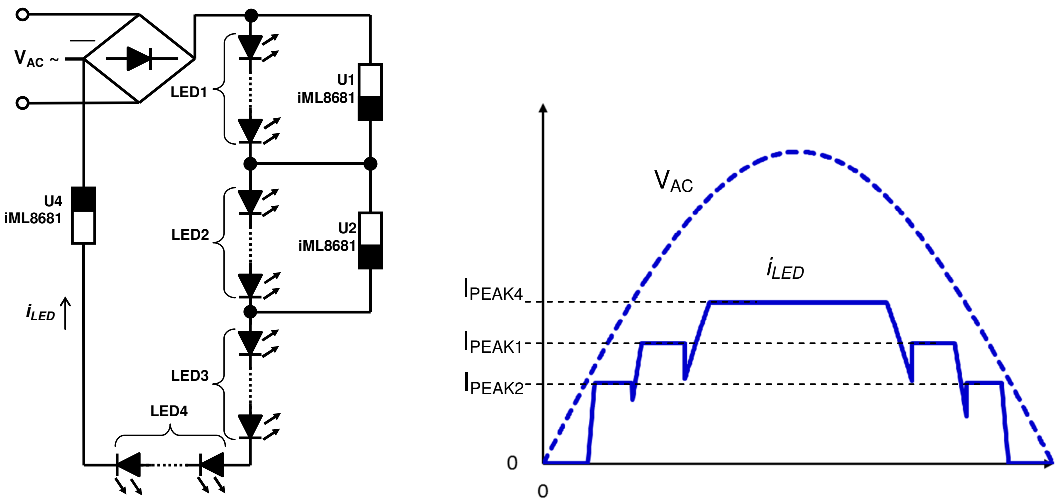


2-stage Driving Scheme and Corresponding Waveform

In the 2-stage driving scheme, two iML8681 chips, U1 and U4, are used. U1 is connected in parallel with LED1 and U4 is connected in series with the entire string. When U1 is turned on, it will clamp the LED current at I_{PEAK1}. When U1 is turned off, U4 will clamp the LED current at I_{PEAK4}.

Beware that I_{PEAK4} must be higher than I_{PEAK1}. Otherwise the circuit will operate as a single-stage driving scheme with U1 kept in the linear region. Usually, U4 must be in Mode 0, and it is recommended that U1 be in Mode 1.

C. 3-Stage Driving Scheme

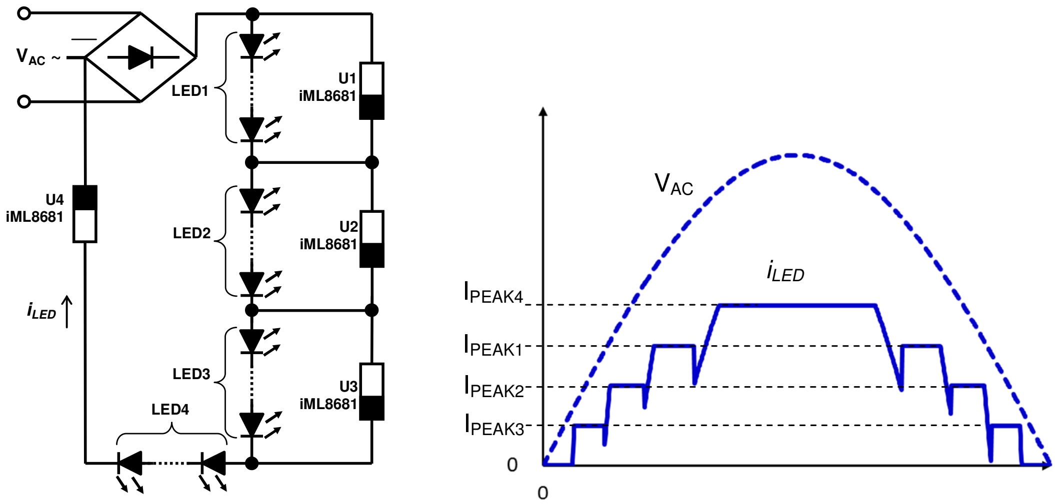


3-stage Driving Scheme and Corresponding Waveform

In the 3-stage driving scheme, three iML8681 chips, U1, U2, and U4 are used. U1 is connected in parallel with LED1; U2 is connected in parallel with LED; and U4 is connected in series with the entire string. Assuming $I_{PEAK4} > I_{PEAK1} > I_{PEAK2}$, U1, U2, and U4 are all turned on at the beginning of the cycle. Because current of U2, I_{PEAK2}, is lowest, U2 will clamp the LED current at I_{PEAK2}. When U2 turns off, U1 will then clamp the LED current at I_{PEAK1}. When U1 and U2 turn off, U4 will clamp the LED current at I_{PEAK4}.

Beware that I_{PEAK4} must be higher than I_{PEAK1} and I_{PEAK2}. The relationship between I_{PEAK1} and I_{PEAK2} determines the sequence that segments LED1 and LED2 light up. If it is desired that LED2 lights up earlier and longer than LED1, I_{PEAK2} should be lower than I_{PEAK1}. Usually, U4 must work in Mode 0, and it is recommended that U1 and U2 work in Mode 1 and Mode 2, respectively.

