New LED Lighting IPD

MIP553

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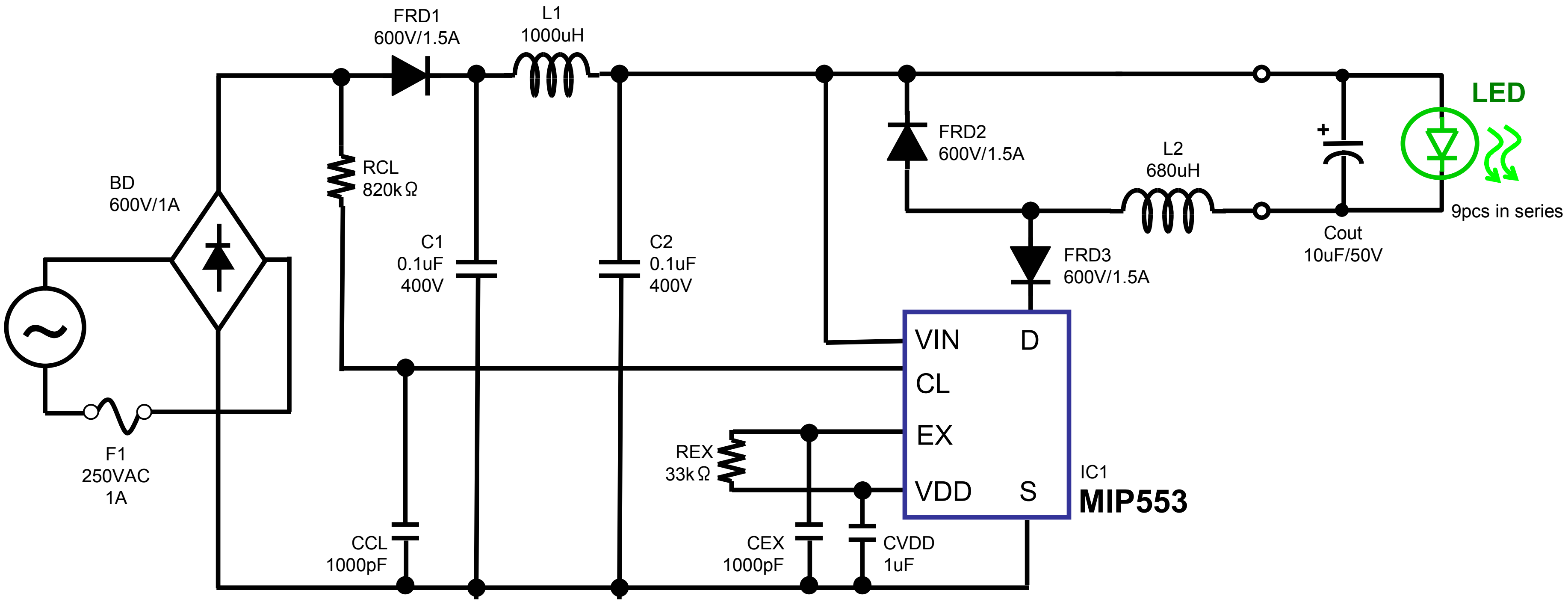
Example of application circuit

Effective for low output voltage specification and high efficiency



"High efficiency and high PF is achieved with low component count"

Components：16

η =85.8%, PF=0.93

Reference data *(When LED12pcs load in series is driven)*

VAC = 120V , VLED = 28.6V , ILED = 0.390A , Po = 11.1W , Pin = 13.0W

η = 85.8% , pF = 0.93

LED current can be adjusted by the constant L2, RCL and REX.

However, the efficiency and PF will change, so please confirm.

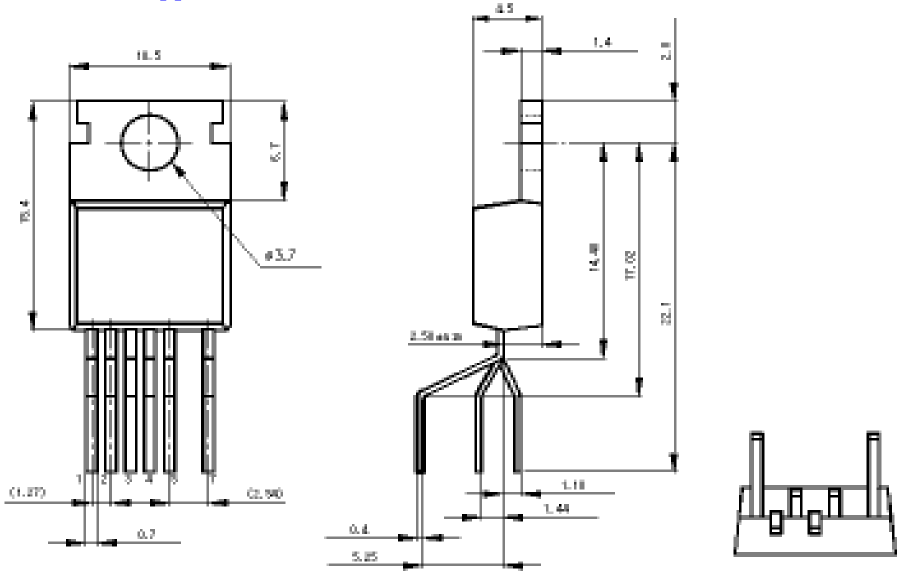
MIP553 Product Specification（Tentative）

■ MIP553

- **Breakdown voltage = 700V ＊**
- **On-resistance = 3.5 Ω(typ.)**
- **DRAIN peak current = 1.5A(typ.)**
  - **⇒ LED average current ≦ 0.70A (standard)**
- **Fixed Off-Time Control (Toff:16us, MaxOn:80us)**
- **Protection functions**
  - **→ Low Input voltage detection**
  - **→ LED Short Circuit (skip mode**
  - **→Over Temperature protection (140 ℃, self-recovery)**

＊ : Reliability test applied voltage 630V

○Package（TO-220IPD7-A2）



※Not compatible pin name, pin arrangement and function with MIP552.
※There is minor difference in function with MIP554.

○Pin arrangement & function

PinNo.	Pin name	Function
1	VIN	Current supply pin for internal circuit & Input voltage detection
2	EX	External adjustment pin to set peak current value
3	CL	Peak current control pin according to input voltage
4	SOURCE	Power MOSFET Source, Circuit GND pin
5	VDD	Reference voltage pin for internal IPD circuit
7	DRAIN	Power MOSFET Drain Pin

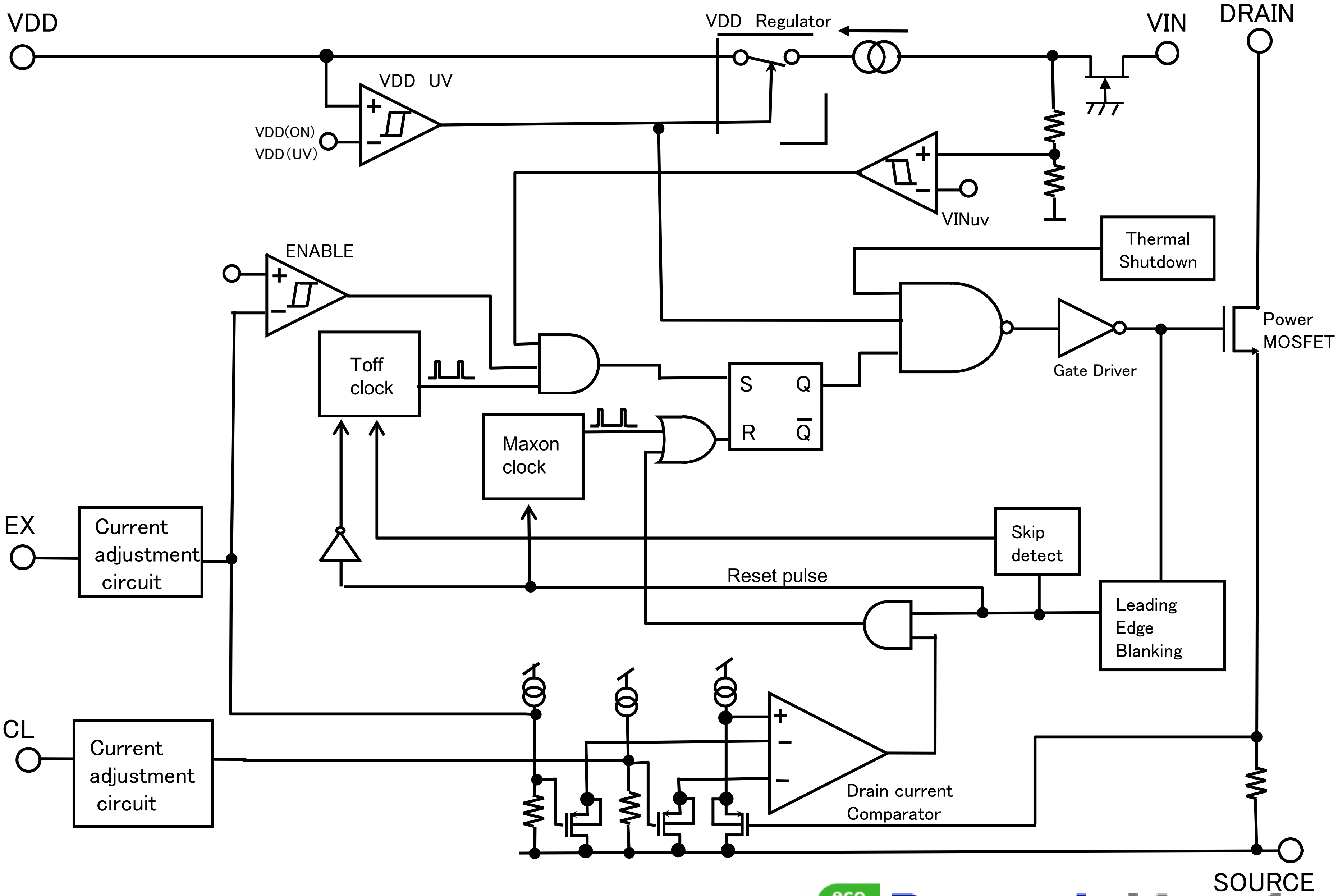
○Pin comparison with MIP552

Pin No.	MIP553	MIP552
1	VIN	EX
2	EX	L
3	CL	VDD
4	SOURCE	SOURCE
5	VDD	VIN
7	DRAIN	DRAIN

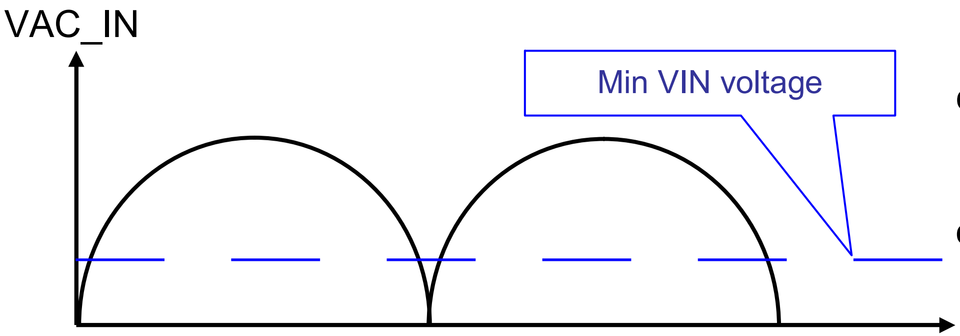
MIP553 vs MIP552 Characteristics Comparison

