DRL60-1

EVALUATION DATA

INDEX

Terminology used

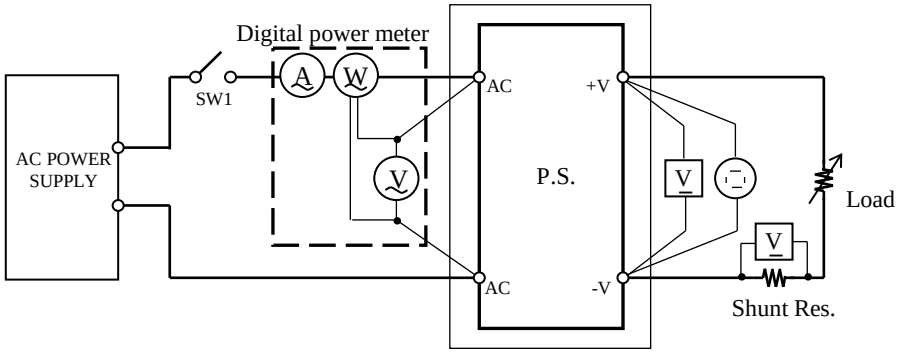
Vin	.....	Input voltage
Vout	.....	Output voltage
Iin	.....	Input current
Iout	.....	Output current
Ta	.....	Ambient temperature
f	.....	Frequency

1. Evaluation Method

1.1 Circuit used for determination

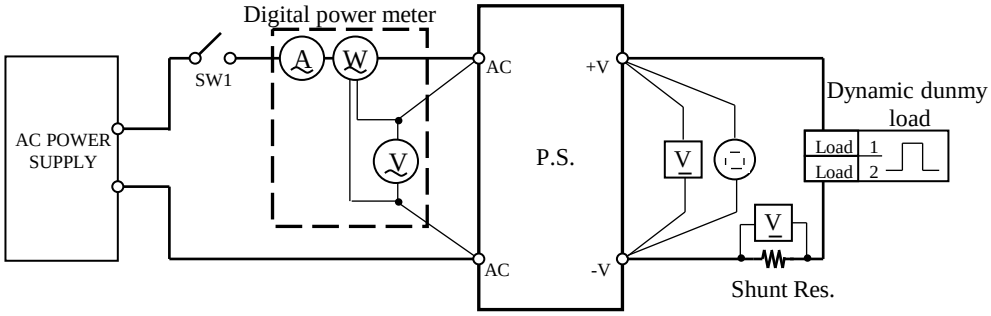
Circuit 1 used for determination

- Steady state data
- Over current protection (OCP) characteristics
- Over voltage protection (OVP) characteristics
- Output rise characteristics
- Output fall characteristics
- Hold up time characteristics

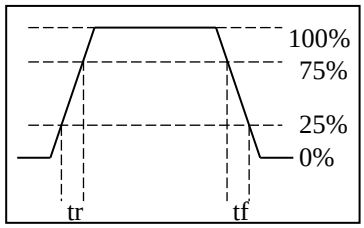


Circuit 2 used for determination

- Dynamic load response characteristics

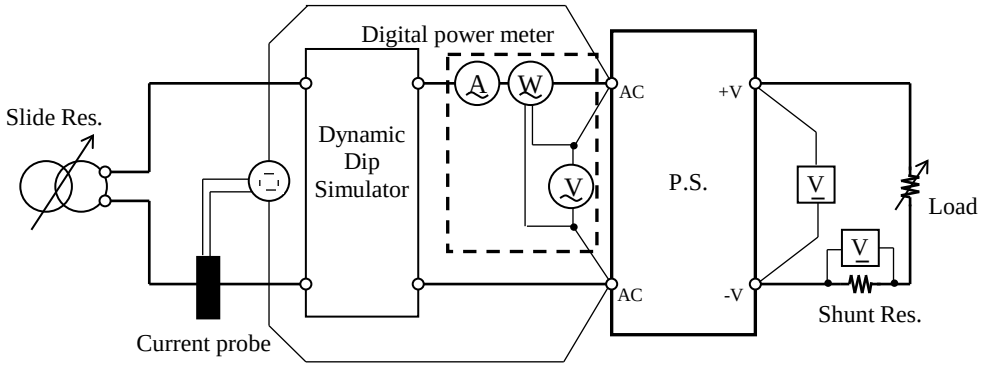


Output current waveform



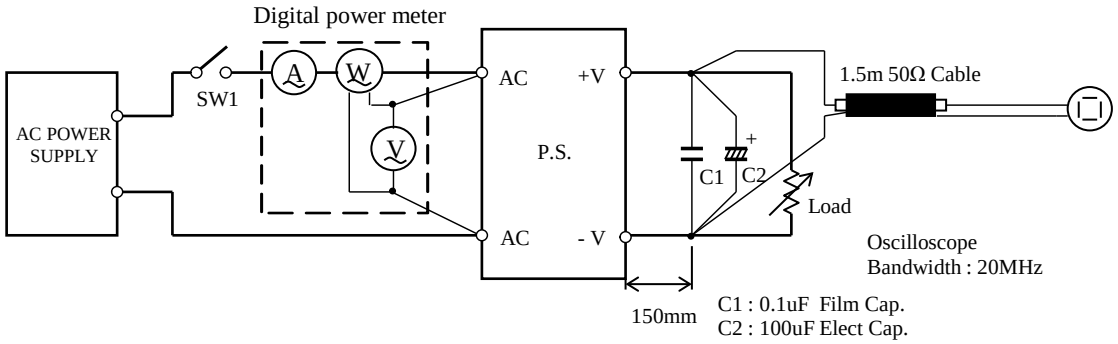
Circuit 3 used for determination

- Inrush current waveform



Circuit 4 used for determination

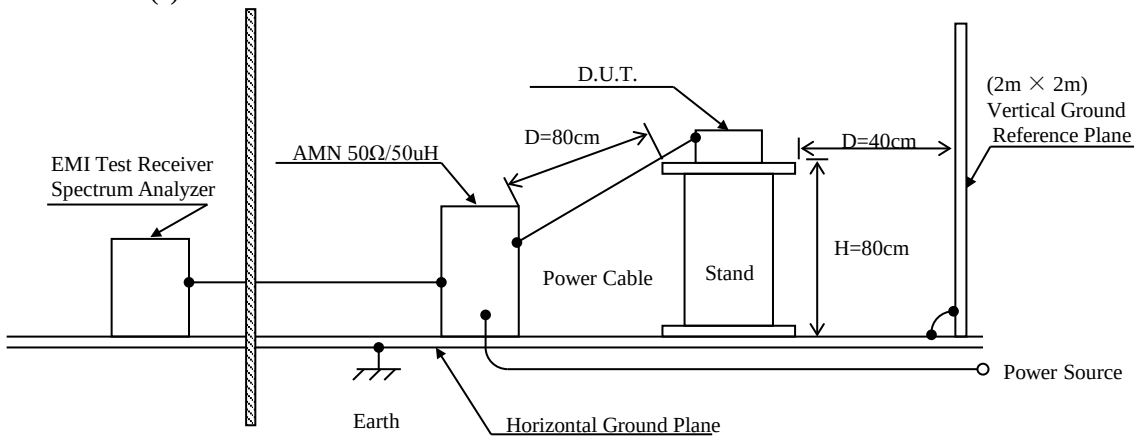
・Output ripple and noise waveform



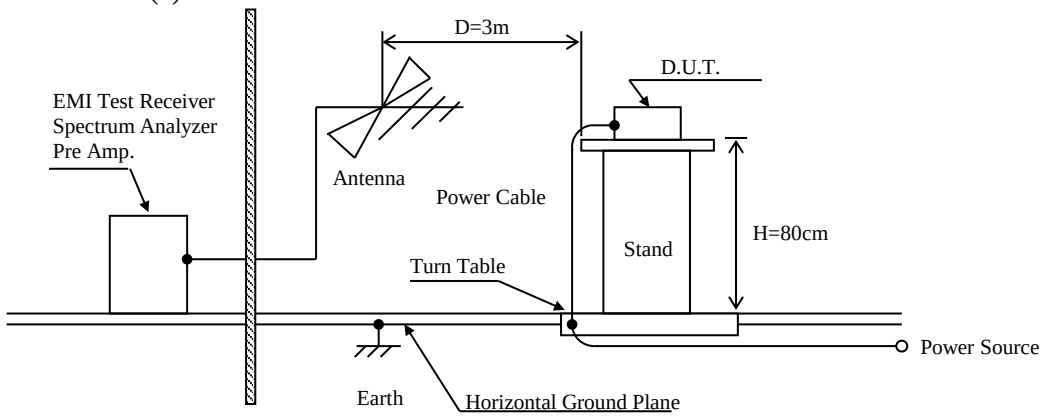
Configuration used for determination

・Electro-Magnetic Interference characteristics

(a) Conducted Emission



(b) Radiated Emission



1.2 List of equipment used

	EQUIPMENT USED	MANUFACTURER	MODEL NO.
1	DIGITAL STORAGE OSCILLOSCOPE	YOKOGAWA ELECT.	DL2054/DL9040
2	DIGITAL MULTIMETER	AGILENT	34970A
3	DIGITAL POWER METER	YOKOGAWA ELECT.	WT210
4	CURRENT PROBE	YOKOGAWA ELECT.	701930
5	DYNAMIC DUMMY LOAD	CHROMA	63030/63610
6	AC SOURCE	KIKUSUI	PCR2000L
7	AC SOURCE	CHROMA	61605
8	CONTROLLED TEMP. CHAMBER	TABAI-ESPEC	63203
9	EMI TEST RECEIVER (Conducted Emission)	ROHDE & SCHWARZ	ESCI-03
10	LISN (Conducted Emission)	ROHDE & SCHWARZ	ENV216
11	BICONICAL ANTENNA (Radiated Emission)	ETS•LINDGREN	3142C
12	EMI TEST RECEIVER (Radiated Emission)	ROHDE & SCHWARZ	ESU 26

2. Characteristics

2.1 Steady state data

(1) Regulation - line and load, Temperature drift / Start up voltage and Drop out voltage

12V

1. Regulation - line and load — Condition Ta : 25 ℃

Iout \ Vin	85VAC	115VAC	230VAC	265VAC	line regulation	
0%	12.071V	12.071V	12.071V	12.072V	1mV	0.008%
50%	12.066V	12.066V	12.067V	12.067V	1mV	0.008%
100%	12.061V	12.061V	12.061V	12.062V	1mV	0.008%
load regulation	10mV	10mV	10mV	10mV		
	0.083%	0.083%	0.083%	0.083%		

2. Temperature drift — Conditions Vin : 115 VAC, Iout : 100 %

Ta	-20℃	+25℃	+71℃	temperature stability	
Vout	12.001V	12.061V	12.077V	76mV	0.633%

3. Start up voltage and Drop out voltage — Conditions Ta : 25 ℃, Iout : 100 %

Start up voltage (Vin)	74.0VAC
Drop out voltage (Vin)	67.0VAC

24V

1. Regulation - line and load — Condition Ta : 25 ℃

Iout \ Vin	85VAC	115VAC	230VAC	265VAC	line regulation	
0%	24.068V	24.068V	24.068V	24.068V	0mV	0.000%
50%	24.040V	24.040V	24.040V	24.039V	1mV	0.004%
100%	24.011V	24.011V	24.011V	24.011V	0mV	0.000%
load regulation	57mV	57mV	57mV	57mV		
	0.238%	0.238%	0.238%	0.238%		

2. Temperature drift — Conditions Vin : 115 VAC, Iout : 100 %

Ta	-20℃	+25℃	+71℃	temperature stability	
Vout	24.034V	24.011V	23.928V	106mV	0.442%

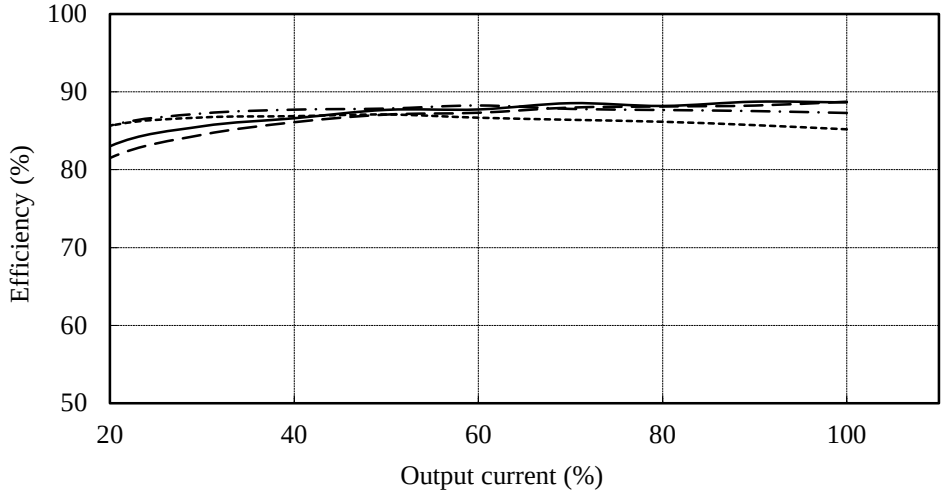
3. Start up voltage and Drop out voltage — Conditions Ta : 25 ℃, Iout : 100 %