D. 4-Stage Driving Scheme



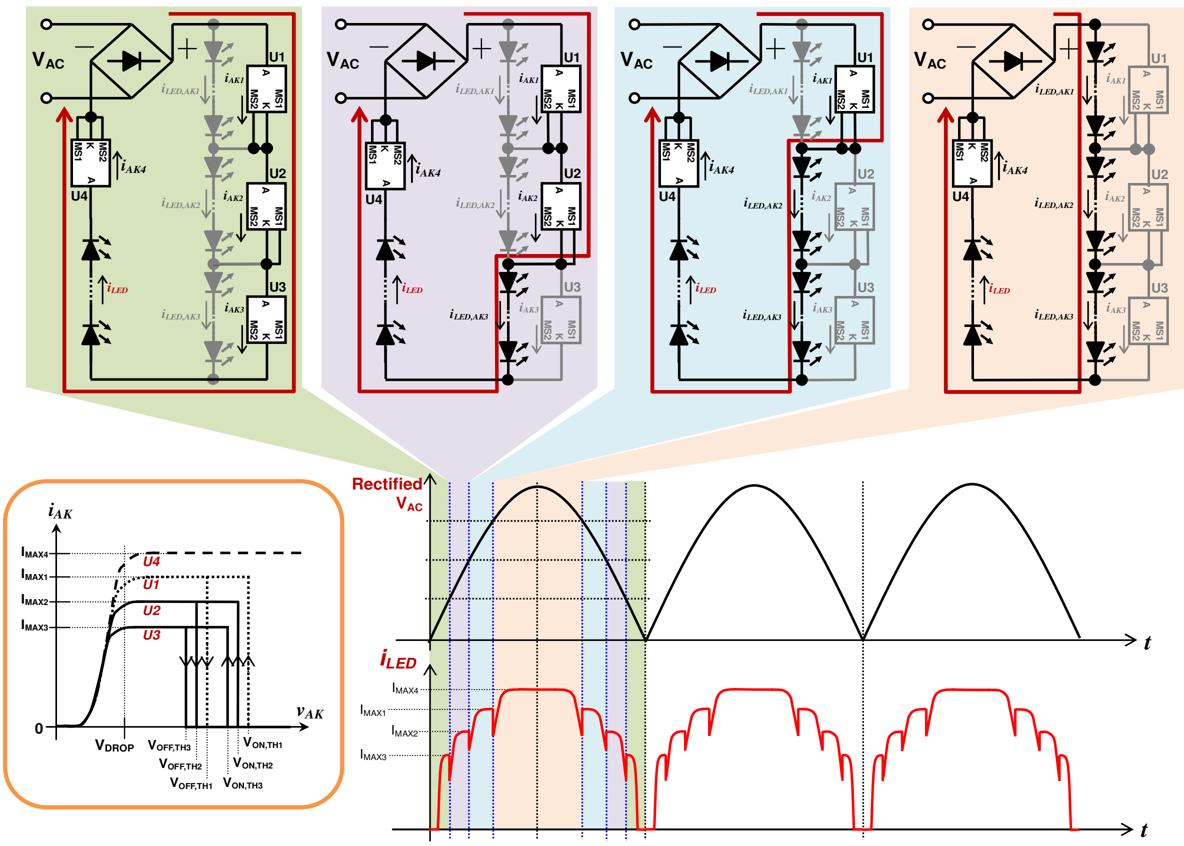
4-stage Driving Scheme and Corresponding Waveform

In the 4-stage driving scheme, four iML8681 chips, U1, U2, U3, and U4 are used. U1, U2, and U3 are connected in parallel with LED1, LED2, and LED3, respectively. U4 is connected in series with the entire string. Assuming $I_{PEAK4} > I_{PEAK1} > I_{PEAK2} > I_{PEAK3}$. U1, U2, U3, and U4 are turned on at the beginning of the cycle. Because the setting current of U3, I_{PEAK3}, is lowest, U3 will clamp the LED current at I_{PEAK3}. When U3 is turned off, U2 will then clamp the LED current at I_{PEAK2}. When U2 is turned off, U1 will then clamp the LED current at I_{PEAK1}. When U1, U2, and U3 are turned off, U4 will clamp the LED current at I_{PEAK4}.

Beware that I_{PEAK4} must be higher than I_{PEAK1}, I_{PEAK2}, and I_{PEAK3}. The relationship between I_{PEAK1}, I_{PEAK2}, and I_{PEAK3} determines the sequence that segments LED1, LED2 and LED3 light up. If LED3 is planned to light up earlier and longer than LED2 and LED1, I_{PEAK3} should be lower than I_{PEAK2} and I_{PEAK1}. Usually, U4 works in Mode 0, and it is recommended that U1, U2, and U3 work in Mode 1, Mode 2, and Mode 3, respectively.

For the 4-stage driving scheme, it is not required that U1 works in Mode 1, U2 works in Mode 2, or U3 works in Mode 3. Only U4 is restricted to operate in Mode 0 and with the highest current level. The system designer can arrange the sequence arbitrarily depending on system needs. Flexibility is an important advantage of iML8681 driving system.

The LED segment lighting sequence for a 4-stage driving scheme is demonstrated in the figure below. In the example, the current path over the rising part of the V_{AC} period is shown step by step.