Items	MIP553	MIP552
Control method	Fix OFF time (16us)	PWM control (44kHz)
Ron	3.5Ω	6.0Ω
ILIMIT	1.5A	1.0A
Driving input voltage	Low input voltage detection function by VIN pin >24V	>45V
EX terminal function	ILIMIT is adjusted by **current** Remote on/off function・・for PWM dimmer	ILIMIT is adjusted by **voltage** Remote on/off function・・for PWM dimmer
CL terminal function **(Modified from L terminal function of MIP552)**	ILIMIT is adjusted by **current** For simple PFC or TRIAC dimmer	-
VDD(ON)	6.5V	5.8V
Protection function	Over temperature protection：140℃（self recovery △70℃) LED short protection（skip mode）	Over temperature protection：140℃（self recovery △70℃) LED short protection（skip mode）

Block diagram

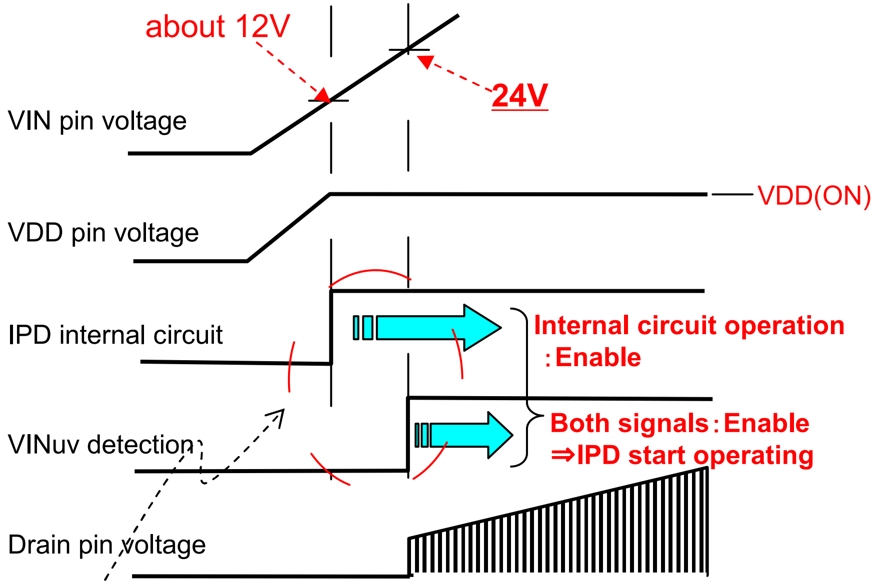


Fixed Driving voltage



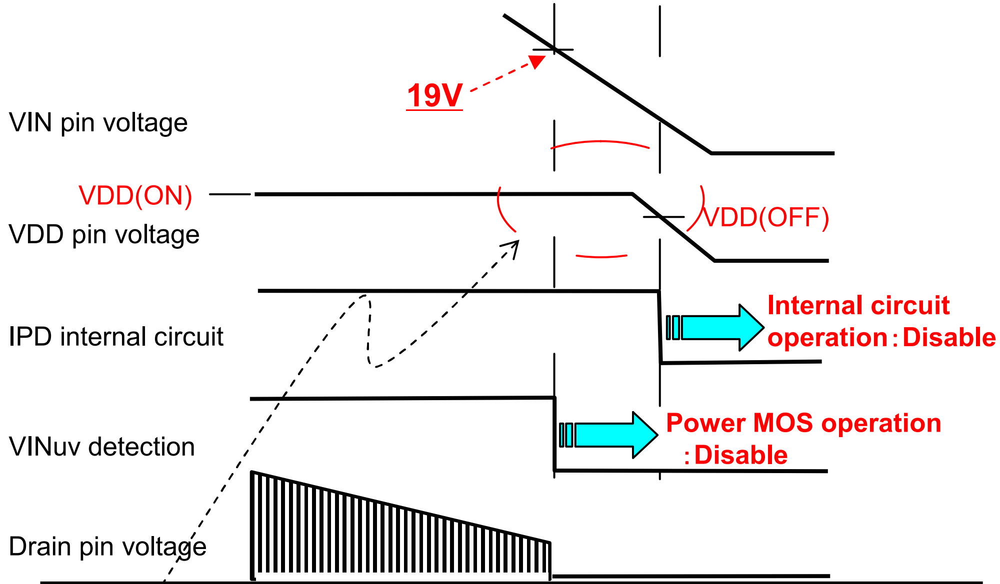
・VDD reaches to startup voltage around VIN≒12V by enhancing current charging capability of VIN pin.
・Start-up driving voltage is set by VIN voltage detecting function. Moreover, hysteresis operation can prevent any unstable operation just after operation start.

Each pin waveform at startup & input voltage rising



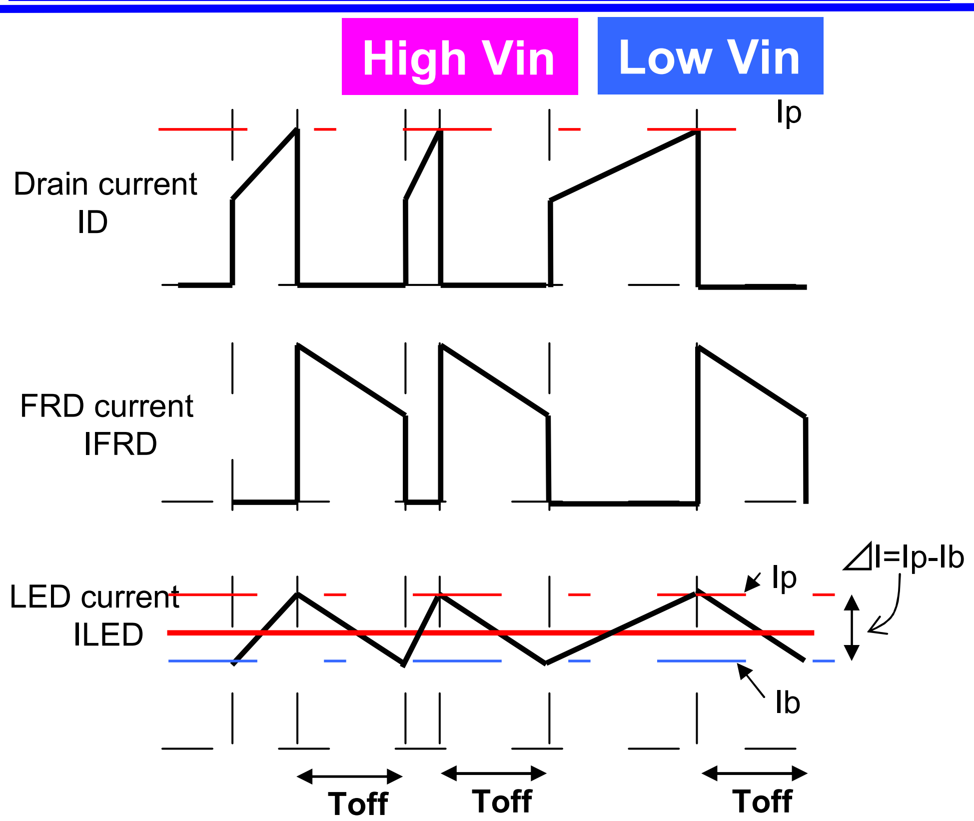
When VDD pin becomes >VDD(ON) and also VIN pin becomes >VINuv, IPD starts operation.
As the charging time to VDD pin capacitor is necessary when power supply startup, VDD pin voltage might become VDD(ON) only after VIN pin becomes >VINuv. This will be different from the figure above.

Each pin waveform at stopping & input voltage dropping



VDD pin maintains VDD(ON) even though IPD oscillation stops.
In this case, when input voltage becomes >VINuv, IPD restarts the operation.
However when input voltage continues to drop, VDD pin becomes <VDD(OFF) due to lower charging capability, and internal circuit also stops the operation.

Fixed OFF time control



・MOS turn-on duration

$$ID = Ib + \frac{(Vin - Vo)}{L} \times Ton \quad \cdots \text{formula ①}$$

・MOS turn-off duration

$$ID = Ip - \frac{Vo}{L} \times Toff \quad \cdots \text{formula ②}$$

・Average current (Io) flowed into LED

$$Io = \frac{Ip + Ib}{2} = Ip - \frac{Vo}{2L} \times Toff \quad \cdots \text{formula ③}$$

★On-time period of Power MOS is depending on Input voltage, (Refer to formula ①).
On-time period becomes shorter at high Vin and longer at low Vin.
On-time is restricted by MAXduty in case of PWM method, and Power MOS might turn off before peak current detection point is reached when Vin is low.
However Power MOS can turn on up to peak current detection value in case of **Off time fixed control.**

（Limitation of Maxon time is set actually.）

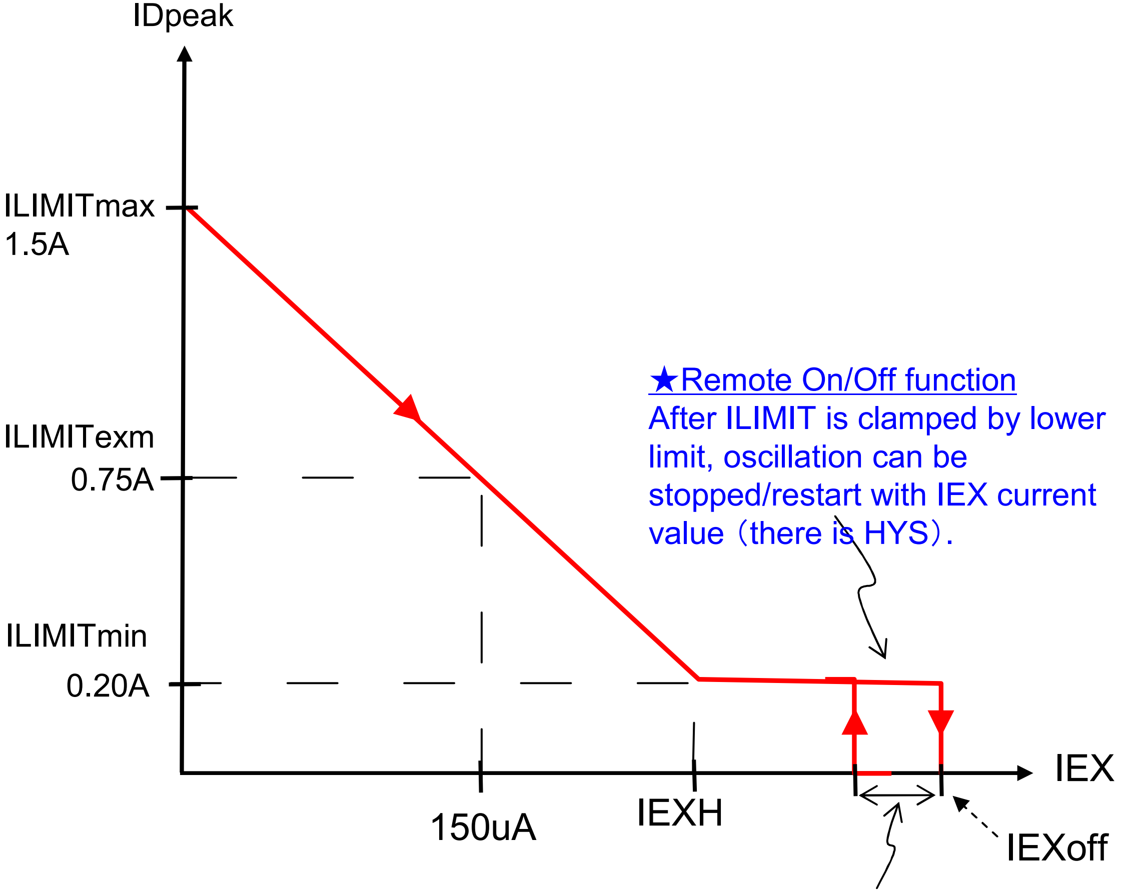
Ripple current ⊿I does not depend on input voltage when it is constantly controlled in continuous mode, and **ILED (Average current value) that flows into LED can be always controlled constantly.**