Start up voltage (Vin)	63.0VAC
Drop out voltage (Vin)	51.0VAC

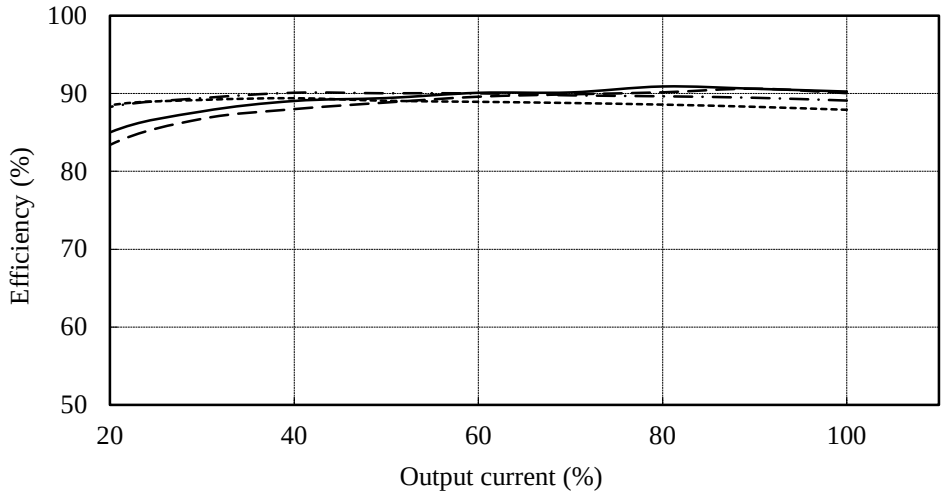
(2) Efficiency vs. Output current

Conditions Vin : 85 VAC ------
: 115 VAC –·–·–
: 230 VAC ——
: 265 VAC – – – –
Ta : 25 ℃

12V



24V



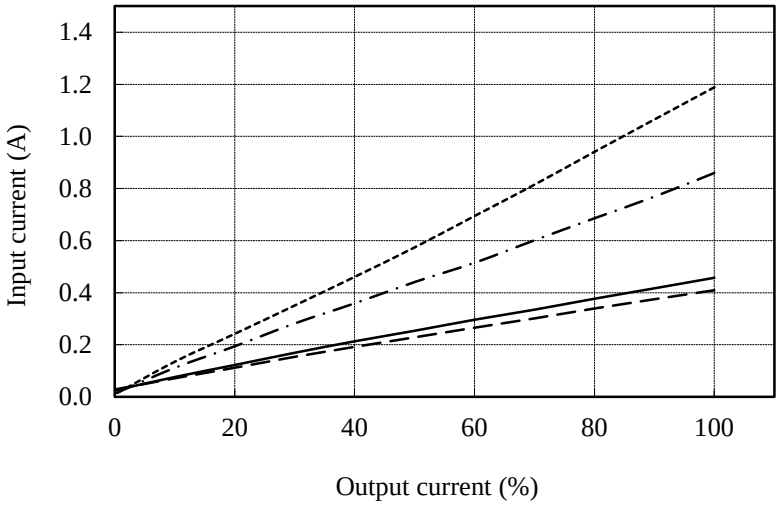
(3) Input current vs. Output current

Conditions Vin : 85 VAC ------
: 115 VAC –·–·–
: 230 VAC ——
: 265 VAC – – – –
Ta : 25 ℃

12V

Io: 100%

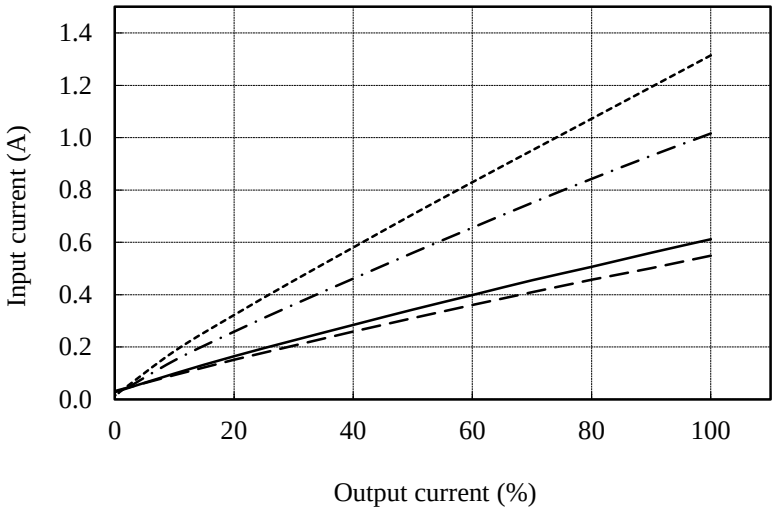
Vin	Input current
85VAC	1.189A
115VAC	0.860A
230VAC	0.457A
265VAC	0.409A



24V

Io: 100%

Vin	Input current
85VAC	1.315A
115VAC	1.016A
230VAC	0.612A
265VAC	0.549A



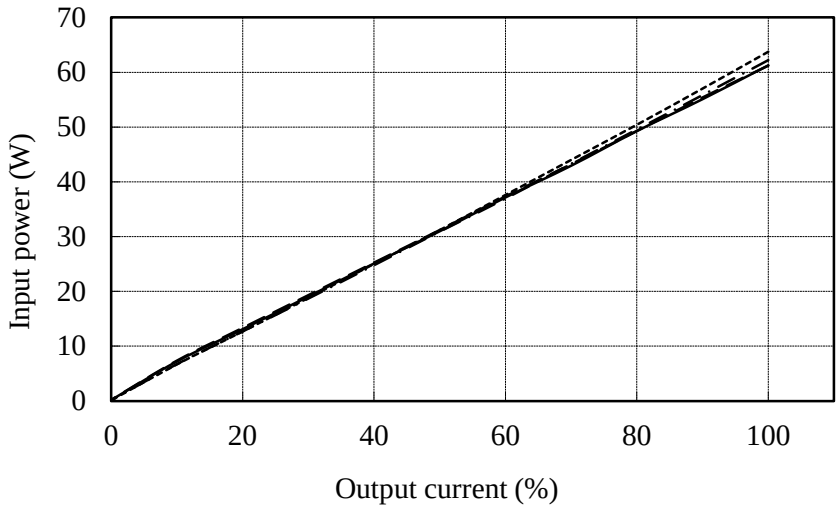
(4) Input power vs. Output current

Conditions Vin : 85 VAC - - - -
: 115 VAC –·–·
: 230 VAC ——
: 265 VAC – – –
Ta : 25 ℃

12V

Io: 100%

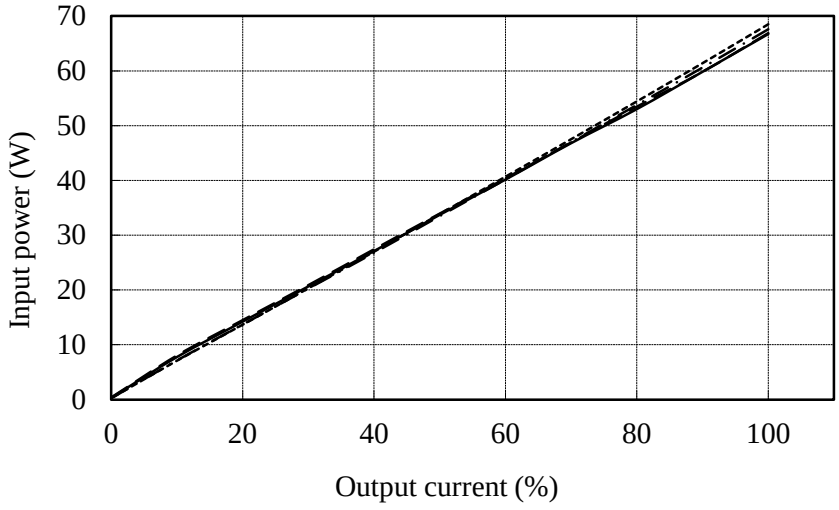
Vin	Input power
85VAC	63.74W
115VAC	62.21W
230VAC	61.26W
265VAC	61.20W



24V

Io: 100%

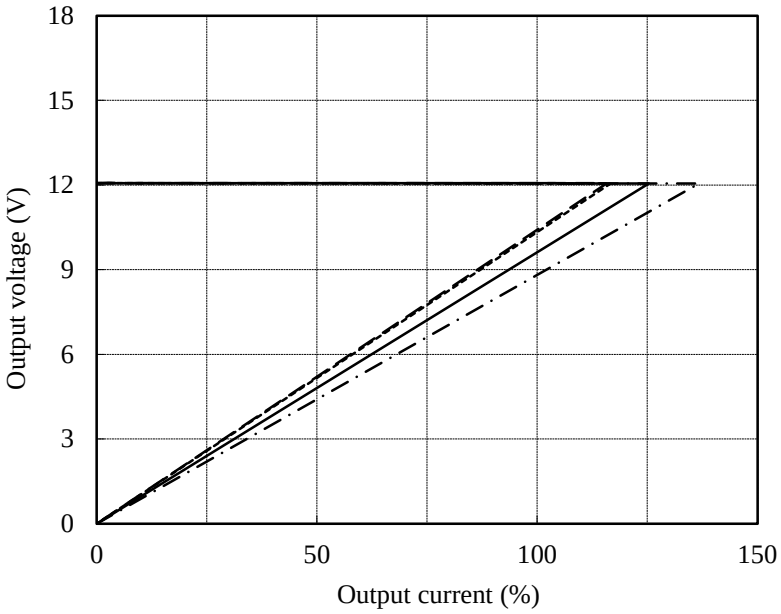
Vin	Input power
85VAC	68.50W
115VAC	67.59W
230VAC	66.72W
265VAC	66.88W



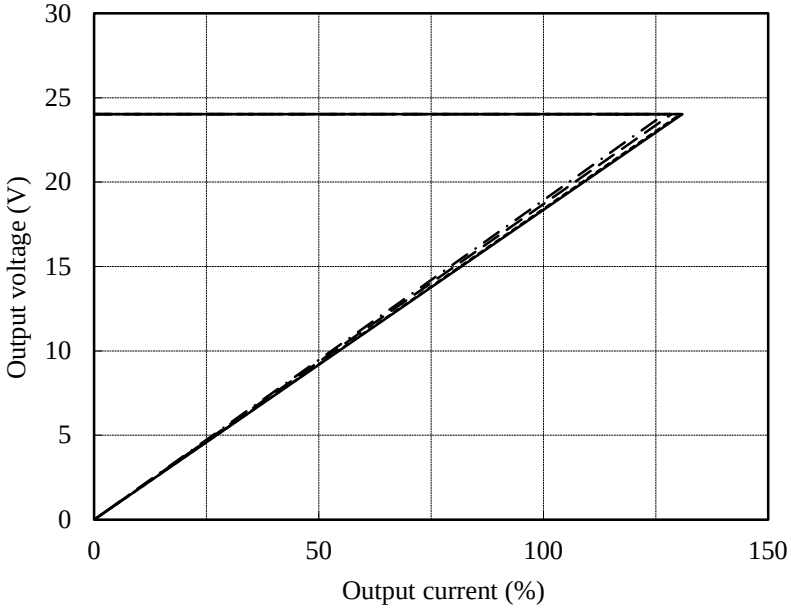
2.2 Over current protection (OCP) characteristics

Conditions Vin : 85 VAC
115 VAC
230 VAC
265 VAC
Ta : 25 ℃

12V



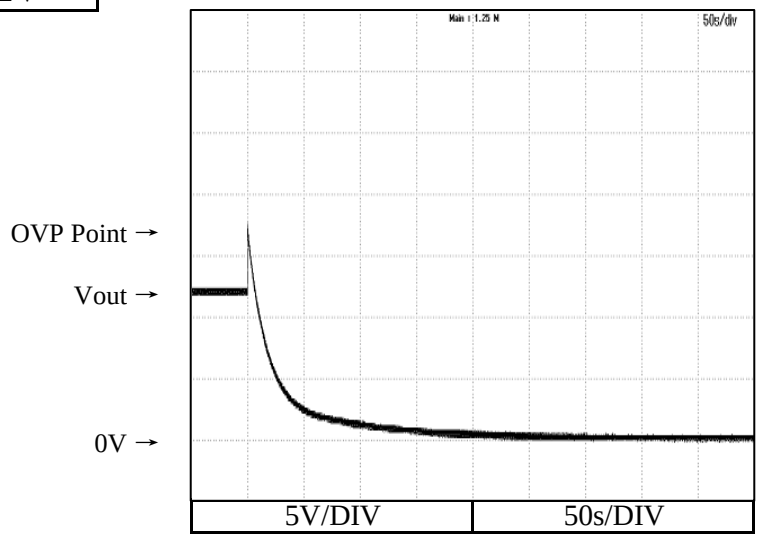
24V



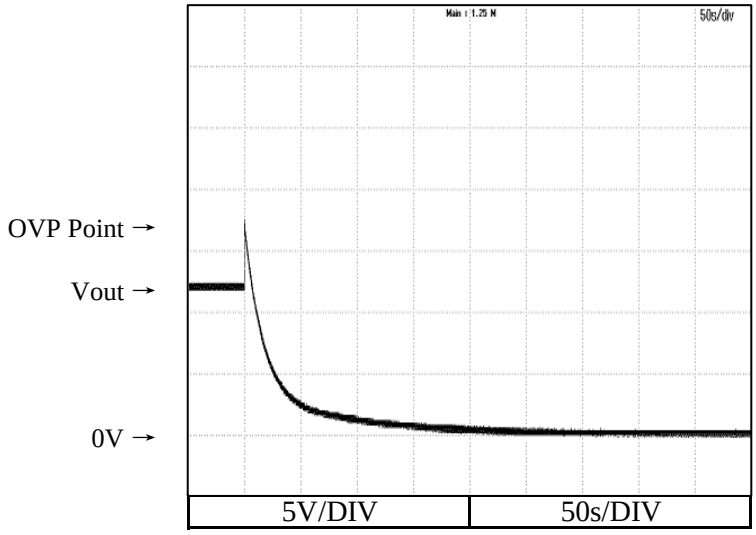
2.3 Over voltage protection (OVP) characteristics

Conditions Vin : 115 VAC
Iout : 0 %
Ta : 25 ℃

12V



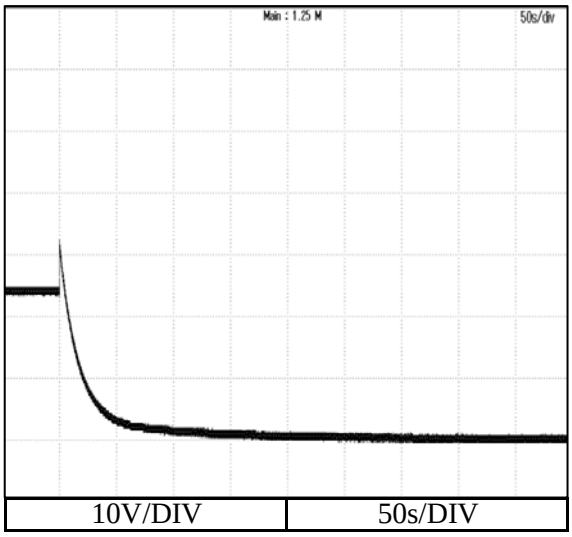
Conditions Vin : 230 VAC
Iout : 0 %
Ta : 25 ℃