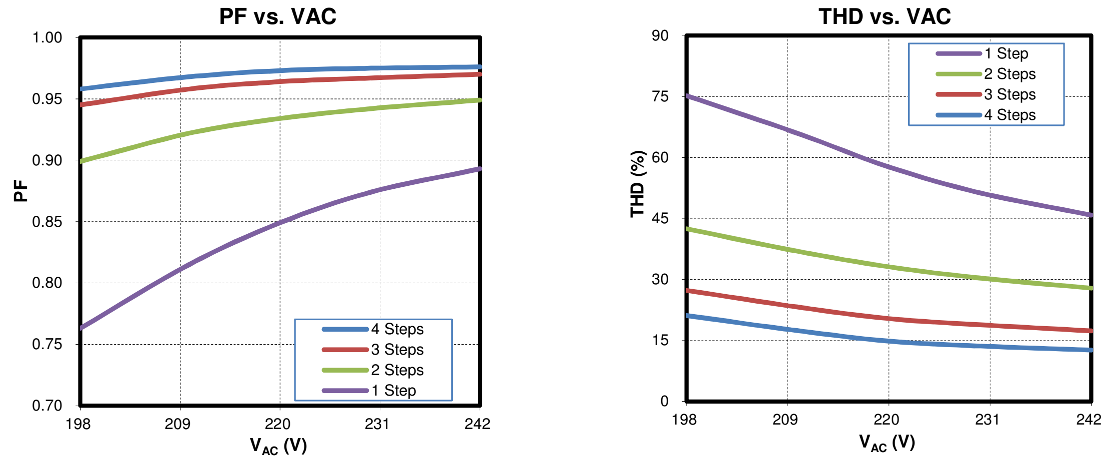


4-stage Driving Scheme Operation Theory

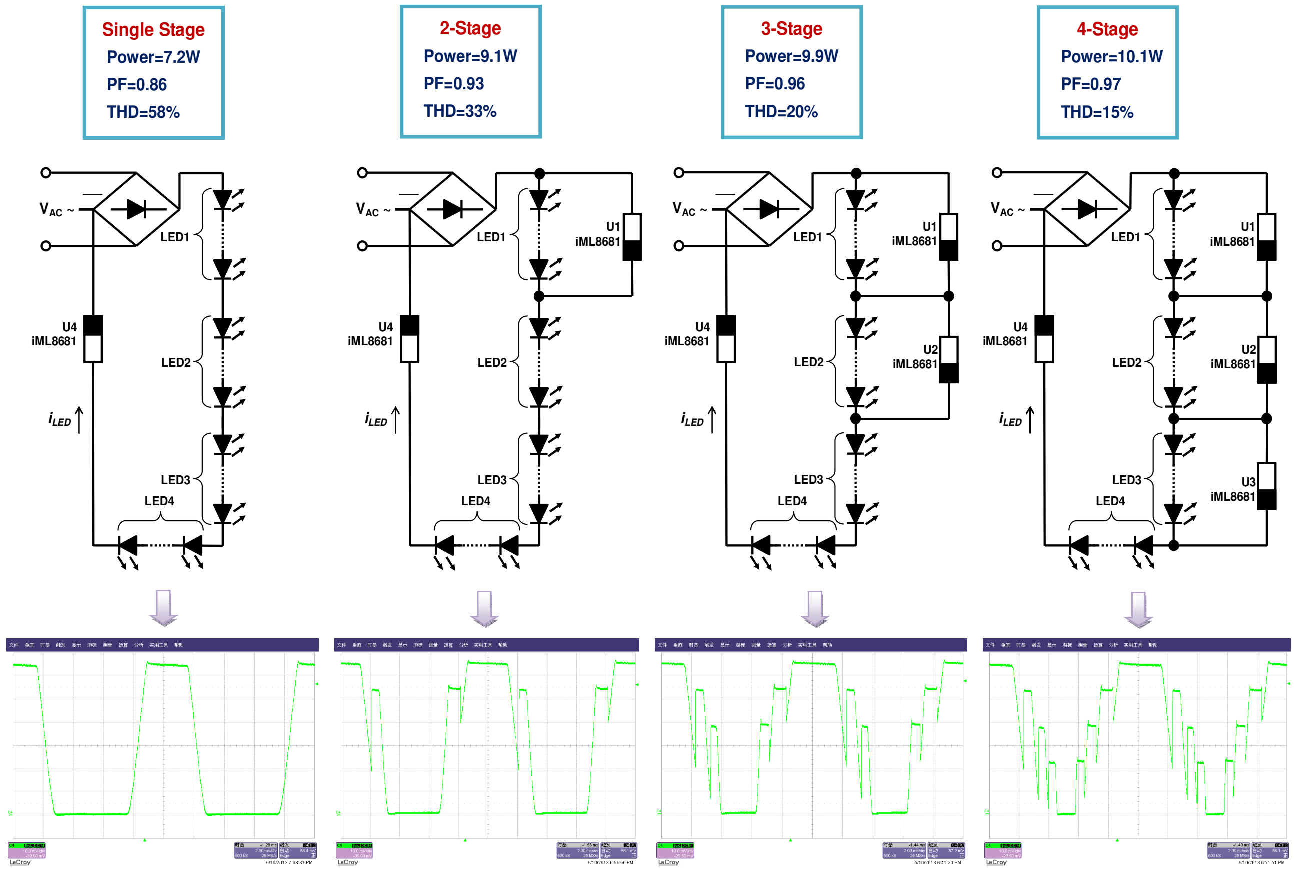
E. Performance comparison of 4 driving schemes

The typical cases of these 4 driving scheme were tested. The test results and waveforms are shown, below. With more stages, the power factor (PF) and total harmonic distortion (THD) are significantly improved.