★Oscillation frequency changes depending on input voltage.
This jitter function can reduce EMI average noise

★Io (LED current) is shown simply as formula ③ and so application designing could be easier.

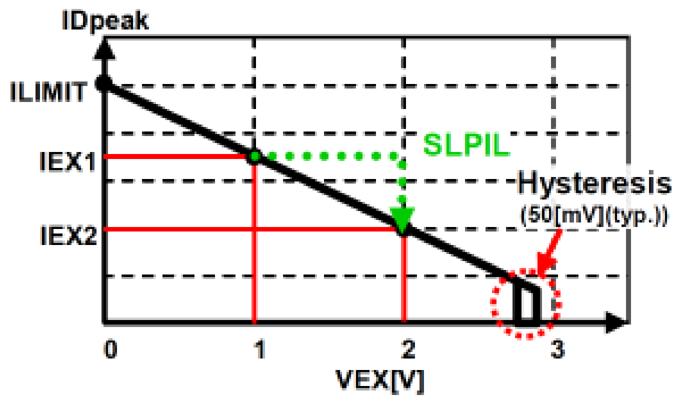
External setting of peak current detection value by EX pin

- ･IDpeak detection value can be set externally by supplying DC current into EX pin.
- ･IDpeak detection value becomes lower with higher IEX supplied current, and it is clamped at ILIMIT(min).
- ･ Apart from IDpeak control function by CL pin, IDpeak detection value can be set individually.
  （IDpeak detection value set by EX pin has the priority.）
- ･Oscillation stops at IEXoff , with hysteresis of IEXhys. It is possible for PWM dimmer control application.



EX pin current

MIP552 EX pin control method

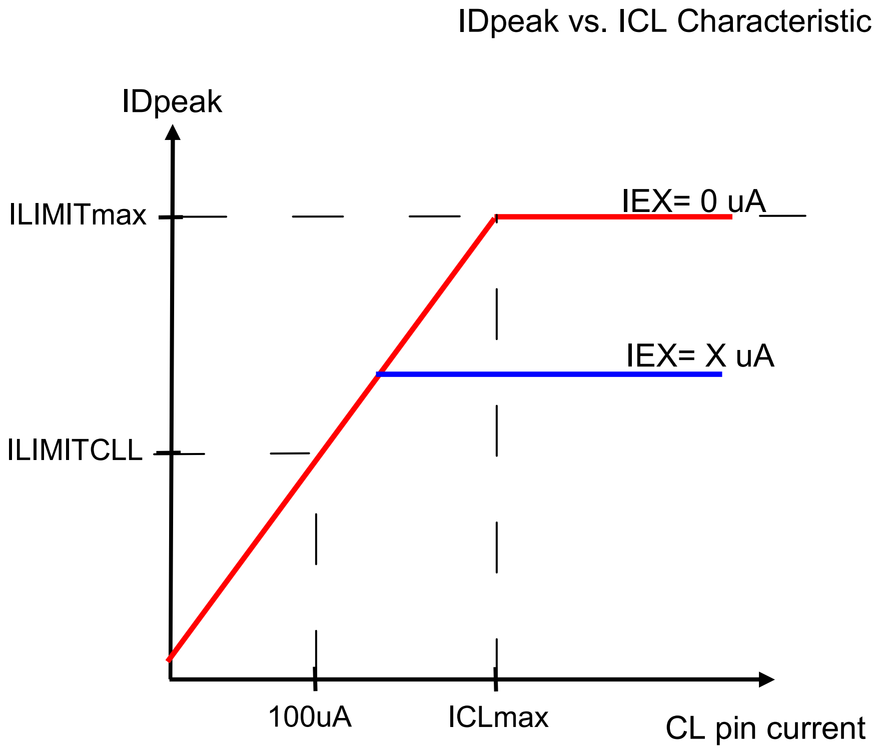


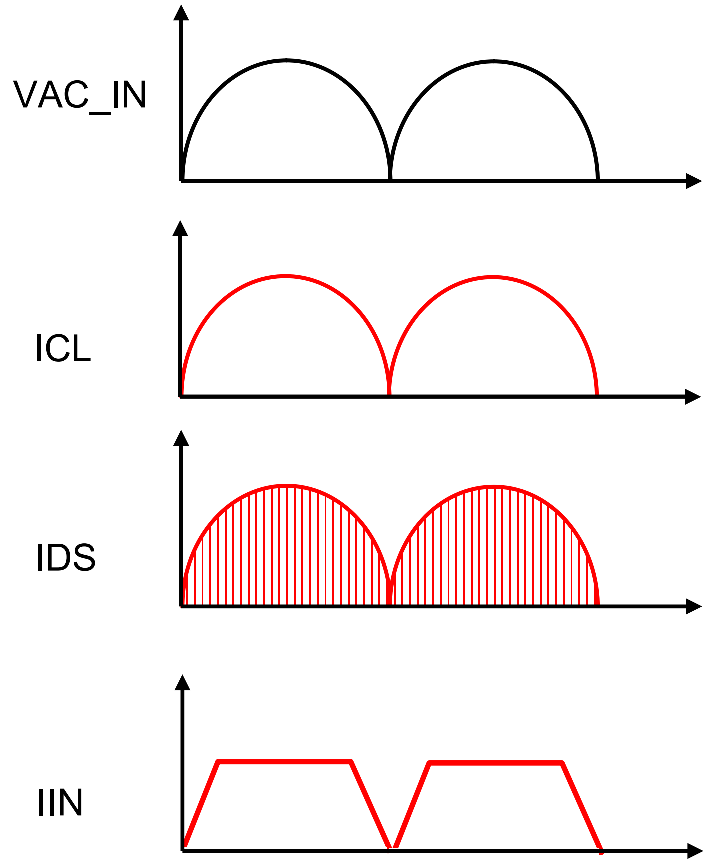
※Control method of EX pin are different for MIP553 and MIP552

In ***MIP552,*** IDpeak is controlled by EX pin voltage as shown in the figure above. IDpeak decreases when VEX increases.

In *MIP553,* IDpeak is controlled by EX pin current .
IDpeak decreases when IEX increases.

Simplified PFC function by CL pin





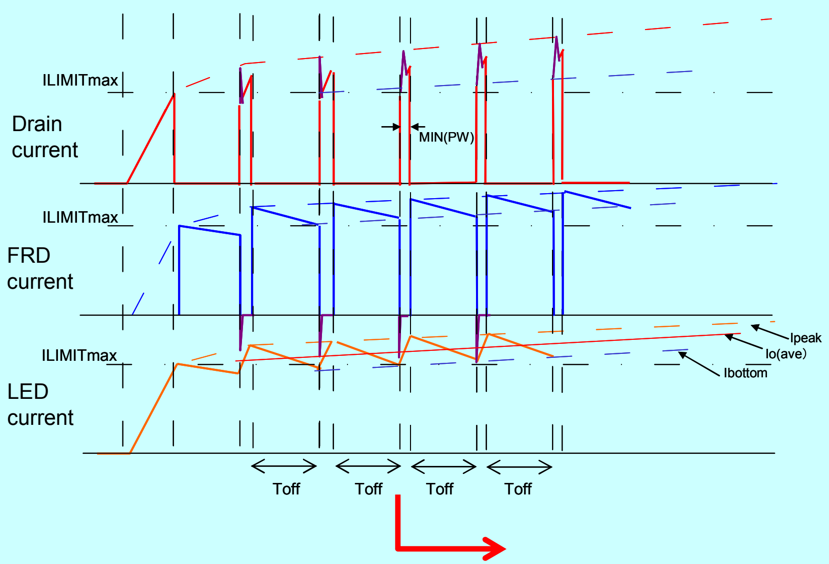
- IDpeak detection value changes according to the DC current supplied into CL pin.
- Please connect a resistor between VDD and CL when the CL function is not used.
- IDpeak level can be changed by EX pin current.

- Input voltage after total rectification is added to CL pin through the resistor and CL current changes linearly depending on input voltage waveform.
- IDpeak detection value changes according to DC current supplied into CL pin.
- When the current value flowed into IPD changes depending on the change of input voltage by the control above, Input current flows during almost all the period as the figure above. Power factor can be improved as a result.

Skip mode

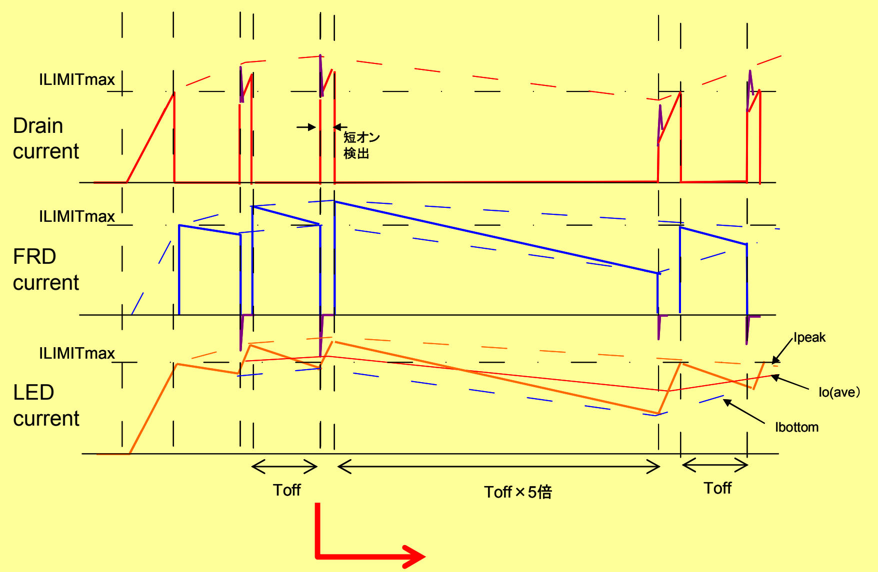
MIN(PW) that Power MOS of this IPD can turn on is designed to be about 410ns.
（Depending on on-time blanking width (TBLK) & Peak current detection delayed time (td(OCL))）
Peak current control is not effective during the operation within minimum pulse width.
In order to avoid this operation, off time is increased to 5 times longer, when on-time of power MOS becomes close to minimum pulse width. (Skip(PW): About 510ns)
Therefore current value at turn on timing of next pulse becomes smaller and on-time becomes longer. This prevents minimum pulse operation.