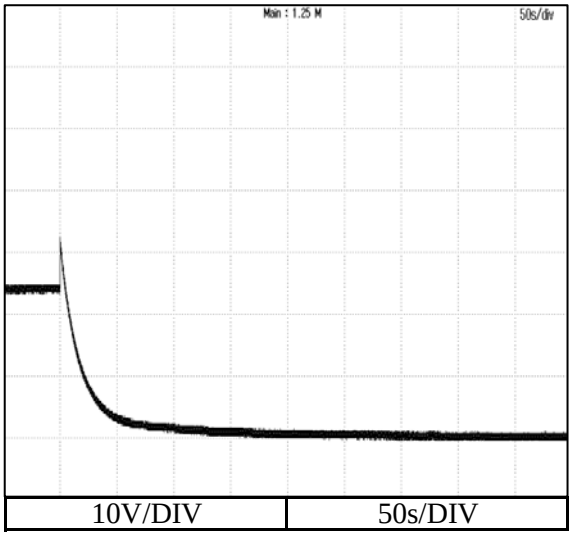
2.3 Over voltage protection (OVP) characteristics

Conditions Vin : 115 VAC
Iout : 0 %
Ta : 25 ℃

24V



Conditions Vin : 230 VAC
Iout : 0 %
Ta : 25 ℃

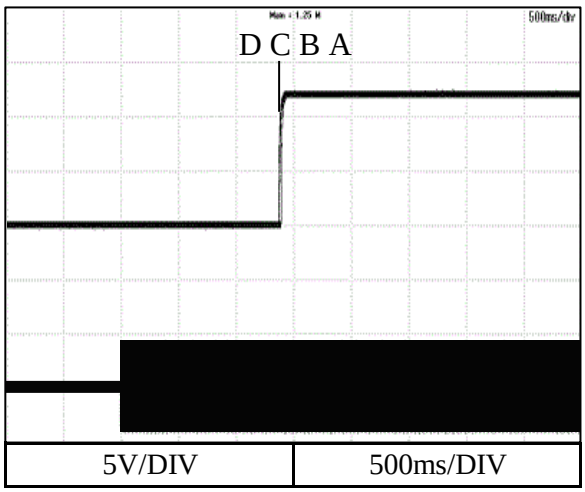


2.4 Output rise characteristics

Conditions Vin : 85 VAC (A)
115 VAC (B)
230 VAC (C)
265 VAC (D)
Ta : 25 ℃

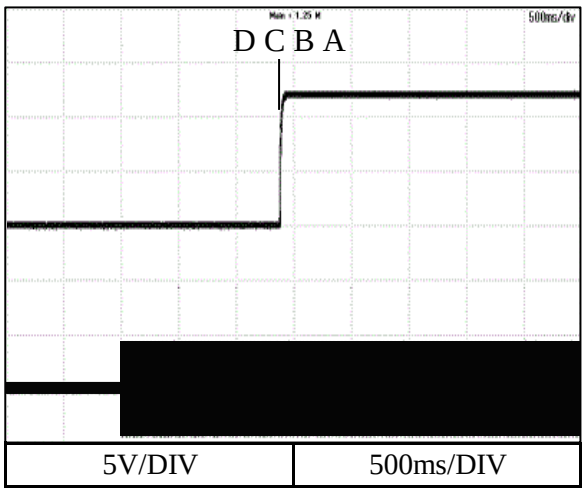
12V

Iout : 0%



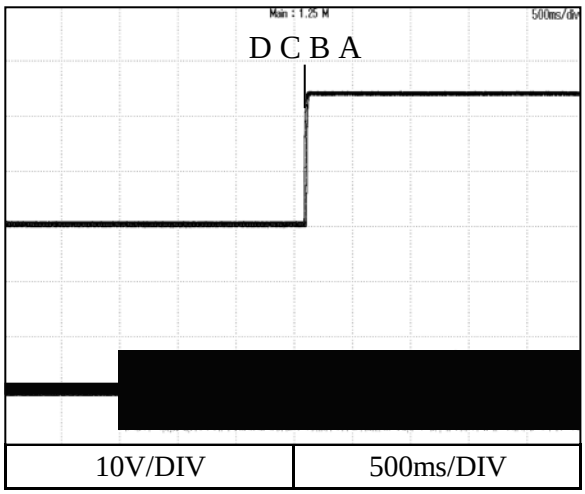
Vout
0V
Vin

Iout : 100%



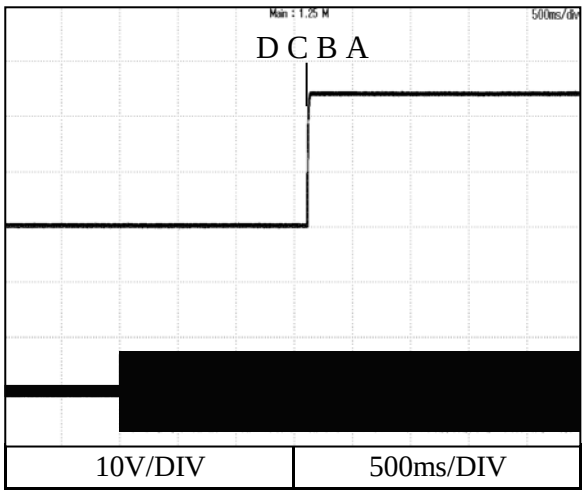
24V

Iout : 0%



Vout
0V
Vin

Iout : 100%

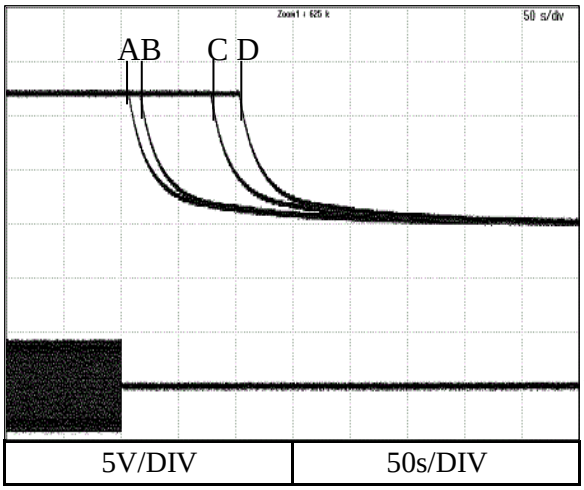


2.5 Output fall characteristics

Conditions Vin : 85 VAC (A)
115 VAC (B)
230 VAC (C)
265 VAC (D)
Ta : 25 ℃

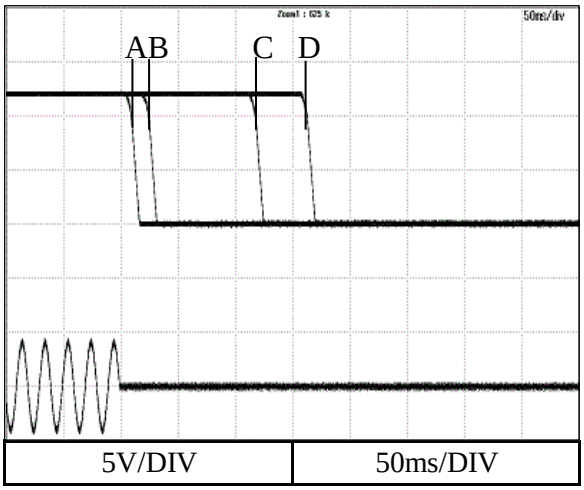
12V

Iout : 0%



5V/DIV | 50s/DIV

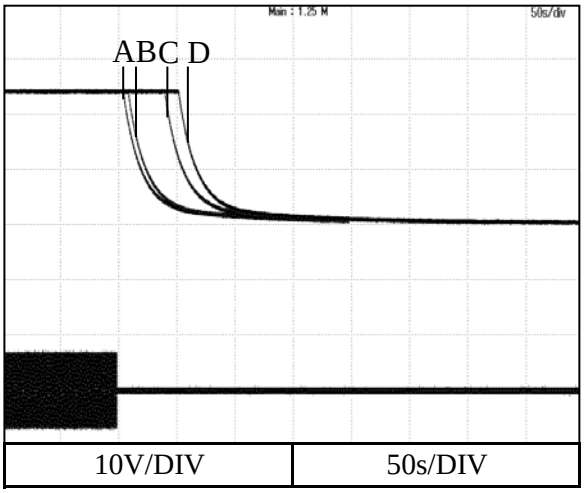
Iout : 100%



5V/DIV | 50ms/DIV

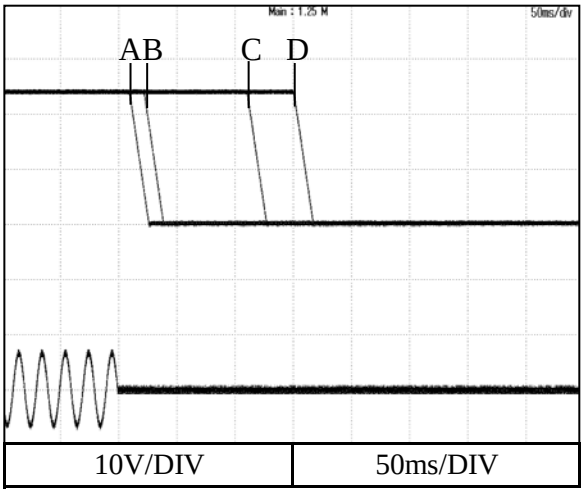
24V

Iout : 0%



10V/DIV | 50s/DIV

Iout : 100%

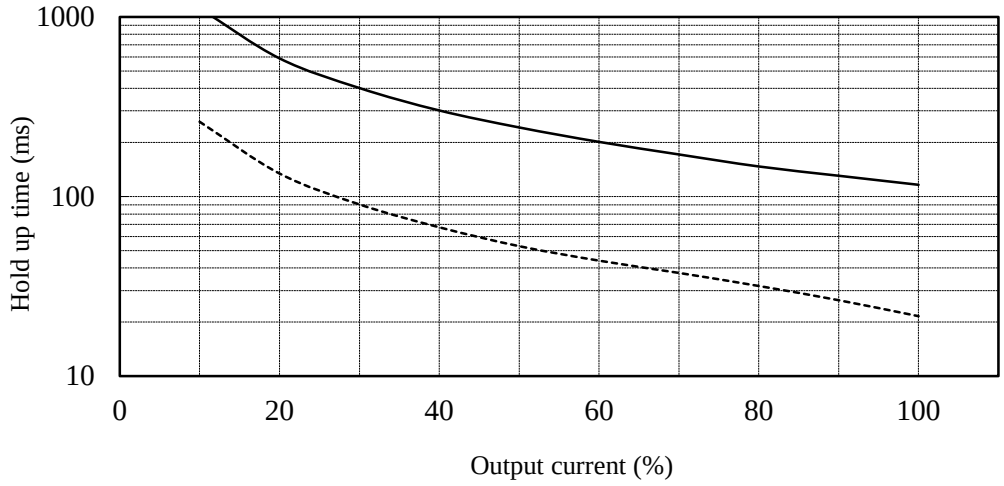


10V/DIV | 50ms/DIV

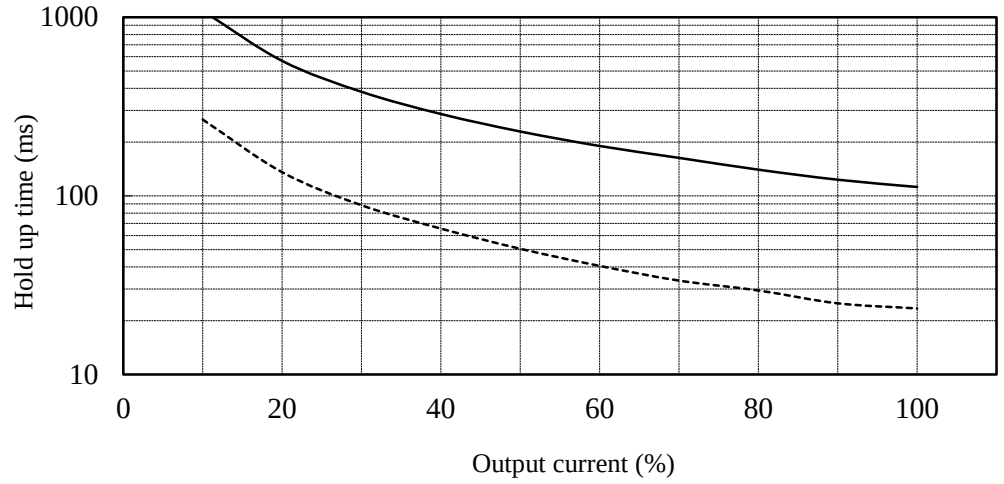
2.6 Hold up time characteristics

Conditions Vin : 115 VAC ------
230 VAC ——
Ta : 25 ℃

12V



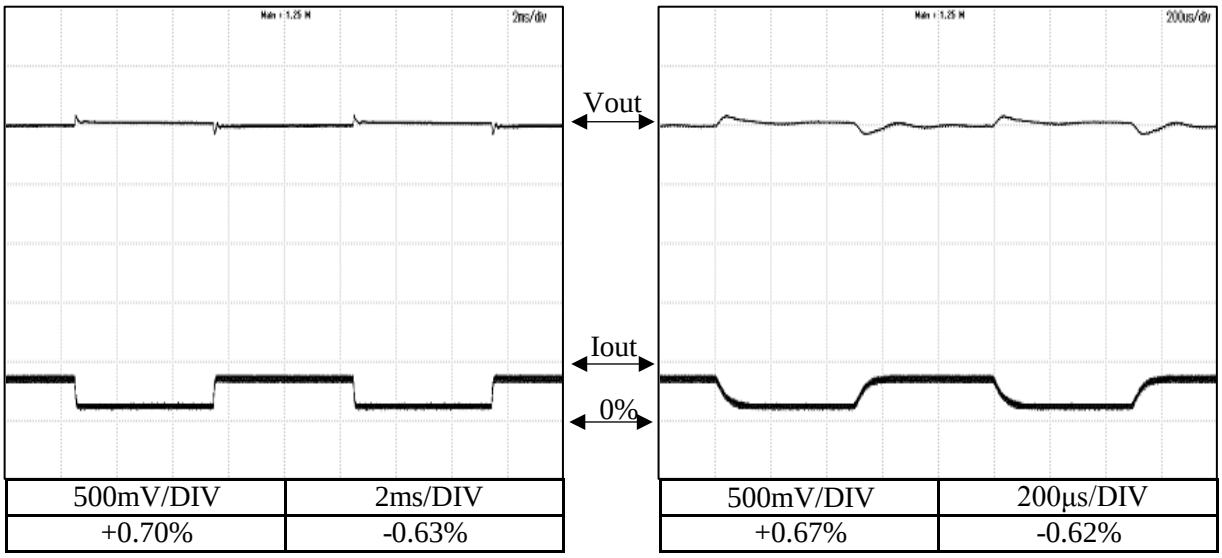
24V



2.7 Dynamic load response characteristics