	Power Factor	THD
Single-stage	0.86	58%
2-stage	0.93	33%
3-stage	0.96	20%
4-stage	0.97	15%



Comparison of PF and THD for 1 through 4 Stage Driving Schemes



LED Current Waveforms of 1 through 4 Stage Driving Scheme

8.2 Total V_F of the LED string

LEDs are current driven components which are very sensitive to forward voltage (V_F). Choosing a suitable V_F for the LED string can improve the performance of the LED lighting system.

To have a suitable total V_F for the LED string, we should consider the AC input voltage and the variation in LED V_F. However, there are fluctuations on the AC input and variations around the LED V_F. Both should be taken into consideration. Generally,

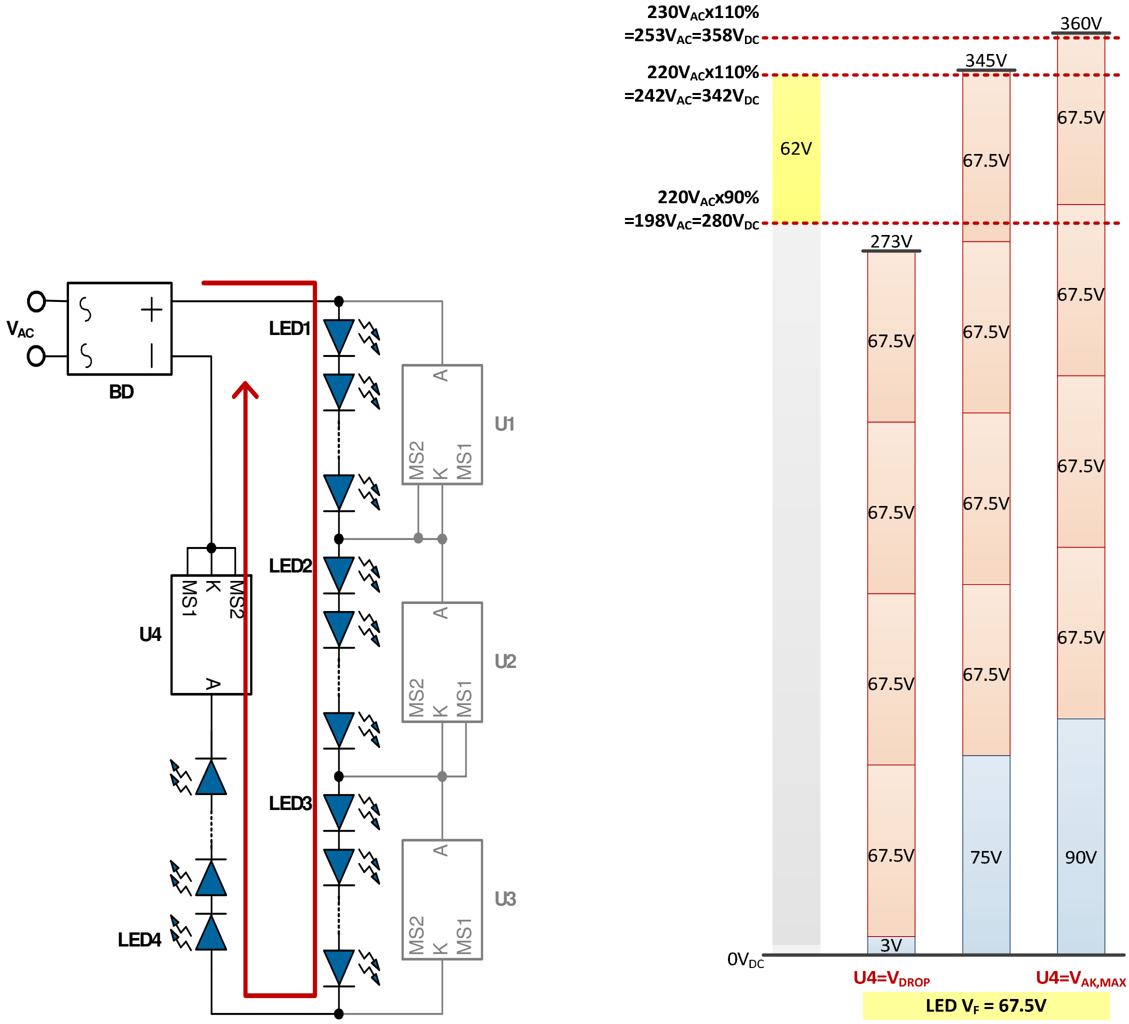
$$\textbf{Rectified } V_{AC,MAX} - v_{AK,MAX} < V_F < \textbf{Rectified } V_{AC,MIN} - V_{DROP}$$

Where, $V_{AC,MAX}$ is the maximum possible V_{AC} voltage, usually 110% of the nominal V_{AC};

$V_{AC,MIN}$ is the minimum possible V_{AC} voltage, usually 90% of the nominal V_{AC}; and

$v_{AK,MAX}$ is the voltage rating of the anode pin to the cathode pin of the iML8681, 90V.

For example, for a V_{AC}=220V power system, the LED total V_F is recommended to be in the range of 252V to 277V. In that case, 4 pieces of 67.5V HV LEDs is very suitable for the application, as shown in the example in below.