Without skip mode function



Output current increases
when min pulse operation is repeated.

With skip mode function



Output current is decreased/increased repeatedly due to the detection before the pulse becomes minimum.

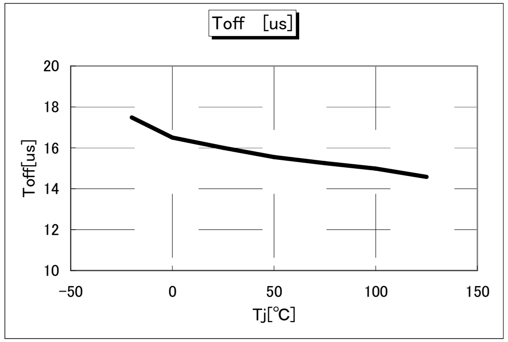
Main specs item

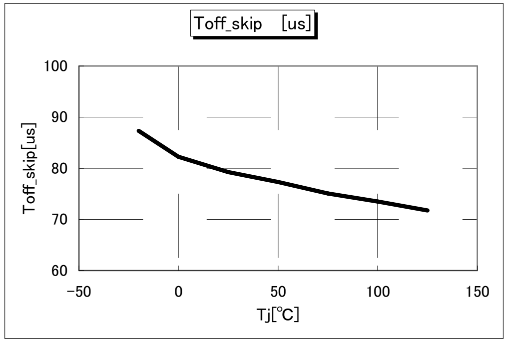
The specs value is tentative. It will be subjected to change in the future.
* Design guarantee item. The final test is not executed.

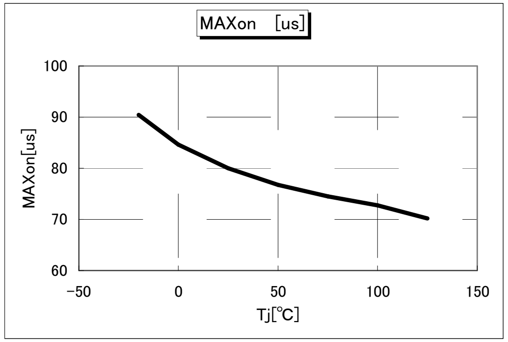
NO	Item	Symbol	Condition	SPEC			Unit
				typ	min	max	
1	Constant OFF time	Toff	VDD=VDD(ON)+0.1V、VD=5V、VIN=50V、IEX=0uA,ICL=ICLmax+50uA	16	14.4	17.6	us
2	Skip mode Constant OFF time	Toff_skip	VDD=VDD(ON)+0.1V、VD=5V、VIN=50V、IEX=0uA,ICL=ICLmax+50uA Ton<Skip(PW)	5.0×Toff	TBD	TBD	us
3	Maximum ON time	MAXon	VDD=VDD(ON)+0.1V、VD=5V、VIN=50V、IEX=0uA,ICL=ICLmax+50uA	80	TBD	TBD	us
4	VDD Start Voltage	VDD(ON)	VIN＝50V、VD=5V,VEX=0uA,ICL=ICLmax+50uA	6.5	TBD	TBD	V
5	VDD Stop Voltage	VDD(UV)	VIN＝50V、VD=5V,VEX=0uA,ICL=ICLmax+50uA	5.5	TBD	TBD	V
6	Circuit Current before Strat	IS1	VDD=VDD(ON)-0.2V、IEX=0uA,ICL=ICLmax+50uA	1.09	TBD	TBD	mA
7	Circuit Current under Switching	IS2	VDD=VDD(ON)+0.1V 、IEX=0uA,ICL=ICLmax+50uA	1.12	TBD	TBD	mA
*8	EX Pin Current for setting ILIMITmin	IEXH	VDD=VDD(ON)+0.1V、VIN=50V、ICL=ICLmax+50uA,ILIMIT⇒ILIMITmin	260			μA
9	EX Pin Current at oscillation stop	IEXoff	VDD=VDD(ON)+0.1V、VIN=50V、ICL=ICLmax+50uA	430	TBD	TBD	μA
10	EX Pin Current Hysteresis at oscillation restart	IEXhys	VDD=VDD(ON)+0.1V、VIN=50V、ICL=ICLmax+50uA	50			μA
11	EX Pin Voltage	VEXM	VDD=VDD(ON)+0.1V、VIN=50V、IEX=150uA	2.55	TBD	TBD	V
		VEXH	VDD=VDD(ON)+0.1V、VIN=50V、IEX=IEXH	2.8	TBD	TBD	V
		VEXoff	VDD=VDD(ON)+0.1V、VIN=50V、IEX=IEXoff	3.2	TBD	TBD	V
12	EX Pin Short Current	IEXSVDD	VEX=VDD,VDD=VDD(ON)+0.1V,VIN=50V	1.0	TBD	TBD	mA
		IEX0	VEX=0V,VDD=VDD(ON)+0.1V,VIN=50V	0			μA
13	CL Pin Current for setting ILIMITmax	ICLmax	VDD=VDD(ON)+0.1V、VIN=50V、IEX=0uA,ILIMIT=ILIMITmax	300	TBD	TBD	μA
14	CL Pin Voltage	VCLmax	VDD=VDD(ON)+0.1V、VIN=50V、ICL=ICLmax	2.9	TBD	TBD	V
15	CL Pin Short Current	ICLSVDD	VDD=VDD(ON)+0.1V、VIN=50V、VCL=VDD	1.30	TBD	TBD	mA
		ICL0	VDD=VDD(ON)+0.1V、VIN=50V、VCL=0V	0			μA
16	Maximum Peak Current Limit	ILIMITmax	VDD=VDD(ON)+0.1V、VIN=50V、IEX=0uA、ICL=ICLmax+50uA	1.5	1.38	1.62	A
*17	ILIMIT ICL100	ILIMITCLL	VDD=VDD(ON)+0.1V、VIN=50V、IEX=0uA、ICL=100uA	0.6			A
18	ILIMIT IEX150	ILIMITexm	VDD=VDD(ON)+0.1V、VIN=50V、IEX=150uA、ICL=ICLmax+50uA	0.75	0.69	0.81	A
19	Minimum Clamp ILIMIT	ILIMITmin	VDD=VDD(ON)+0.1V、VIN=50V、IEX=IEXH+20uA、ICL=ICLmax+50uA	0.2	TBD	TBD	A
*20	Leading Edge Blanking Delay	ton(BLK)		200	150	250	ns
*21	Peak Current Limit Delay	td(OCL)		200			ns
22	Minimum on-pulse width	MIN(PW)	VIN=50V、VD=35V、VDD:open、IEX=0uA、ICL=ICLmax+50uA	410	TBD	TBD	ns
*23	Skip detect on-pulse width	Skip(PW)	VIN=50V、VDD=VDD(ON)+0.1V、IEX=0uA、ICL=ICLmax+50uA	510			ns
*24	Thermal Shutdown Junction Temperature	TOTPj		140	130	150	℃
*25	Thermal Shutdown Hysteresis	⊿TOP		70			℃
26	ON-State Resistance	RDS(ON)	VDD=VDD(ON)+0.1V、VIN=50V、IEX=0uA、ICL=ICLmax+50uA、IDS=300mA	3.5		TBD	Ω
27	OFF-State leakage Current of DRAIN Pin	IDSS	VDD=VDD(ON)+0.1V,VCL=0V,IEX=IEXoff+10uA,VDS=630V	1		TBD	μA
28	Breakdown Voltage of DRAIN Pin	VDSS	VDD=VDD(ON)+0.1V,VCL=0V,IEX=IEXoff+10uA,IDS=100uA		700		V
29	Rise Time	tr	VDD=VDD(ON)+0.1V、VIN=50V、IEX=0uA, ICL=ICLmax+50uA,VDS=5V	100			ns
30	Fall Time	tf		50		80	ns
31	OFF-State leakage Current of VIN Pin	IIN(LEAK)	VDD=VDD(ON)+0.1V,VCL=0V,IEX=IEXoff+10uA,VIN=450V	26		TBD	μA
32	Breakdown Voltage of VIN Pin	BVVIN	VDD=VDD(ON)+0.1V,VCL=0V,IEX=IEXoff+10uA,IIN=100uA		500		V
33	VDD Charging Current	CHRG10	VIN=40V、VDD=0V、EX、CL:open	-10	TBD	TBD	mA
		CHRG15	VIN=40V、VDD=5.5V、EX、CL:open	-6.5	TBD	TBD	mA
34	VIN start Voltage	VINuv	VDD:open、VD=5V、IEX=0uA、ICL=ICLmax+50uA	24	TBD	TBD	V
35	VIN start Voltage Hysteresis	VINhys	VDD:open、VD=5V、IEX=0uA、ICL=ICLmax+50uA	19			V

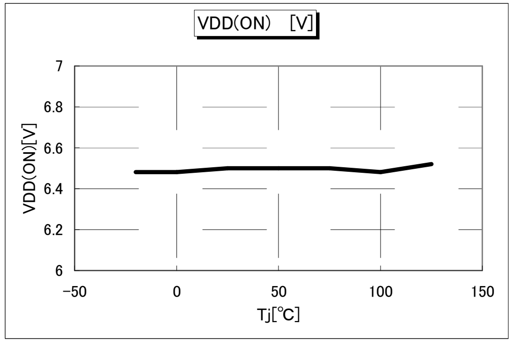
Temperature characteristic data ①

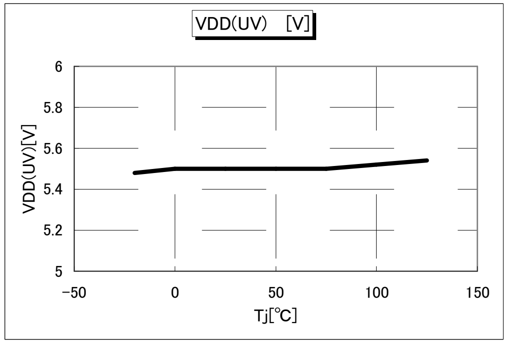
※This is reference data for WS. There may be changes in the end-product.