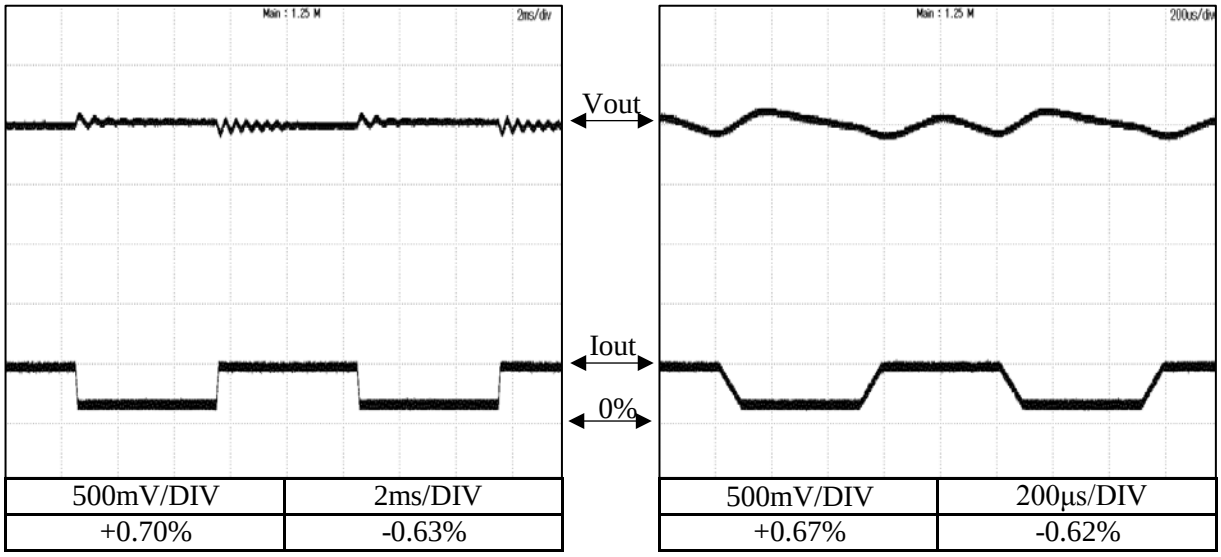
Conditions Vin : 115 VAC
Iout : 25 %◄► 75 %
(tr = tf = 75us)
Ta : 25 ℃

12V



500mV/DIV	2ms/DIV	500mV/DIV	200µs/DIV
+0.70%	-0.63%	+0.67%	-0.62%

24V

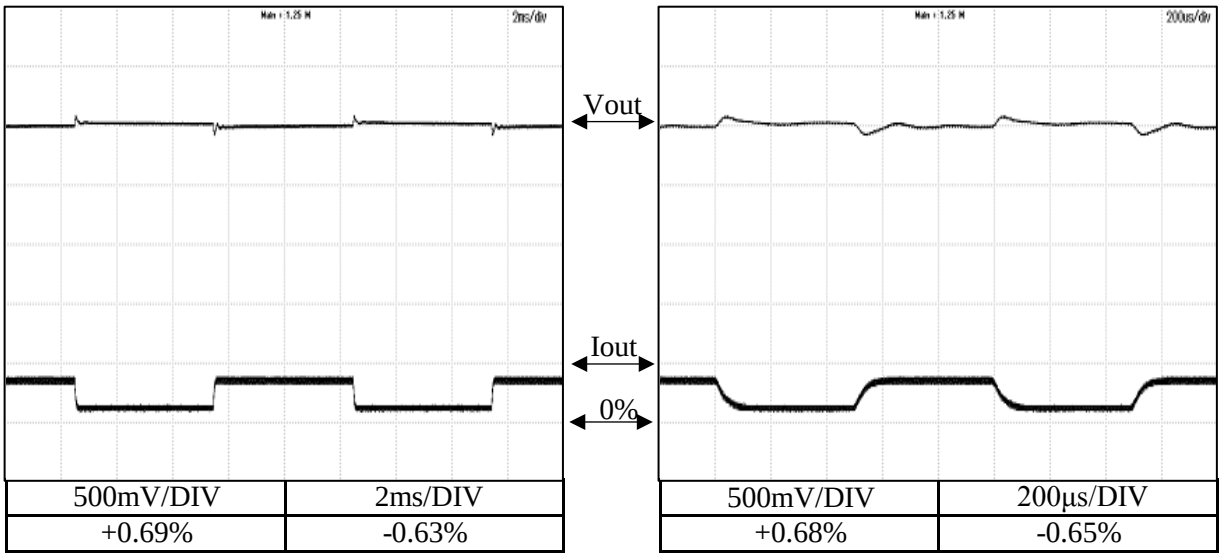


500mV/DIV	2ms/DIV	500mV/DIV	200µs/DIV
+0.70%	-0.63%	+0.67%	-0.62%

2.7 Dynamic load response characteristics

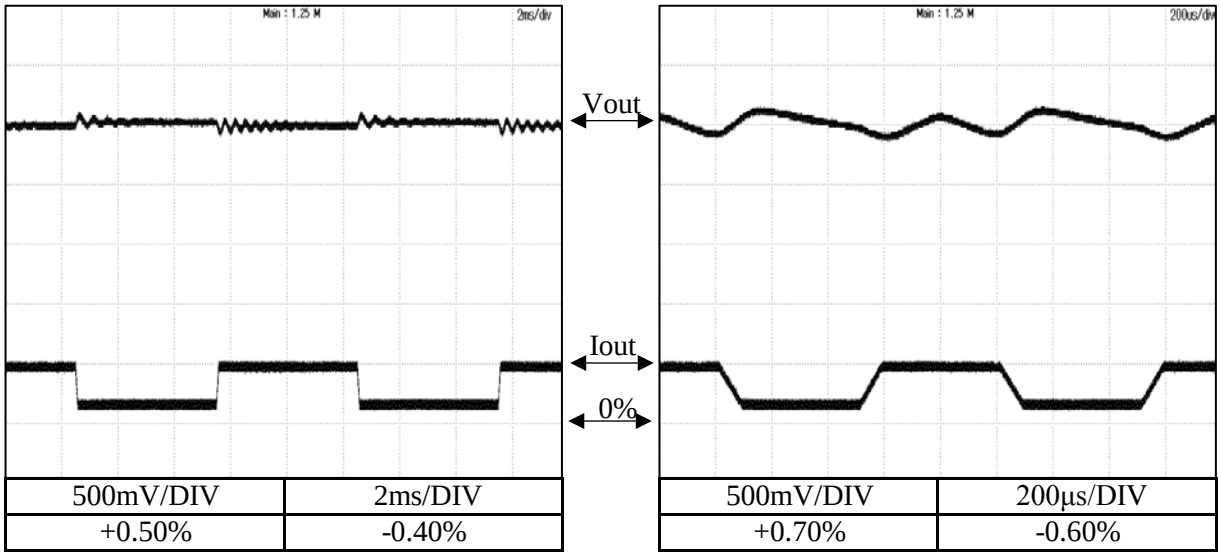
Conditions Vin : 230 VAC
Iout : 25 %◄► 75 %
(tr = tf = 75us)
Ta : 25 ℃

12V



500mV/DIV	2ms/DIV	500mV/DIV	200μs/DIV
+0.69%	-0.63%	+0.68%	-0.65%

24V



500mV/DIV	2ms/DIV	500mV/DIV	200μs/DIV
+0.50%	-0.40%	+0.70%	-0.60%

2.8 Response to brown out characteristics

Conditions Vin : 115 VAC
Iout : 100 %
Ta : 25 ℃

A : Output voltage does not drop.
B,C : Output voltage drop down not reaching 0V.
D : Output voltage drops until 0V.

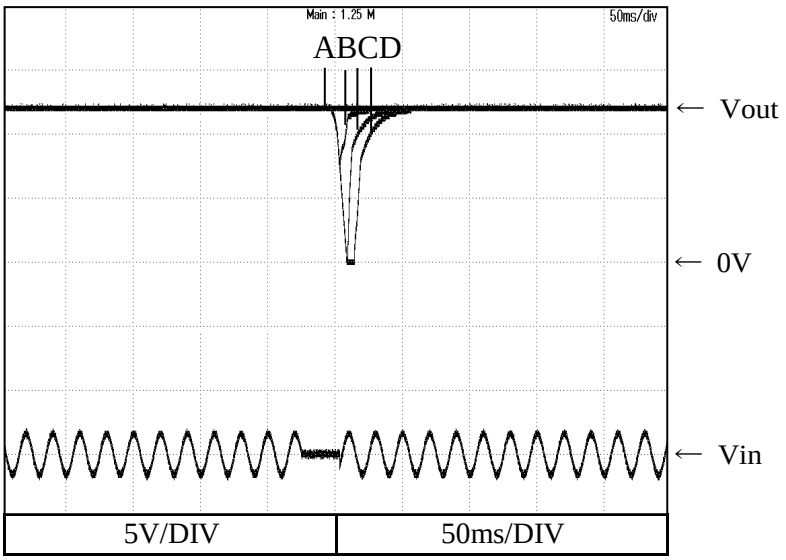
12V

A = 20ms

B = 25ms

C = 35ms

D =39ms



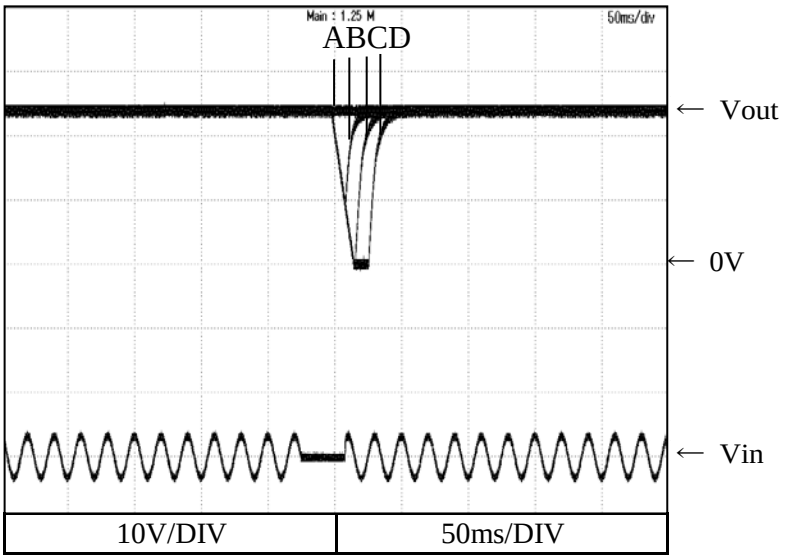
24V

A=25ms

B=33ms

C=40ms

D=50ms

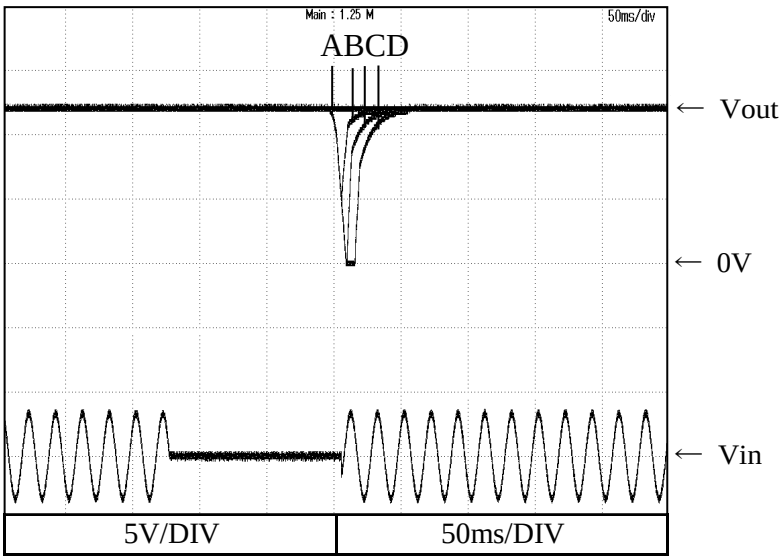


2.8 Response to brown out characteristics

Conditions Vin : 230 VAC
Iout : 100 %
Ta : 25 ℃

A : Output voltage does not drop.
B,C : Output voltage drop down not reaching 0V.
D : Output voltage drops until 0V.