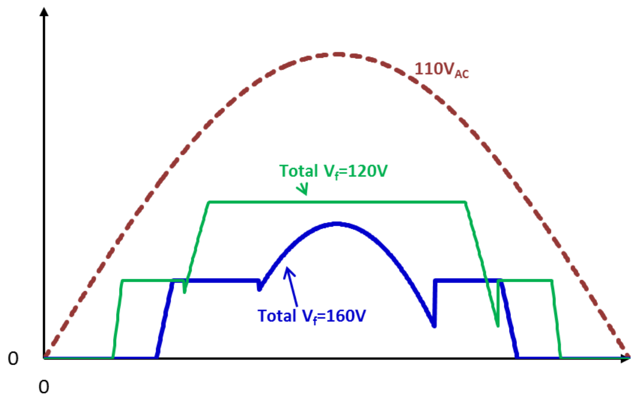
LED V_F Consideration vs. V_{AC} Fluctuation Range

However, in the range allowed, the LED total V_F is recommended to be as high as possible in order to achieve higher efficiency. Therefore, the simple guideline is:

Rectified $V_{AC,Nominal}$ x 83% < LED Total V_F < Rectified $V_{AC,Nominal}$ x 89%

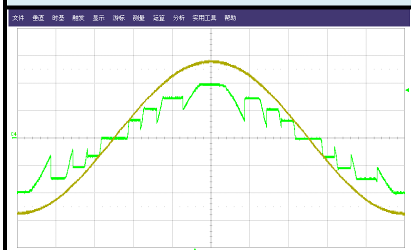
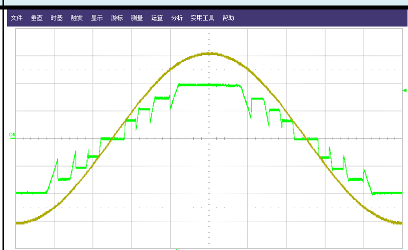
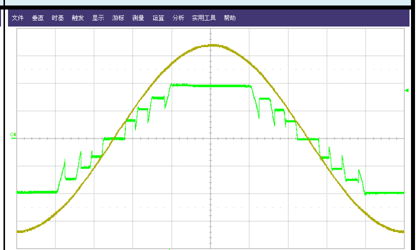
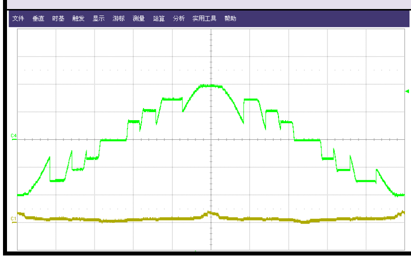
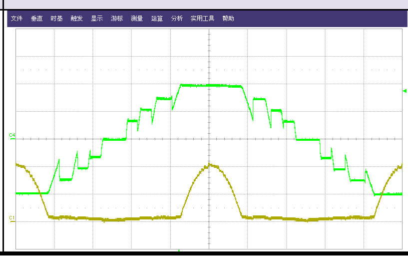
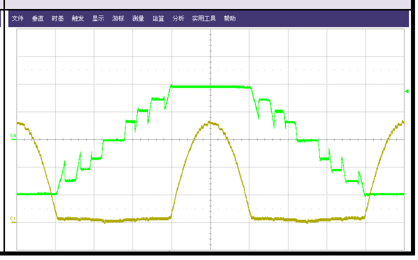
Please refer to the table in below for a summary of the recommended LED total V_F in $100V_{AC}/110V_{AC}/120V_{AC}/220V_{AC}$ power systems. For example, in a $110V_{AC}$ power system, the total V_F of the LED string is recommended to be in the range of 129V~138V. For a $220V_{AC}$ power system, the total V_F of the LED string is recommended to be in the range of 258V~277V. In these cases, the voltage gap between V_{AC} peak and the total V_F becomes the maximum voltage drop across the Anode pin and the Cathode pin of the iML8681 U4 chip series connected at the bottom of the LED string. If the total V_F is higher than V_{AC} peak, i.e. V_F=160V when $V_{AC}=110V_{AC}$, U4 will remain in the linear region and the LED current will not reach the predetermined regulated level, as shown in the figure, below. On the other hand, if the total V_F is much lower than V_{AC} peak, i.e. V_F=50V when V_{AC}=110VA$_C$, the voltage across the Anode pin and the Cathode pin of U4 will be as high as 106V, which is higher than the maximum rating (90V) of the chip and may damage the chip.

AC Input Voltage (rms)		DC Peak Voltage	Recommended Total V_F	Maximum Voltage Drop on U4
$100V_{AC}$ Power system	110V (MAX.)	156V	117~125V	39V
	100V (TYP.)	141V		24V
	90V (MIN.)	127V		10V
$110V_{AC}$ Power system	121V (MAX.)	171V	129~138V	42V
	110V (TYP.)	156V		27V
	99V (MIN.)	140V		11V
$120V_{AC}$ Power system	132V (MAX.)	187V	140~151V	47V
	120V (TYP.)	170V		30V
	108V (MIN.)	153V		13V
$220V_{AC}$ Power System	242V (MAX.)	342V	258~277V	84V
	220V (TYP.)	311V		53V
	198V (min.)	280V		22V



LED Current Waveforms under Different Total V_F Conditions with $110V_{AC}$

The measured waveforms of V_{AC}, LED current, and voltage drop across U4 are shown, below.

V_{AC} vs. LED Current @ V_{AC}=198V	V_{AC} vs. LED Current @ V_{AC}=220V	V_{AC} vs. LED Current @ V_{AC}=242V
		
U4 V_{AK} vs. LED Current @ V_{AC}=198V	**U4 V_{AK} vs. LED Current @ V_{AC}=220V**	**U4 V_{AK} vs. LED Current @ V_{AC}=242V**
		

8.3 Selection for Option

For better performance, consider not only the average current, but also, the actual LED V_F at the expected peak current. The steps for selecting the most suitable option are:

1. Determine the product type considering V_{AC} range, power of the lamp, number of stages, and the LED V_F in each stage.
2. Choose the most suitable options for the actual LED V_F at the expected peak current.