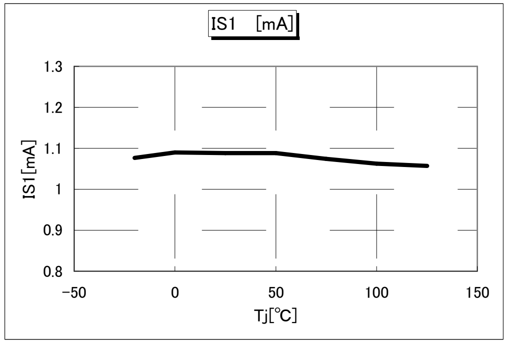


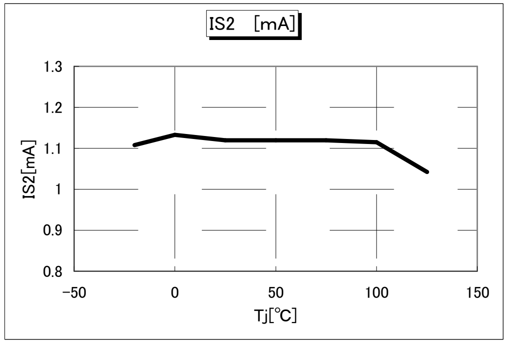


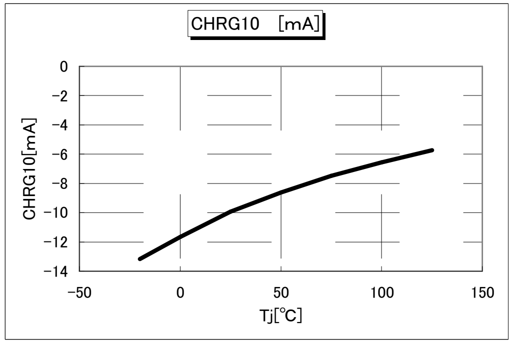


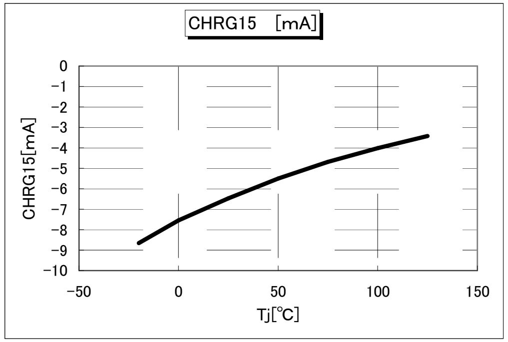


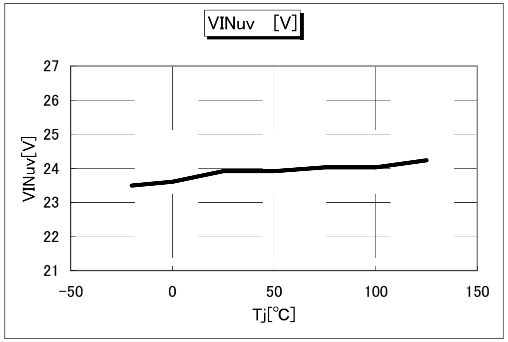


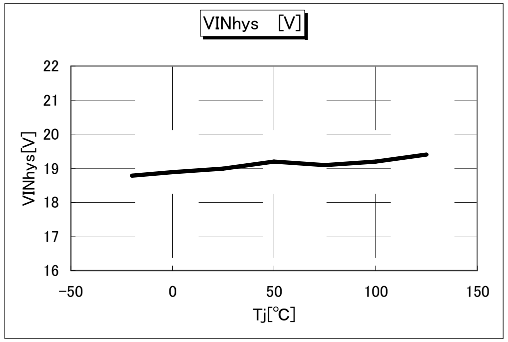


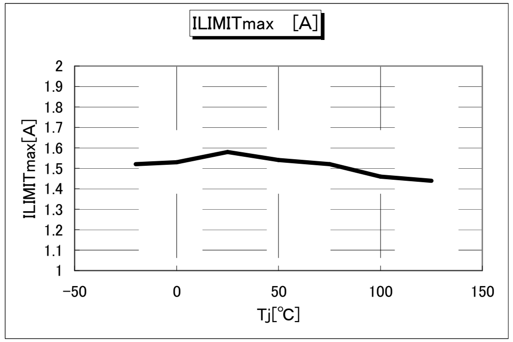












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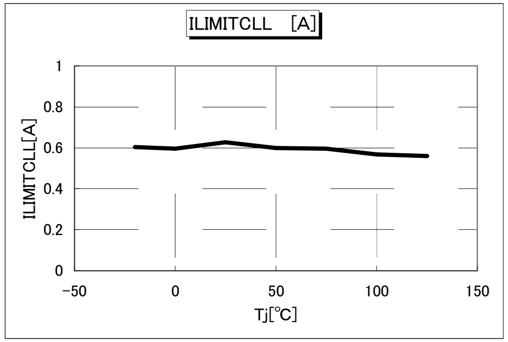
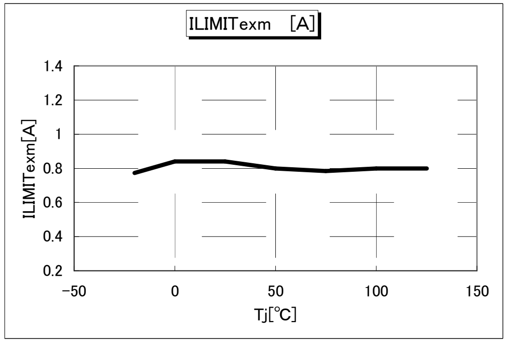
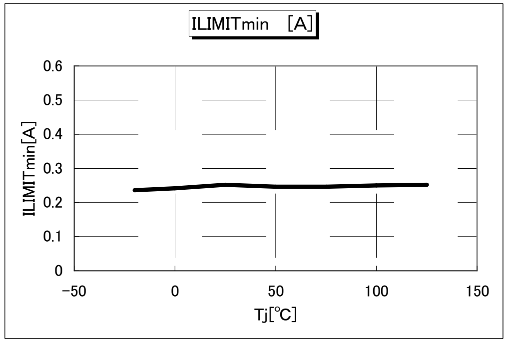
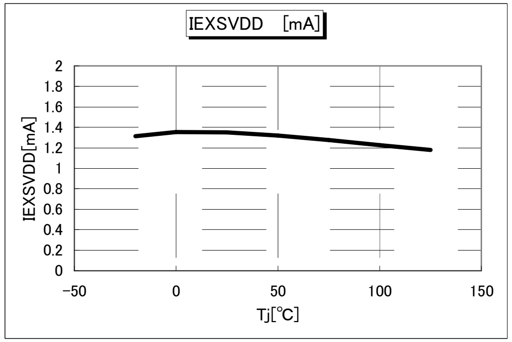
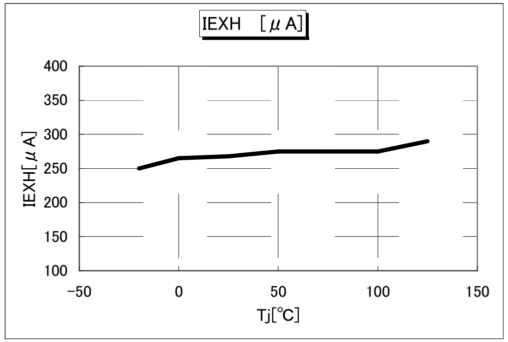
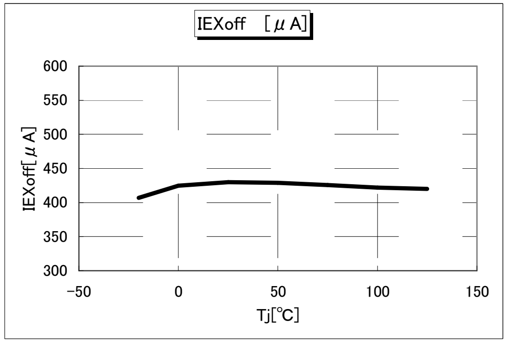