12V



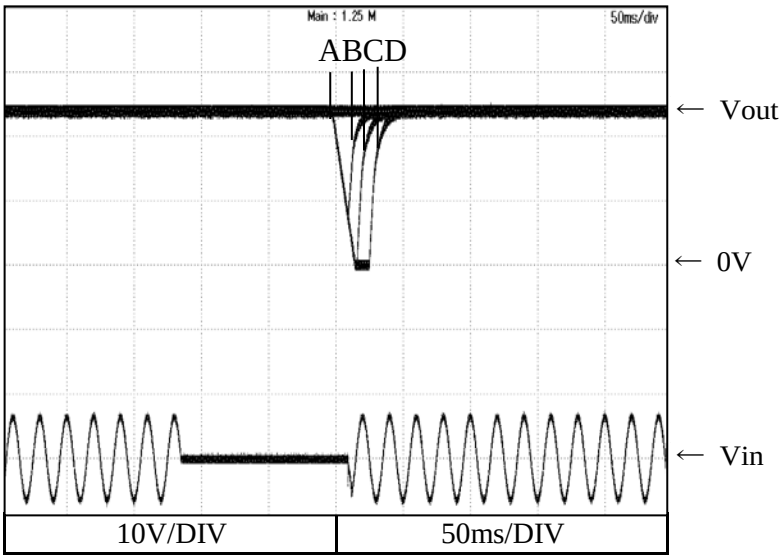
A = 119ms

B = 129ms

C = 133ms

D = 139ms

24V



A=110ms

B=124ms

C=131ms

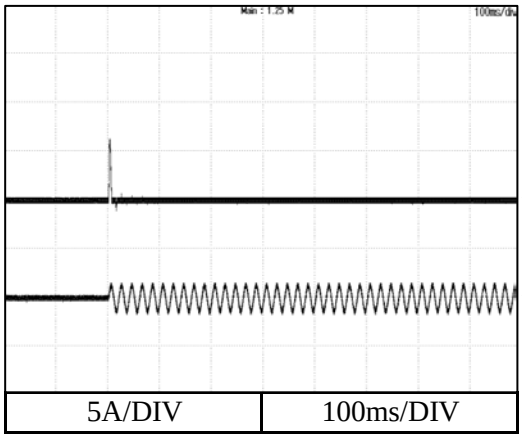
D=140ms

2.9 Inrush current waveform

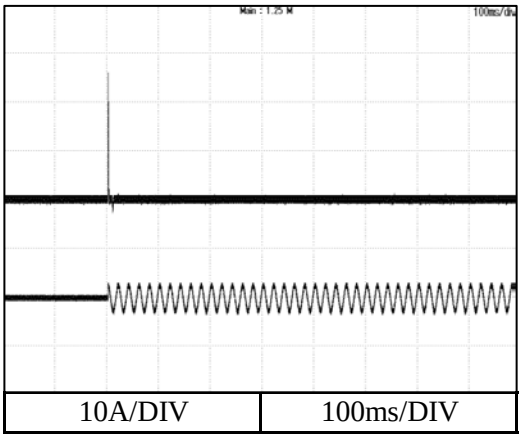
12V

Conditions Vin : 115 VAC
Iout : 100 %
Ta : 25 ℃
(Cold start)

Switch on phase angle of input AC voltage
ϕ = 0°

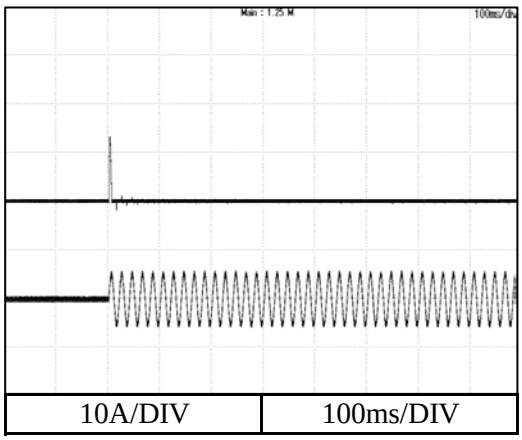


Switch on phase angle of input AC voltage
ϕ = 90°

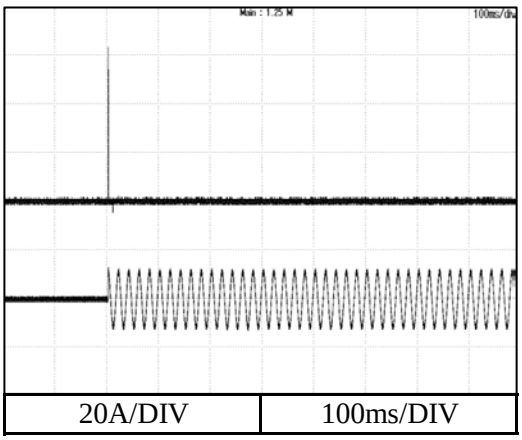


Conditions Vin : 230 VAC
Iout : 100 %
Ta : 25 ℃
(Cold start)

Switch on phase angle of input AC voltage
ϕ = 0°



Switch on phase angle of input AC voltage
ϕ = 90°

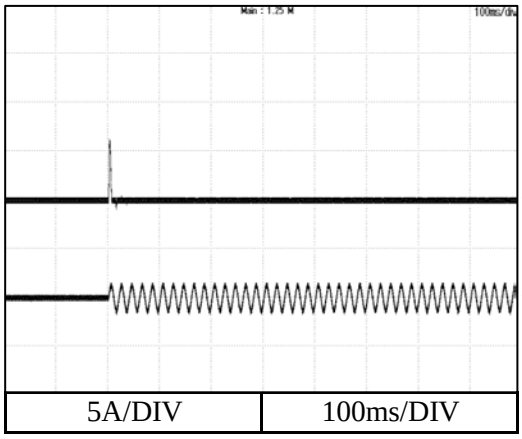


2.9 Inrush current waveform

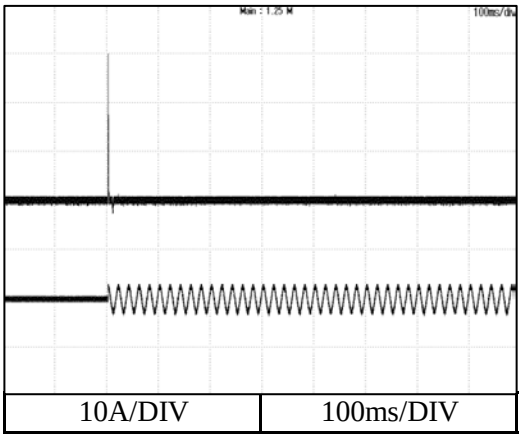
24V

Conditions Vin : 115 VAC
Iout : 100 %
Ta : 25 ℃
(Cold start)

Switch on phase angle of input AC voltage
ϕ = 0°

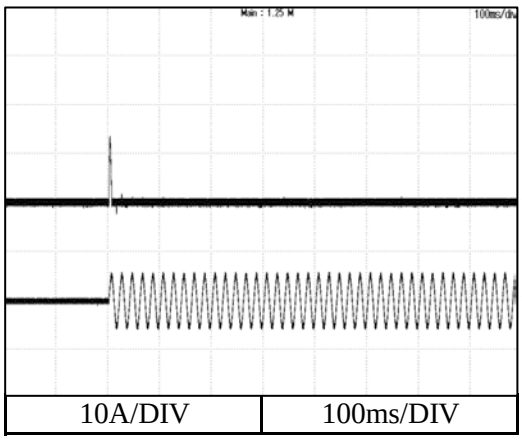


Switch on phase angle of input AC voltage
ϕ = 90°

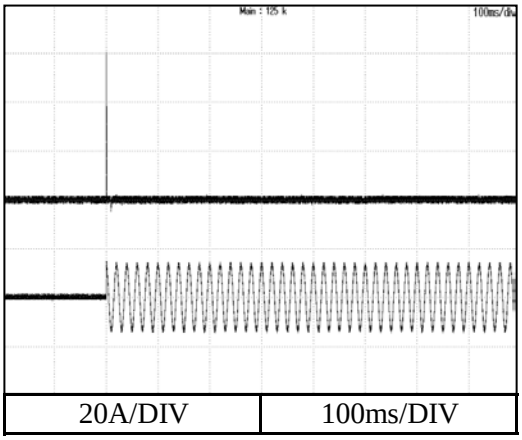


Conditions Vin : 230 VAC
Iout : 100 %
Ta : 25 ℃
(Cold start)