Step 1. Determine the product type

The iML8681 provides a number of options with different regulating currents and ON/OFF voltages for different combinations of AC source, lamp power, and LED V_F in each segment. Please refer to the table, below. When the LED V_F and product type are determined, the system designer can determine suitable options based on the table as a quick start.

LED V_F		67V		52V		36V		
LED Number		4		5		4		
iML8681 Chip Number		4		4		4		
V_{AC} (V)		230	220	230	220	120	110	100
Power	6W	K11/K12	K11/K12	K41/K42	K51/K52	N11/N12	N21/N22	N31/N32
	8W	K21/K22	K21/K22	K61/K62	K71/K72	N41/N42	N51/N52	N61/N62
	10W	K31/K32	K31/K32	K81/K82	K91/K92	N71/N72	N81/N82	N91/N92

Step 2. Voltage Matching for U1

For better voltage matching, the $V_{ON,TH}$ of stage 1 (U1) and the actual LED V_F at the expected peak current should be considered. Please refer to the following figure. The driving scheme and the i-v curves of the LED1 segment for a 2-stage network are shown. The peak regulating current of U1 and U4, I_{PEAK1} and I_{PEAK4}, are also shown.

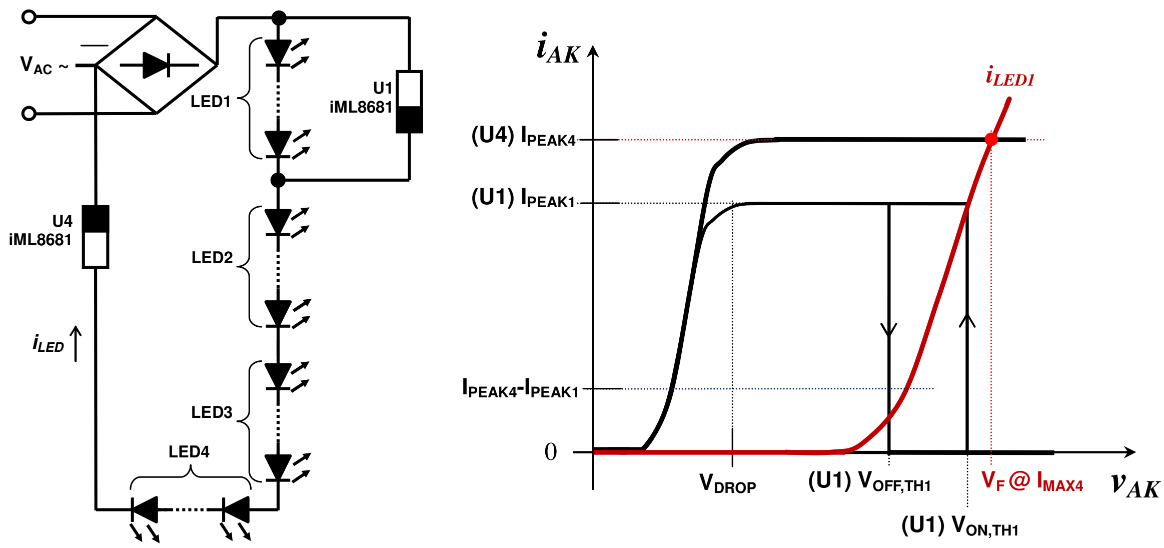
$V_{OFF,TH1}$ of U1 should be lower than the V_F of LED1 at $i_{LED1}=I_{PEAK4}-I_{PEAK1}$. Otherwise, i_{LED} will be clamped at I_{PEAK4} and v_{AK1} will be clamped at the V_F of LED1 at $i_{LED1}=I_{PEAK1}-I_{PEAK4}$. Consequently, U1 will remain in the on-state during the V_{AC} rising period, reducing efficiency.

$V_{ON,TH1}$ of U1 should be lower than the V_F of LED1 at I_{PEAK4}. Otherwise, U1 will remain in the off-state until v_{AK} of U1 ramps down to be lower than $V_{OFF,TH1}$ as V_{AC} falls. As a result, the current notch will become more serious. Note that, the maximum value of $V_{ON,TH1}$ should be taken into consideration and the V_F drops due to high temperature should also be considered. As a rule of thumb:

$$\mathbf{V_{ON,TH1,MAX} < (LED1\ V_F\ @\ I_{MAX4}\ @\ 85°C) - 2V}$$

where, 2V is a guard band.

After the option for U1 (Mode 1) is determined, U4 (Mode 0) is determined since U4 can be the same option.



Driving Scheme and i-v Curves of the LED String with 2-stage iML8681

If the 3-stage or 4-stage driving schemes are used, also follow the selection rules, above, to choose the best option for U1 (Mode 1). The same option can be applied for U2 (Mode 2) and U3 (Mode 3). The settings of MS1 and MS2 by PCB layout will distinguish them.

8.4 V_F Variation

When all of the LEDs are turned on, it is recommended that (LED total V_F) + (V_{DROP} of U4) be lower than (rectified V_{AC} peak) when V_{AC} is the 90% of the nominal value (minimum fluctuation level). In order not to damage U4, (rectified V_{AC} peak) – (LED total V_F) should be lower than the voltage rating of U4 when V_{AC} is 110% of the nominal value (maximum fluctuation level).