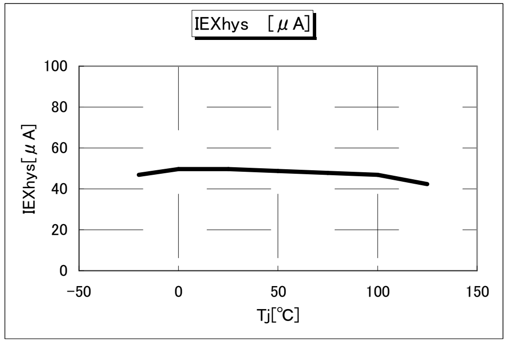


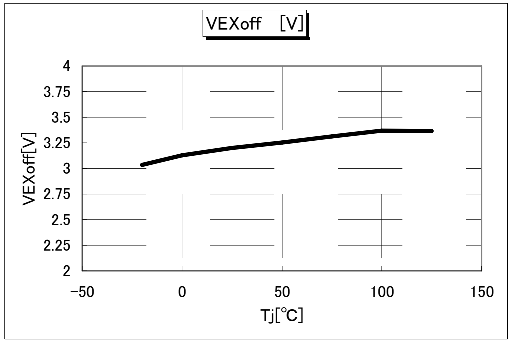


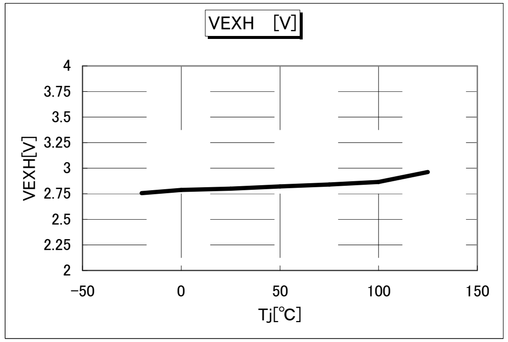


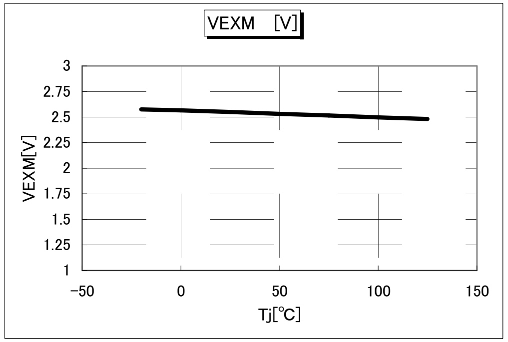


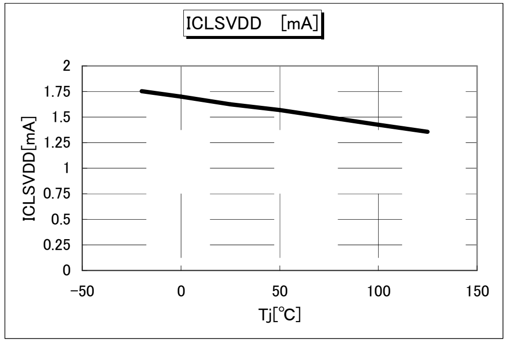


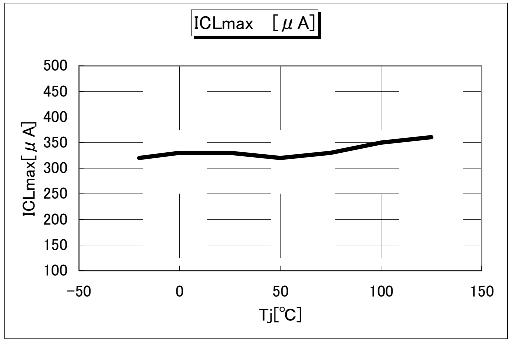






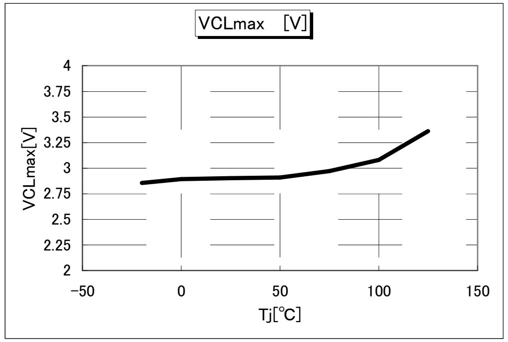


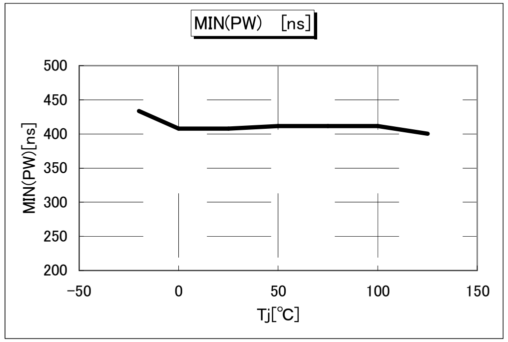


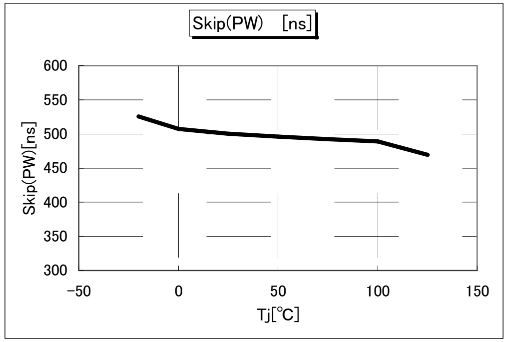


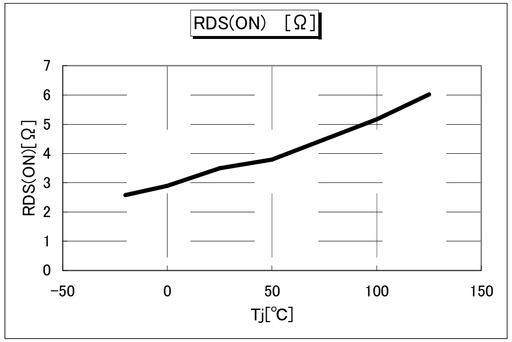
Temperature characteristic data ③

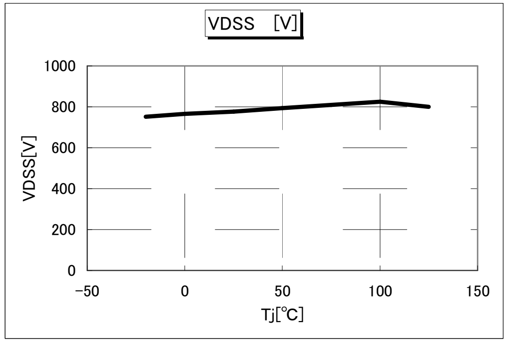
※This is reference data for WS. There may be changes in the end-product.

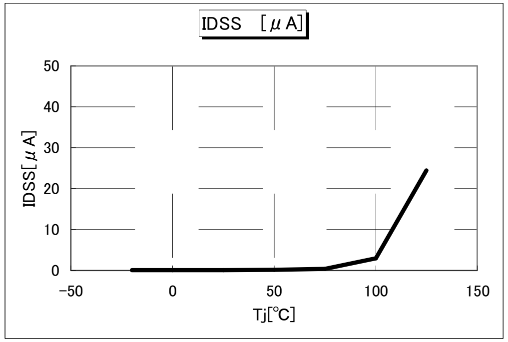


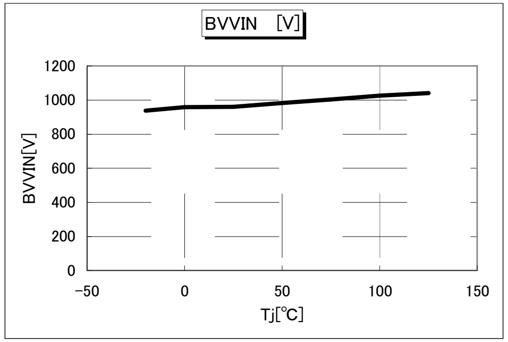


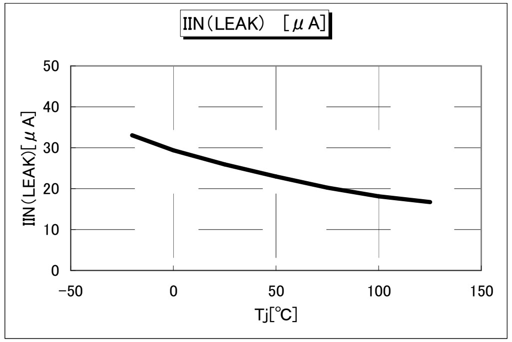








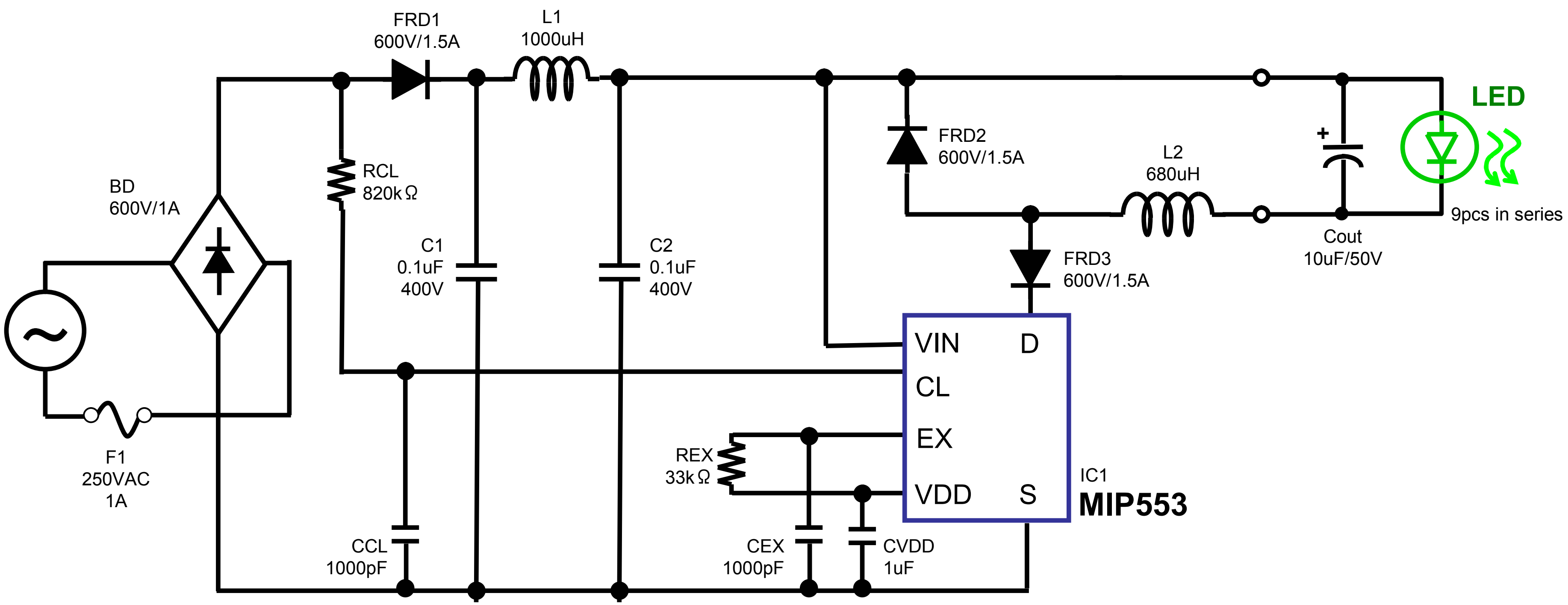




Example of application circuit

For Buck type／simple PFC function

Effective for low output voltage specification and high efficiency



"High efficiency and high PF is achieved with low component count"

Components：16

η =85.8%, PF=0.93

Reference data *(When LED12pcs load in series is driven)*

VAC = 120V , VLED = 28.6V , ILED = 0.390A , Po = 11.1W , Pin = 13.0W

η = 85.8% , pF = 0.93

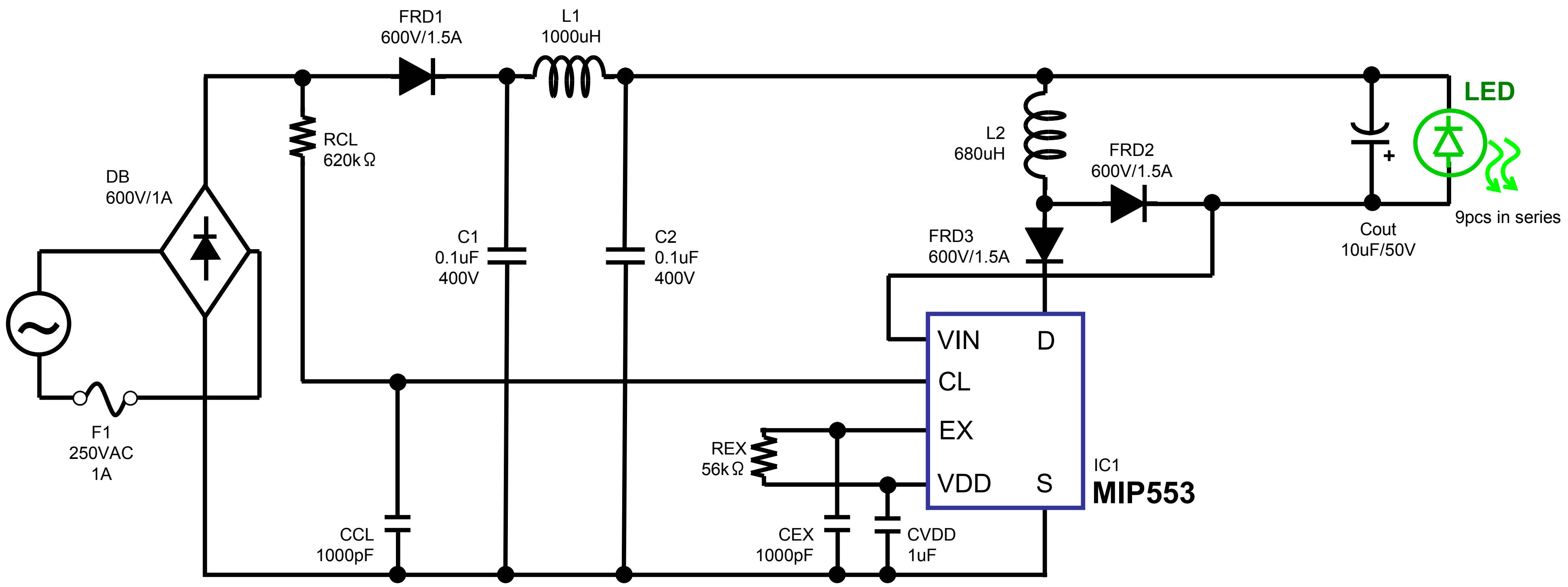
LED current can be adjusted by the constant L2, RCL and REX.