Switch on phase angle of input AC voltage
ϕ = 0°



Switch on phase angle of input AC voltage
ϕ = 90°

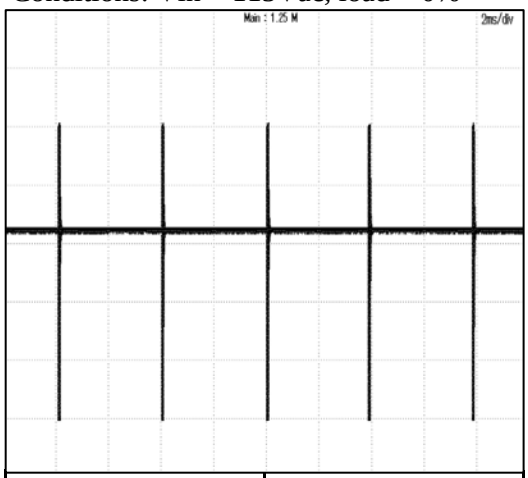


2.10 Switching frequency

12V

Condition : 25 ℃

Conditions: Vin = 115Vac, load = 0%



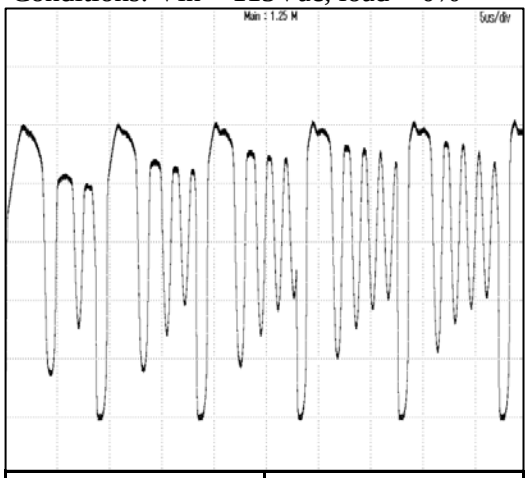
100V/DIV	2ms/DIV
Result	Fsw=0.24kHz

Zoom

Vds

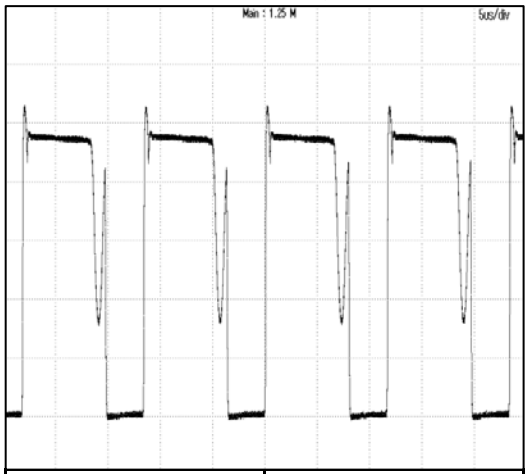
0V

Conditions: Vin = 115Vac, load = 0%



50V/DIV	5us/DIV
Result	Fsw=104kHz

Conditions: Vin = 115Vac, load = 50%

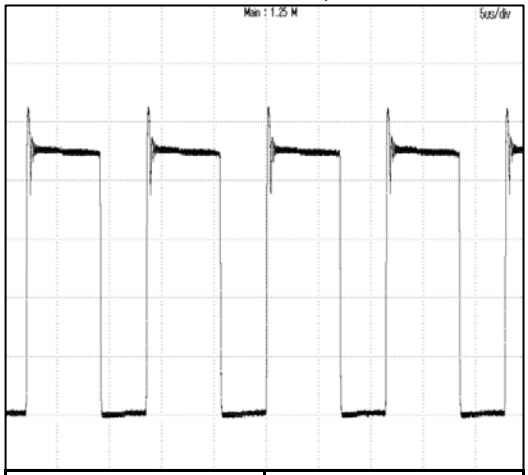


50V/DIV	5us/DIV
Result	Fsw=85.4-98kHz

Vds

0V

Conditions: Vin = 115Vac, load = 100%



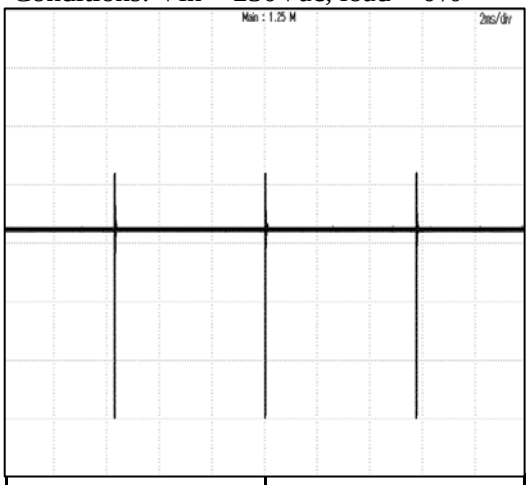
50V/DIV	5us/DIV
Result	Fsw=85.6-98.4kHz

2.10 Switching frequency

12V

Condition : 25 ℃

Conditions: Vin = 230Vac, load = 0%



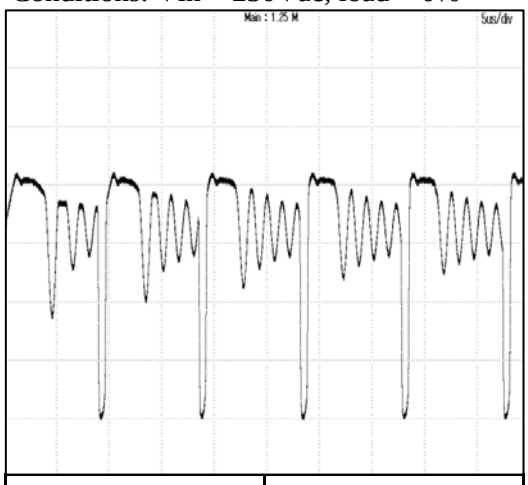
100V/DIV	2ms/DIV
Result	Fsw=0.158kHz

Zoom

Vds

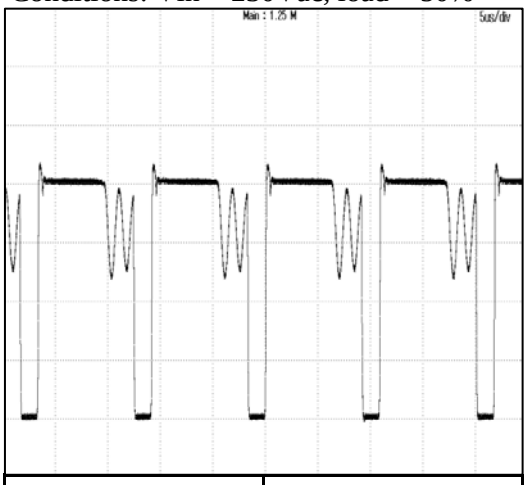
0V

Conditions: Vin = 230Vac, load = 0%



100V/DIV	5us/DIV
Result	Fsw=105kHz

Conditions: Vin = 230Vac, load = 50%

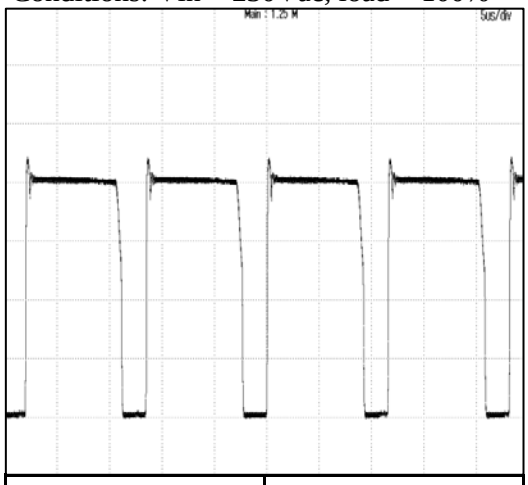


100V/DIV	5us/DIV
Result	Fsw=85.3-98.2kHz

Vds

0V

Conditions: Vin = 230Vac, load = 100%



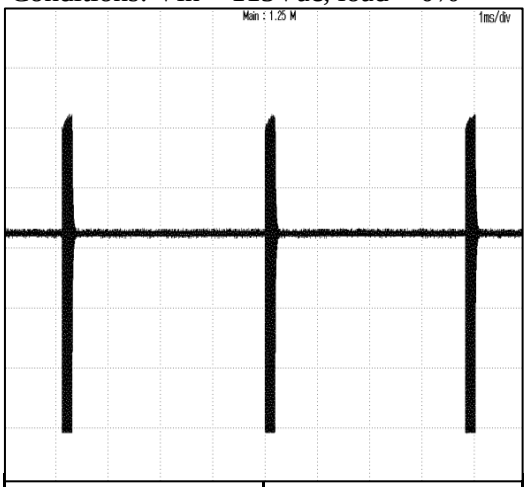
100V/DIV	5us/DIV
Result	Fsw=85.5-97.5kHz