However, the real LED V_F is distributed over a wide range in volume. For example, for a 67V HV LED, the real V_F may be between 63.5V and 71.5V. The LED V_F is usually sorted into many bins during production. This makes the design of lighting network using the iML8681 a little complicated.

Take a 67V LED as an example. Please refer to the figure, below.

If V_F is at the typical value (i.e. V_F center bin = 67.5V)

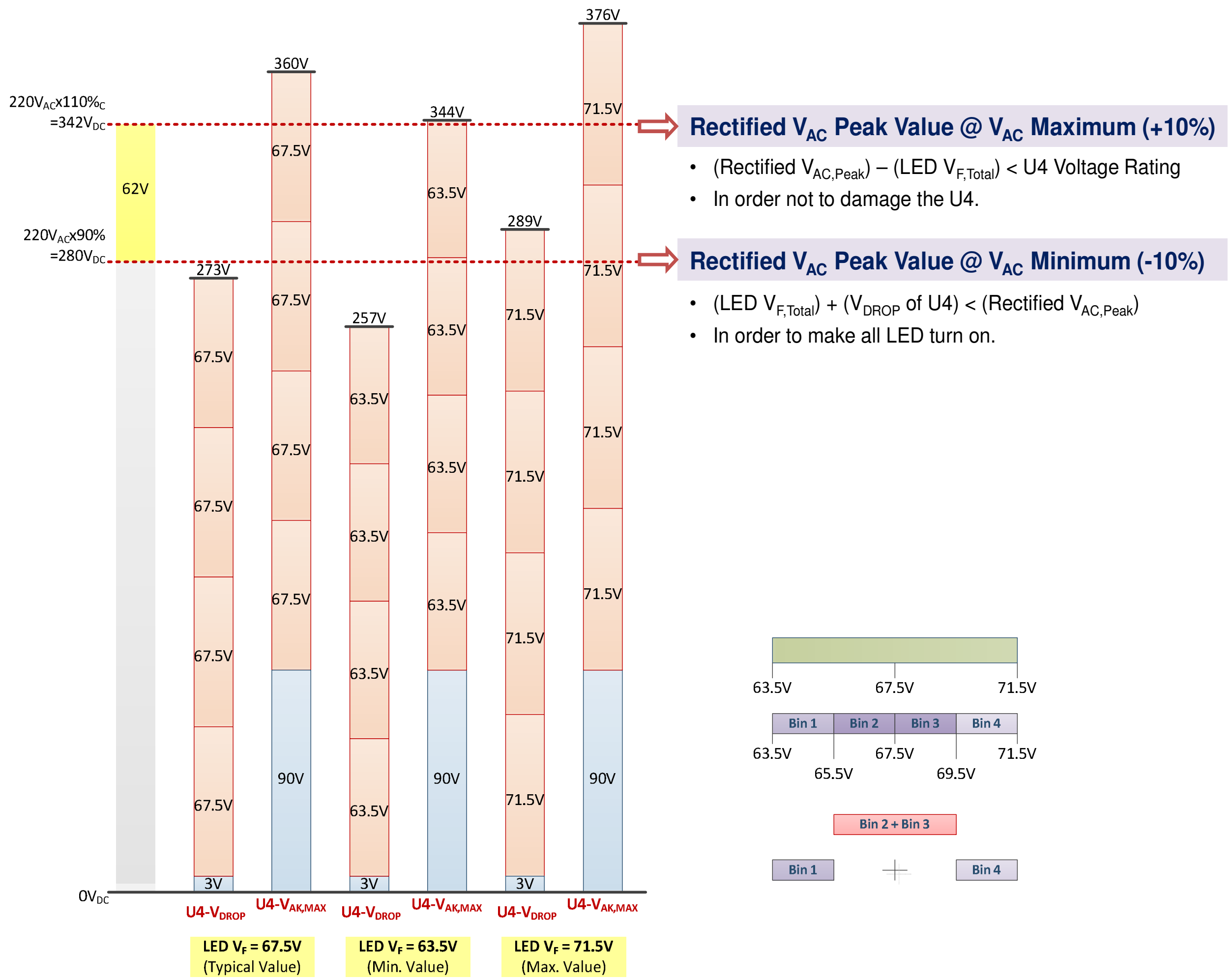
➔ Just match the V_{AC} operating range.

If V_F is at the minimum value (i.e. V_F bottom bin = 63.5V)

➔ U4 needs a higher voltage rating. The iML8681 just matches.

If V_F is at the maximum value (i.e. V_F top bin = 71.5V)

➔ The top segment group of LEDs may not turn on when the V_{AC} power fluctuates to the minimum level.