However, the efficiency and PF will change, so please confirm.

Example of application circuit

Buck-Boost Type／Simple PFC function

Effective for high output voltage specification and high PF



"High PF is achieved with low component count"

PF=0.95

Reference data *(When LED10pcs load in series is driven)*

VAC = 120V , VLED = 28.4V , ILED = 0.379A , Po = 10.7W , Pin = 13.4W

η = 80.4% , pF = 0.95

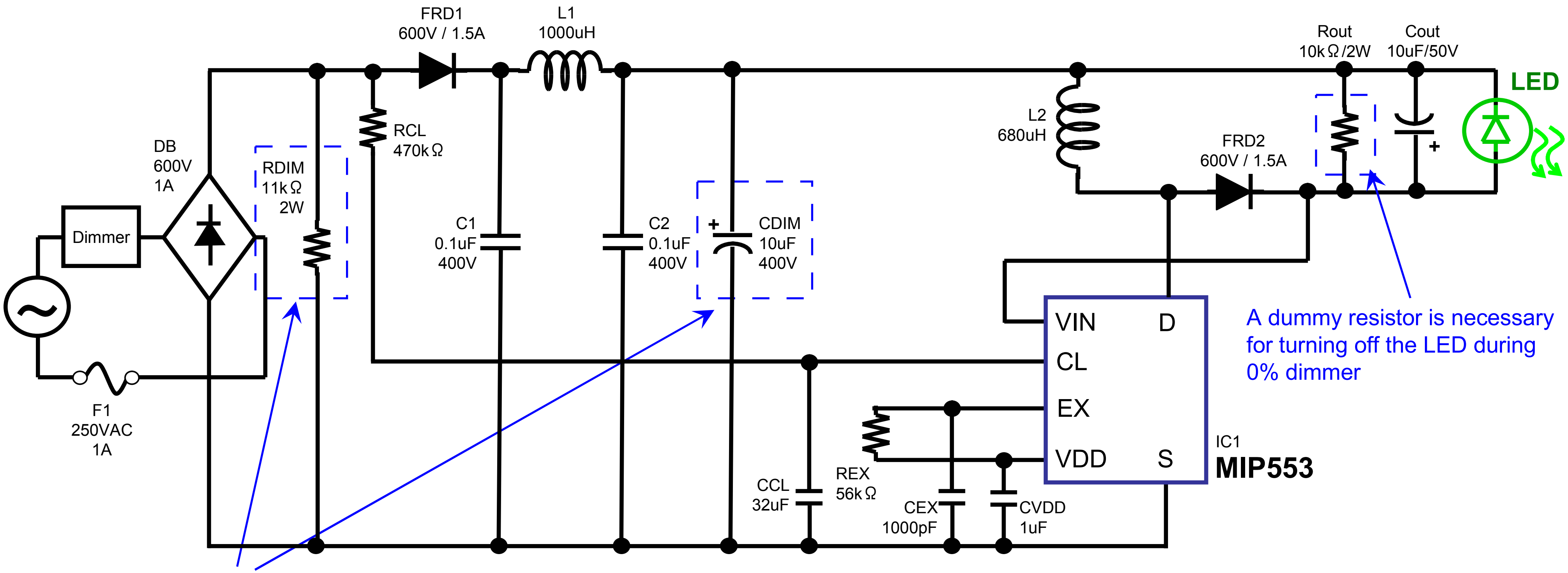
LED current can be adjusted by the constant L2, RCL and REX.

However, the efficiency and PF will change, so please confirm.

Example of application circuit

Buck-Boost Type／Simple PFC function

For TRIAC dimmer（Reference circuit）



These components are necessary for smooth dimming operation when connected to a TRIAC dimmer.

"TRIAC dimmer is achieved with low component count"

Components：18

Please adjust the value of L2, RCL and REX when LED current is increased.

Please adjust RCL, RDIM and CDIM to prevent malfunction of the dimmer.

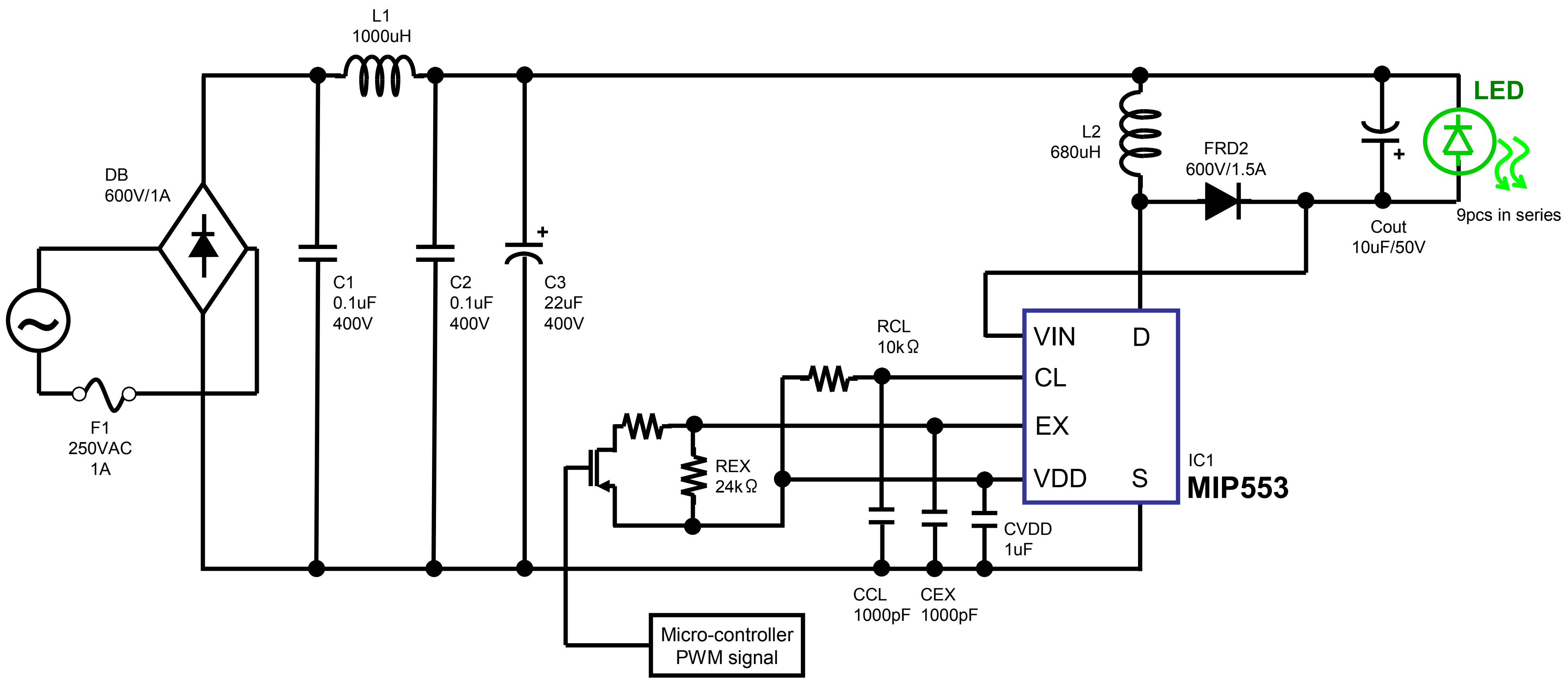
Moreover, a dummy resistor Rout is necessary to turn of the LED during 0% dimmer.

※Buck-Boost type is recommended for flicker-free dimming.
(The buck type will cause oscillation to occur during the stopping period at low input condition)

Example of application circuit

Buck-Boost type／PWM dimmer

For PWM dimmer（Reference circuit）



The circuit diagram above is a reference circuit.

The LED current at 100% dimmer can be adjusted by L2, RCL and REX.

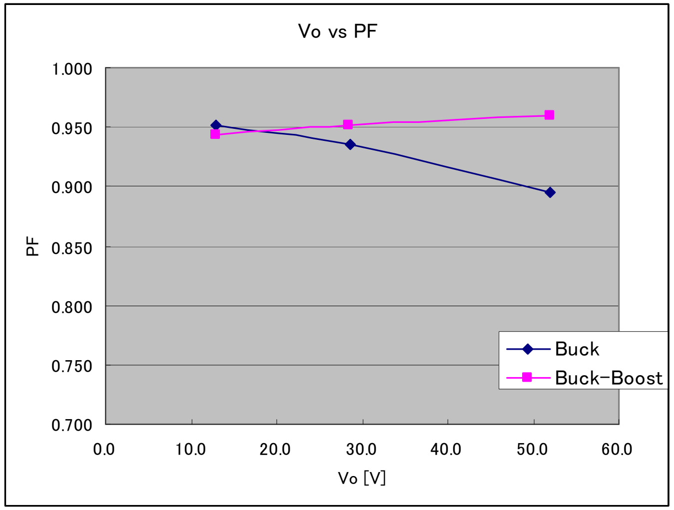
Please modify the circuit configuration according to the micro-controller used.