2.10 Switching frequency

24V

Condition : 25 ℃

Conditions: Vin = 115Vac, load = 0%



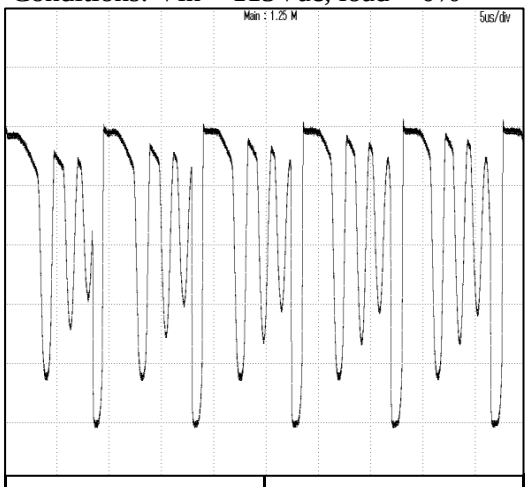
50V/DIV	1ms/DIV
Result	Fsw=0.328kHz

Zoom

Vds

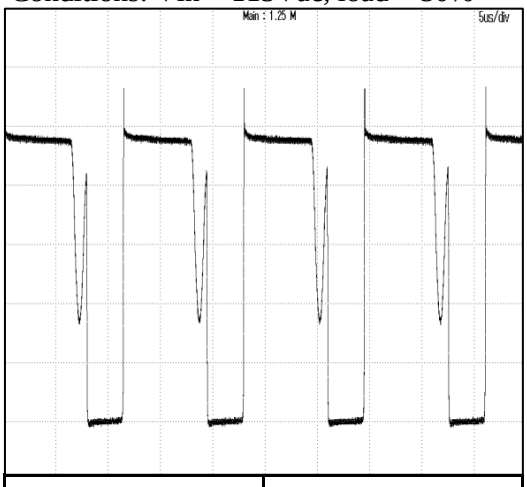
0V

Conditions: Vin = 115Vac, load = 0%



50V/DIV	5us/DIV
Result	Fsw=104.8kHz

Conditions: Vin = 115Vac, load = 50%

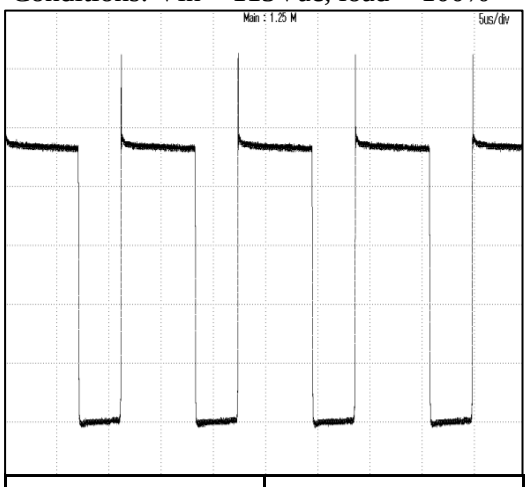


50V/DIV	5us/DIV
Result	Fsw=87-97.8kHz

Vds

0V

Conditions: Vin = 115Vac, load = 100%



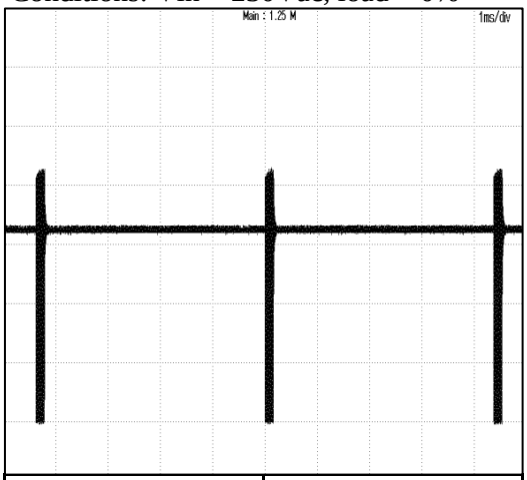
50V/DIV	5us/DIV
Result	Fsw=89-94.7kHz

2.10 Switching frequency

24V

Condition : 25 ℃

Conditions: Vin = 230Vac, load = 0%



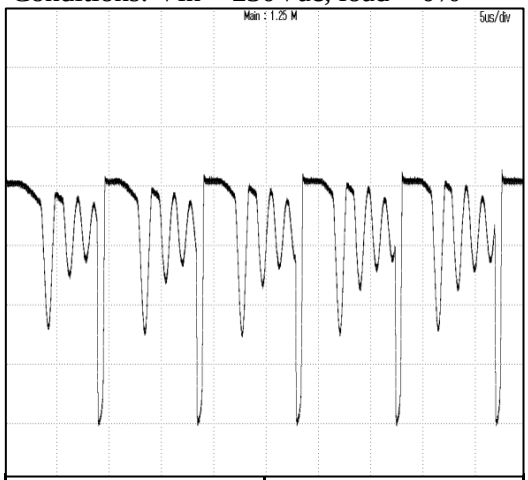
100V/DIV	1ms/DIV
Result	Fsw=0.219kHz

Zoom

Vds

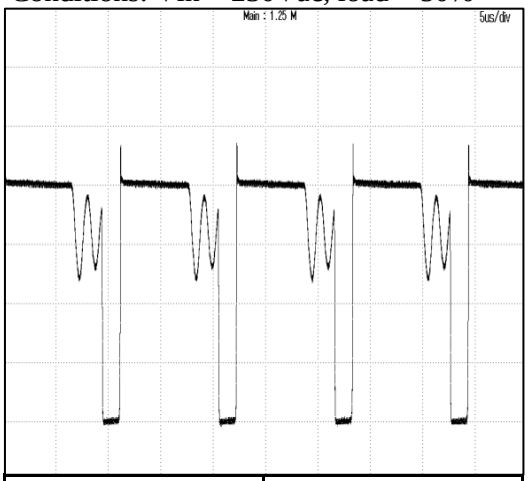
0V

Conditions: Vin = 230Vac, load = 0%



100V/DIV	5us/DIV
Result	Fsw=105kHz

Conditions: Vin = 230Vac, load = 50%

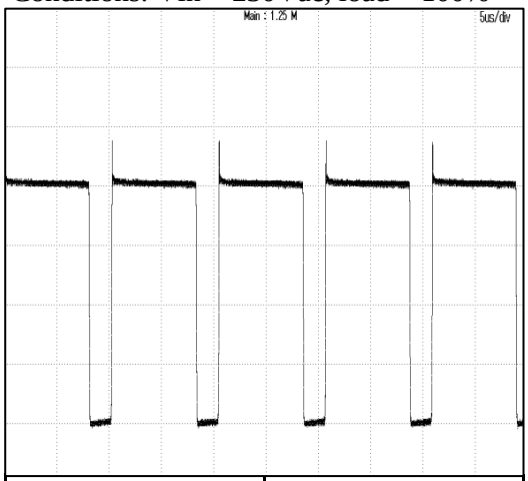


100V/DIV	5us/DIV
Result	Fsw=87-93kHz

Vds

0V

Conditions: Vin = 230Vac, load = 100%



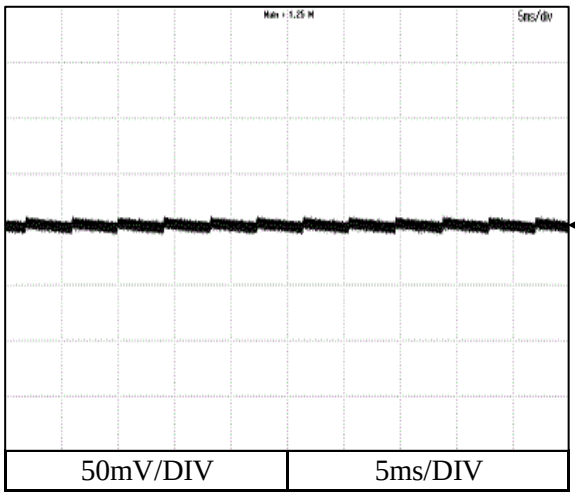
100V/DIV	5us/DIV
Result	Fsw=87-94kHz

2.11 Output ripple and noise waveform

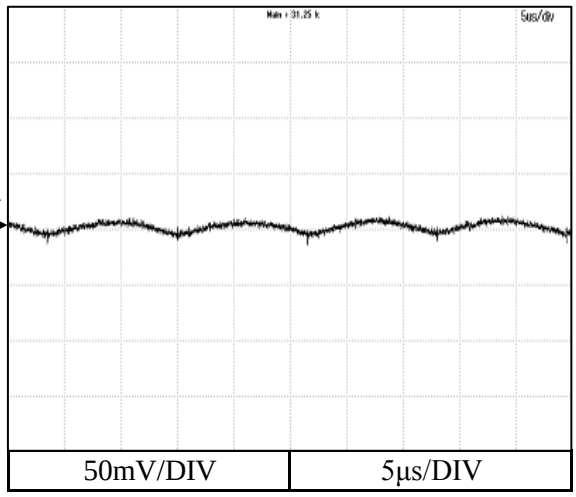
Conditions Vin : 115 VAC
Ta : 25 ℃

12V

Iout : 0%

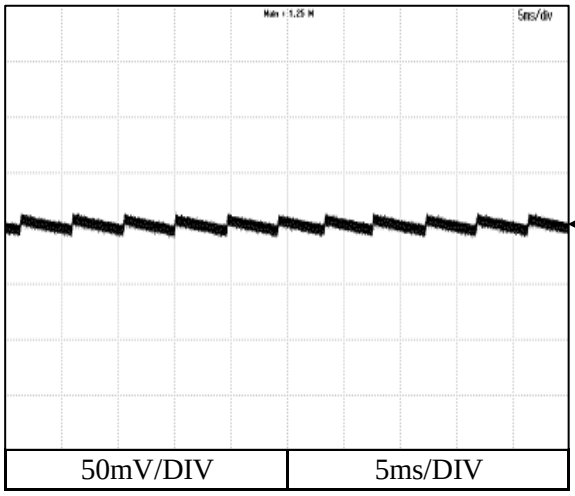


Iout : 100%

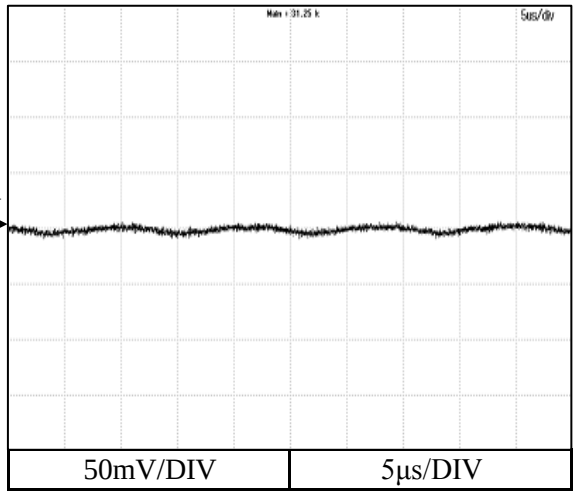


24V

Iout : 0%



Iout : 100%

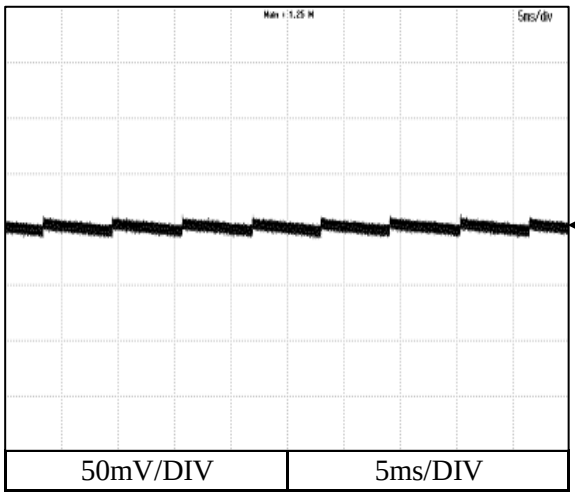


2.11 Output ripple and noise waveform

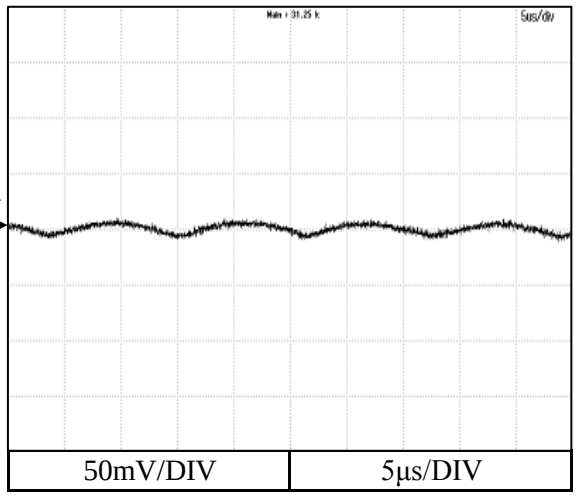
Conditions Vin : 230 VAC
Ta : 25 ℃

12V

Iout : 0%

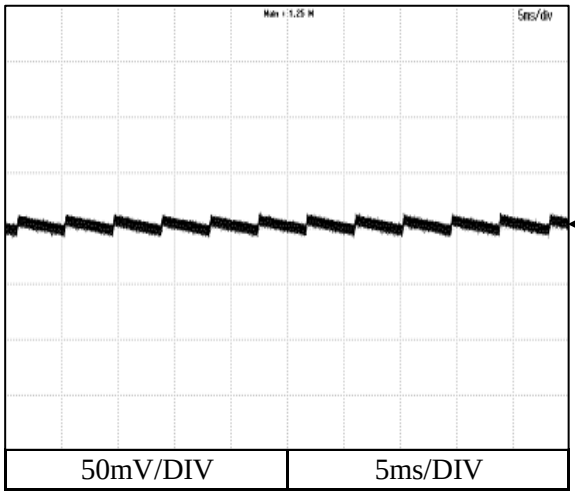


Iout : 100%

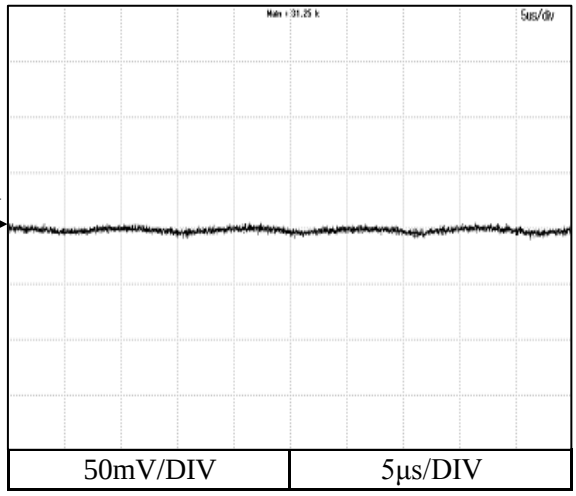


24V

Iout : 0%



Iout : 100%



2.12 Electro-Magnetic Interference characteristics

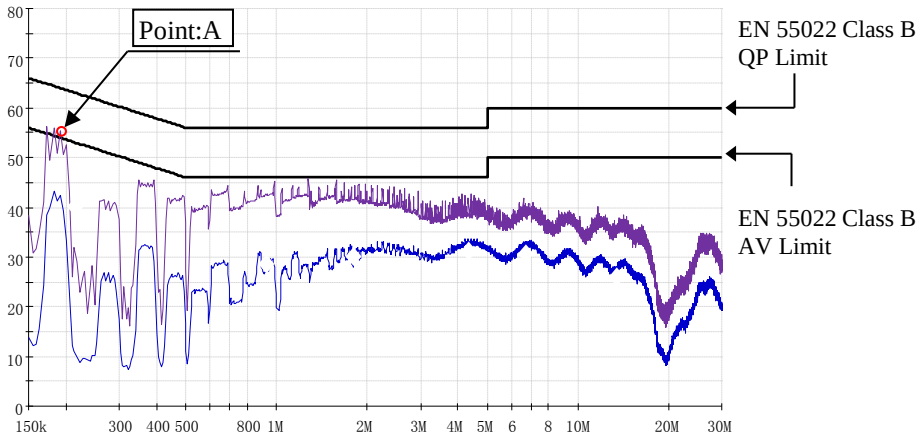
Conditions Vin : 115 VAC
Iout : 100 %
Ta : 25 ℃

Conducted Emission

12V

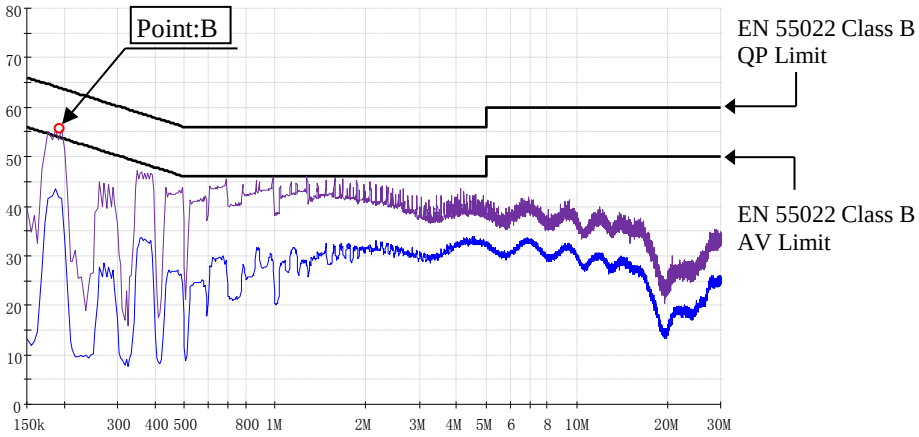
Ref. Data	Point A (0.188MHz) Limit (dBuV)	Measure (dBuV)
QP	64.4	53.8
AV	54.4	42.4

Phase : L



Ref. Data	Point B (0.194MHz) Limit (dBuV)	Measure (dBuV)
QP	63.8	54.0
AV	53.8	43.6

Phase : N



Limit of EN55011-B,VCCI-B,FCC-B are same as its EN55022 class B.

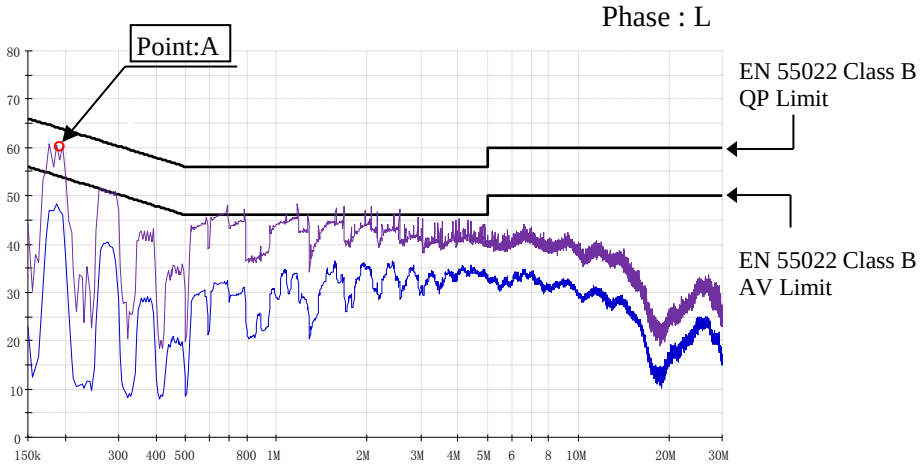
2.12 Electro-Magnetic Interference characteristics

Conditions Vin : 230 VAC
Iout : 100 %
Ta : 25 ℃

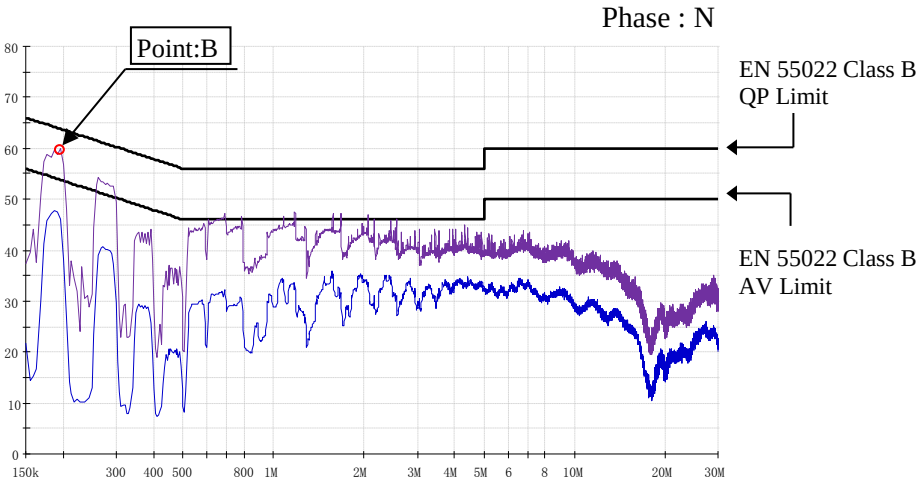
Conducted Emission

12V

Ref. Data	Point A (0.194MHz) Limit (dBuV)	Measure (dBuV)
QP	63.8	58.6
AV	53.8	48.6



Ref. Data	Point B (0.194MHz) Limit (dBuV)	Measure (dBuV)
QP	63.8	58.9
AV	53.8	48.3



Limit of EN55011-B,VCCI-B,FCC-B are same as its EN55022 class B.

2.12 Electro-Magnetic Interference characteristics

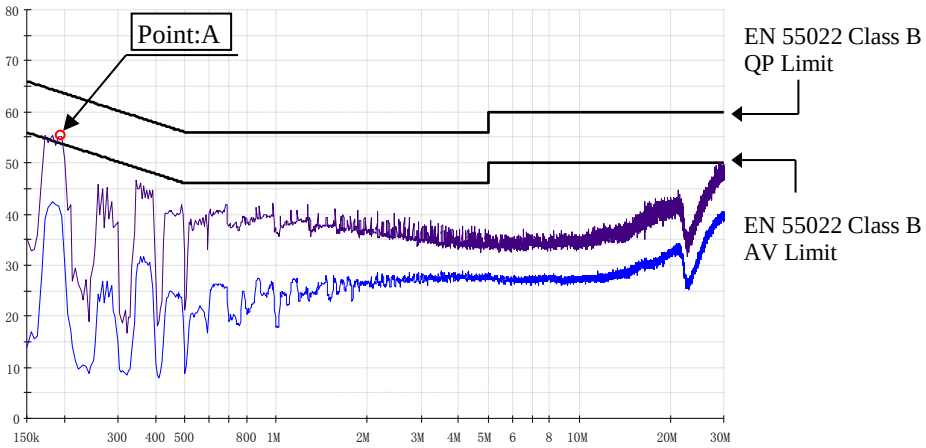
Conditions Vin : 115 VAC
Iout : 100 %
Ta : 25 ℃

Conducted Emission

24V

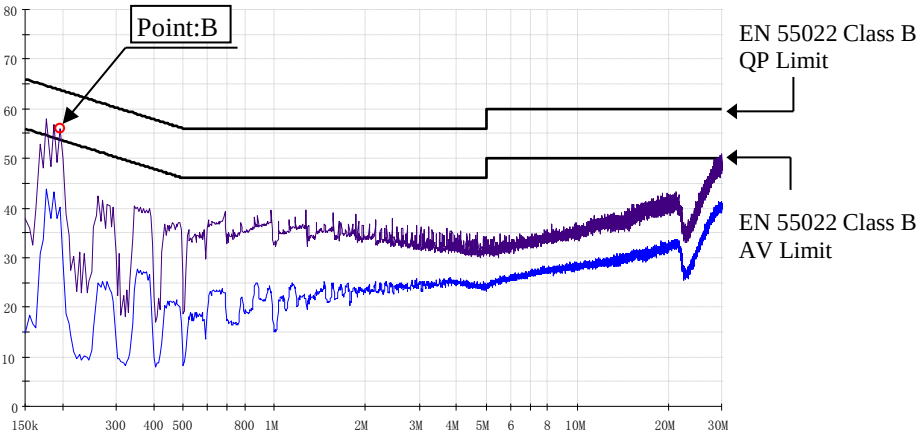
Ref. Data	Point A (0.195MHz) Limit (dBuV)	Measure (dBuV)
QP	63.7	55.0
AV	53.7	42.5

Phase : L



Ref. Data	Point B (0.195MHz) Limit (dBuV)	Measure (dBuV)
QP	63.7	55.1
AV	53.7	44.0

Phase : N



Limit of EN55011-B,VCCI-B,FCC-B are same as its EN55022 class B.