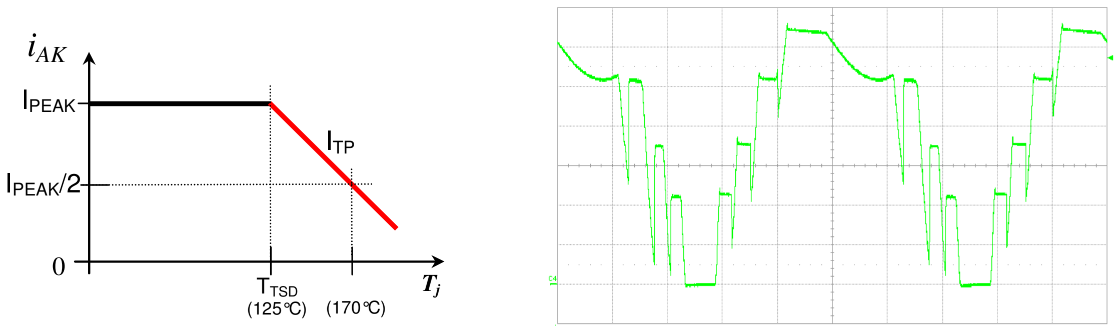
LED V_F Variation vs. V_{AC} Range

So, if 67V LEDs are sorted in to 4 bins: Bin 1 = 63.5V ~ 65.5V; Bin 2 = 65.5V ~ 67.5V; Bin 3 = 67.5V ~ 69.5V; and Bin 4 = 69.5V ~ 71.5V, it is recommended to select the iML8681 option according to the Bin 2 V_F value. Then, both Bin 2 and Bin 3 LEDs can be used. For the LEDs in the Bin 1 and Bin 4, if a ~4% decrease in PF and an ~8% increase in THD are acceptable, then the LEDs in the Bin 1 and Bin 4 can be used in the same option (BOM) as Bin 2 and Bin 3. If better performance is desired, different options for Bin 1 and Bin 4 are needed. Further, if the 67V LED is composed of discrete low voltage LEDs, such as 3V, 6V, or 9V, mixing of the Bin 1 LEDs and Bin 4 LEDs in lamp production is possible.

In summary, if the iML8681 option is selected for typical V_F, the decrease of PF and increase of THD is acceptable with V_F ± 5% range.

8.5 Thermal Protection

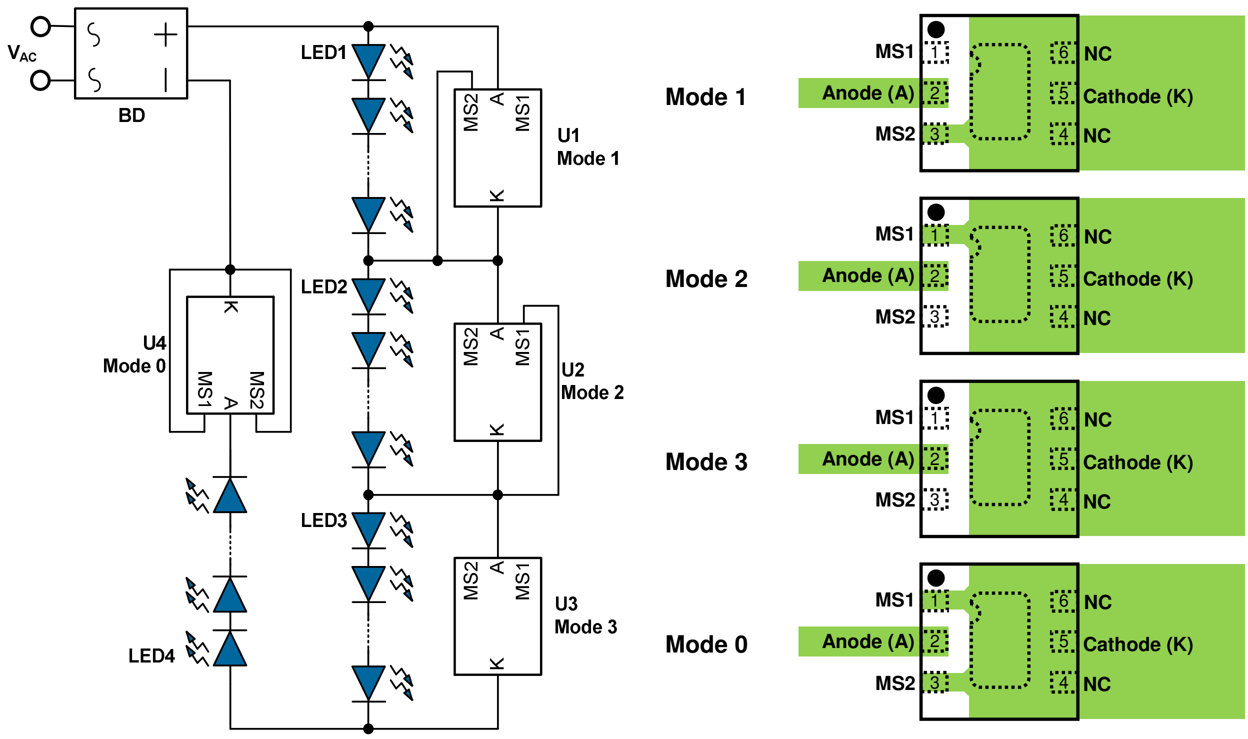
The thermal protection function is embedded to prevent permanent damage caused by high junction temperature (T_J). Please refer to the figure in below for the curves and the measured waveforms. When the junction temperature, T_J, is higher than 125℃, the thermal protection is activated and the peak current starts to ramp down linearly at a rate of around -1.1%/℃. This feature helps the system to achieve thermal steady state.



Linear Ramp Down Type Thermal Protection Function

8.6 Layout Suggestion

The MS1 pin and MS2 pin are on the same side of the package as the Anode (A) pin, not the Cathode (K) pin. The MS1 and MS2 pins can be connected to K pin through the exposed pad. The NC pins (4 and 6) can also be connected to the exposed pad and the K pin to enhance the power dissipation ability.



Layout Suggestion for Improving the Power Dissipation Ability