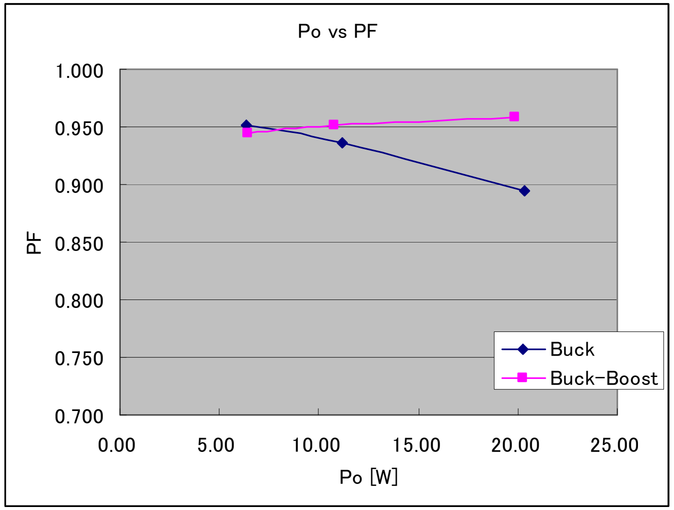
Evaluation data

Power Factor and Efficiency

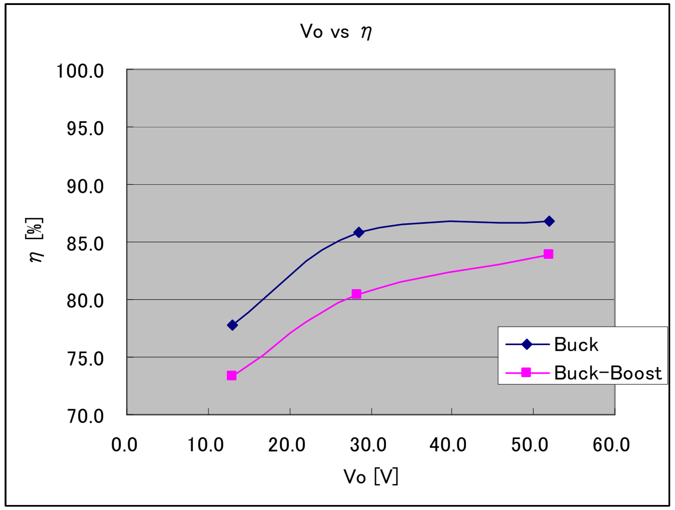
<Measurement condition>
- ・Input：AC120V
- ・Load：LED
  - 12V / 500mA
  - 27V / 400mA
  - 54V / 400mA
  - （Constants adjusted for each specification）
- ・Circuit：Buck、Buck-Boost
- ・Ta：Normal temperature （about27℃） Open frame

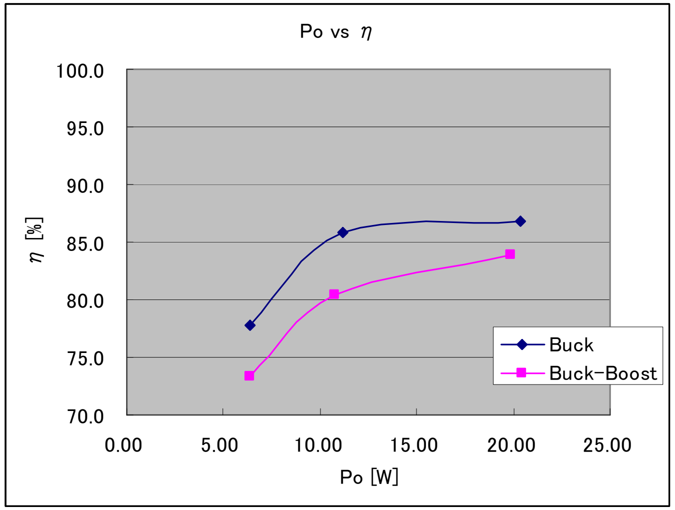
■Power Factor data





■Efficiency data

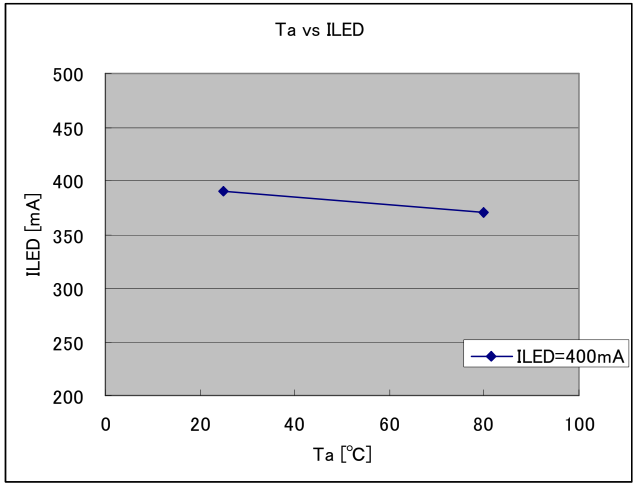




■LED Current accuracy

Temperature characteristic（※Confirmation of temperature effect on ILIMIT）

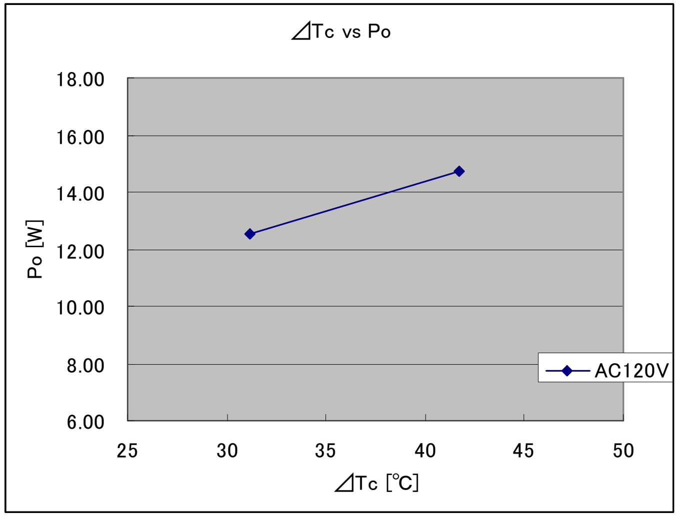
＜**Measurement condition**＞
- ・Input：AC120V
- ・Load：LED 9pcs
  27V / 400mA
- ・Circuit：Buck
  Without input filter capacitor
- ・Ta：Normal Temperature
  （about 27℃）
  Open frame



■Driving ability（Heat generation evaluation）

＜Measurement condition＞
- Input：AC120V
- Load：LED 9pcs（about 27V）（LED current adjusted）
- Circuit：Buck
- Ta：Normal temperature（about 27℃）Open frame

VIN	FL	Iin	Pin	Io	Vo	Po	η	Tc	⊿Tc
VAC	Hz	mA	W	mA	V	W	%	℃	℃
120	50	133.4	14.60	436	28.8	12.55	85.9	58.2	31.2
120	50	152.8	17.45	508	29.0	14.75	84.5	68.7	41.7



LED Short Operation

＜Measurement condition＞
・Input：AC100V
・Load：LED 9pcs（about 27V）
・Circuit：Buck

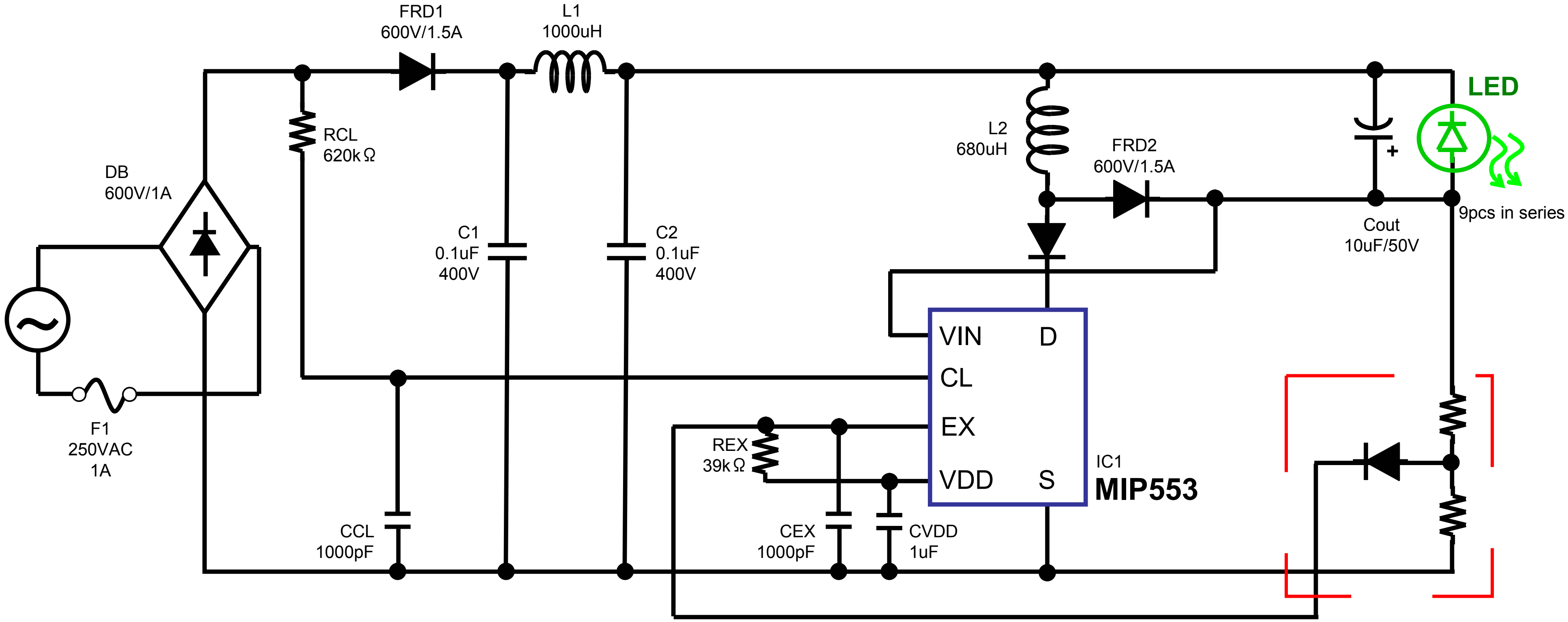
■It is confirmed that the protection function during LED short is able to operate.

Pin=15W ⇨ Reduce to Pin=1.7W

Short occur

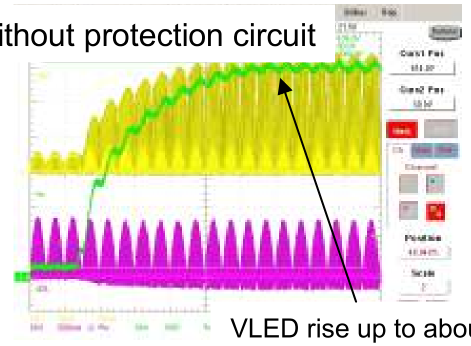
LED Open protection application

Oscillation stop function with EX pin Buck-Boost)



＜Measurement condition＞
- Input：AC50V
- Load：LED 9pcs（about 27V）
- Circuit：Buck-Boost
  LED parallel capacitor 10uF

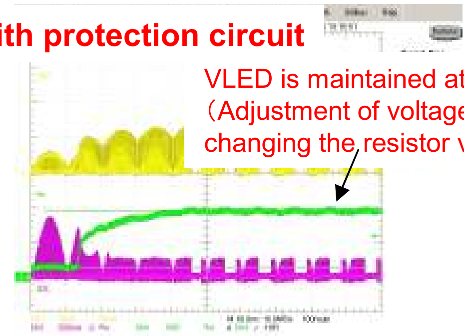
Without protection circuit



VLED rise up to about 600V

With protection circuit

VLED is maintained at about 200V.
（Adjustment of voltage is possible by changing the resistor value）



Power supply design support tool

For the simplification of the external components design, such as the L value of the coil, CL resistance (RCL), EX resistance (REX), etc., a calculation sheet shown in the figure below has been prepared.
If the sheet is required, please contact us.