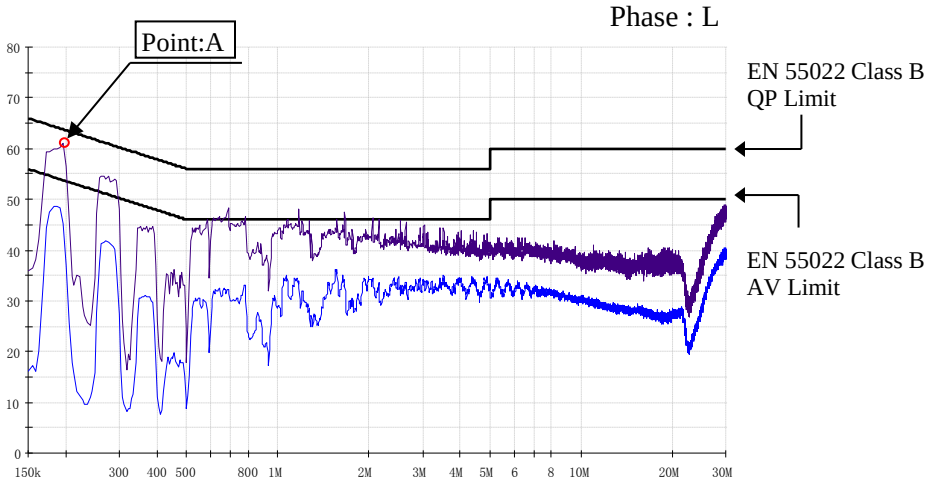
2.12 Electro-Magnetic Interference characteristics

Conditions Vin : 230 VAC
Iout : 100 %
Ta : 25 ℃

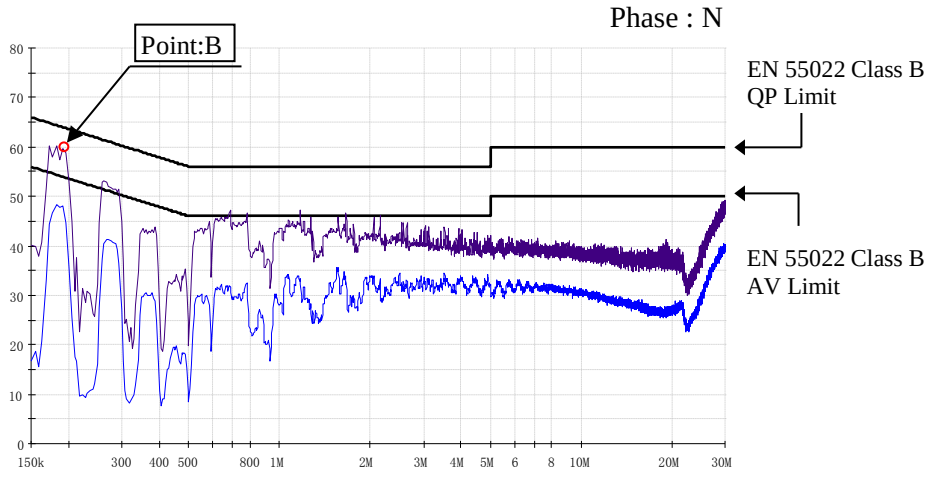
Conducted Emission

24V

Ref. Data	Point A (0.195MHz) Limit (dBuV)	Measure (dBuV)
QP	63.7	60.1
AV	53.7	49.0



Ref. Data	Point B (0.195MHz) Limit (dBuV)	Measure (dBuV)
QP	63.7	57.2
AV	53.7	48.0



Limit of EN55011-B,VCCI-B,FCC-B are same as its EN55022 class B.

2.12 Electro-Magnetic Interference characteristics

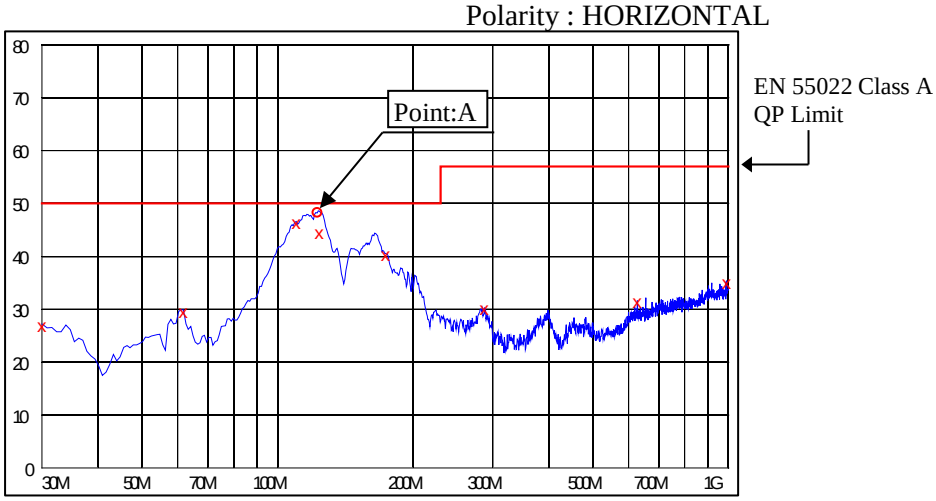
Conditions Vin : 115 VAC
Iout : 100 %
Ta : 25 ℃

Radiated Emission

12V

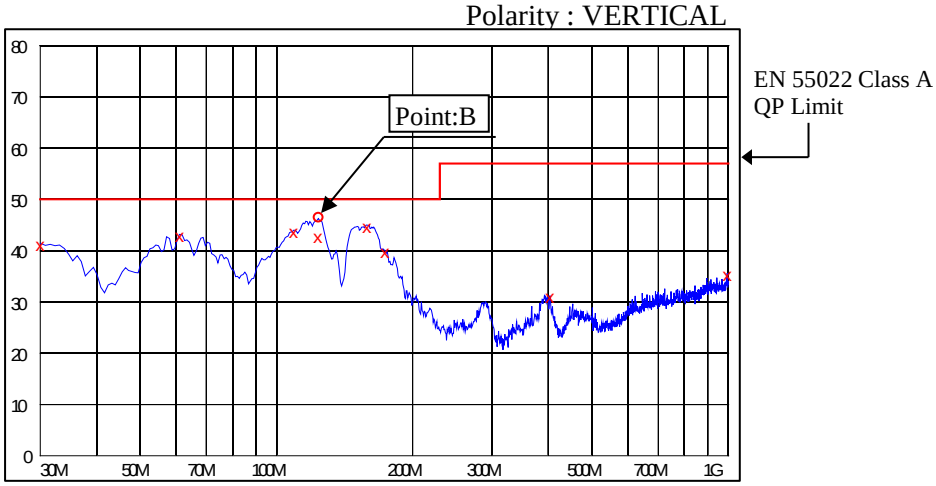
Ref. Data	Point A (130MHz) Limit (dBuV)	Measure (dBuV)
QP	50.0	44.9

Polarity : HORIZONTAL



Ref. Data	Point B (130MHz) Limit (dBuV)	Measure (dBuV)
QP	50.0	45.0

Polarity : VERTICAL



Limit of EN55011-A,VCCI-A,FCC-A are same as its EN55022 class A.

2.12 Electro-Magnetic Interference characteristics

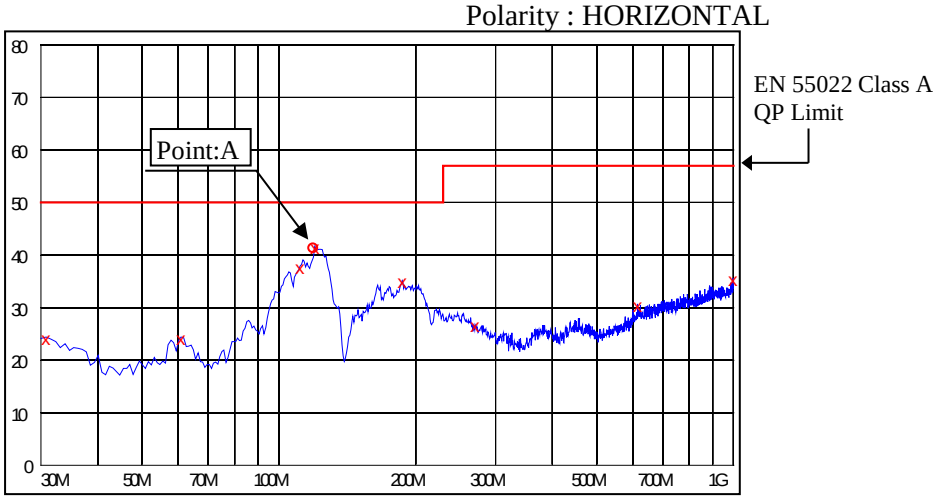
Conditions Vin : 230 VAC
Iout : 100 %
Ta : 25 ℃

Radiated Emission

12V

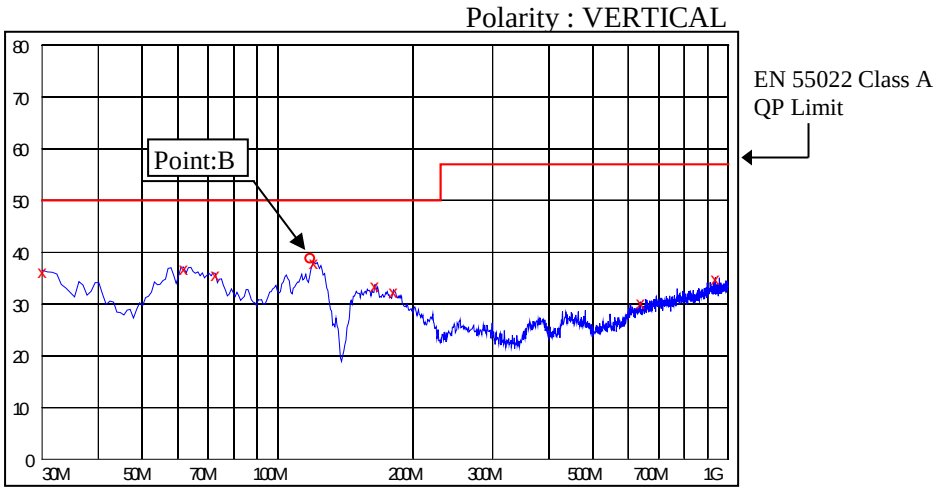
Ref. Data	Point A (130MHz) Limit (dBuV)	Measure (dBuV)
QP	50.0	41.6

Polarity : HORIZONTAL



Ref. Data	Point B (130MHz) Limit (dBuV)	Measure (dBuV)
QP	50.0	38.3

Polarity : VERTICAL



Limit of EN55011-A,VCCI-A,FCC-A are same as its EN55022 class A.

2.12 Electro-Magnetic Interference characteristics

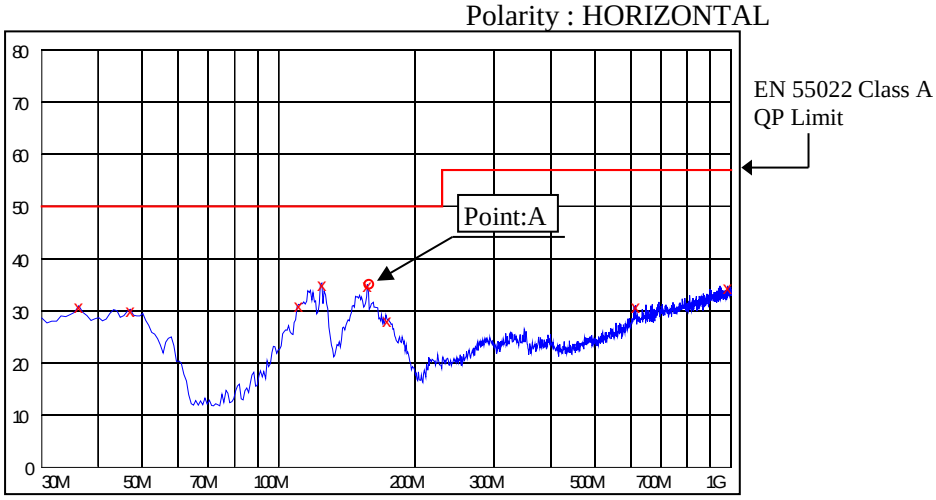
Conditions Vin : 115 VAC
Iout : 100 %
Ta : 25 ℃

Radiated Emission

24V

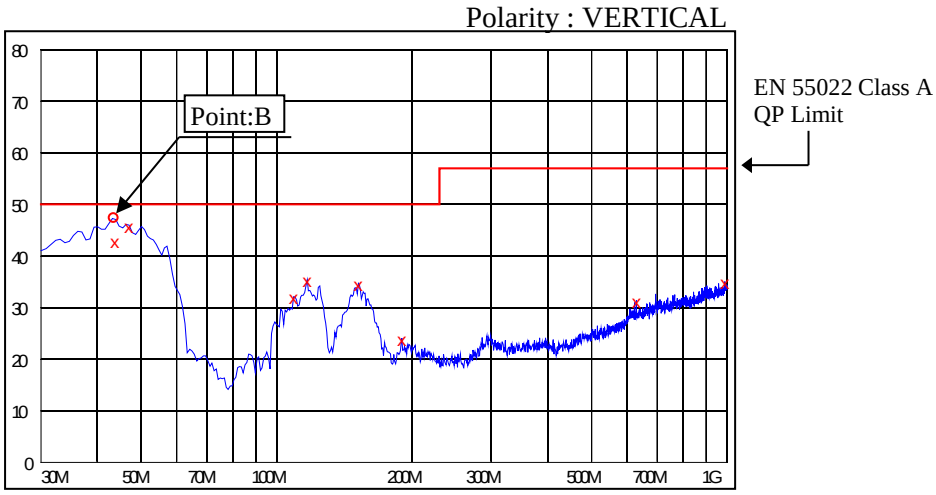
Ref. Data	Point A (160MHz) Limit (dBuV)	Measure (dBuV)
QP	50.0	35.3

Polarity : HORIZONTAL



Ref. Data	Point B (45MHz) Limit (dBuV)	Measure (dBuV)
QP	50.0	43.1

Polarity : VERTICAL



Limit of EN55011-A,VCCI-A,FCC-A are same as its EN55022 class A.

2.12 Electro-Magnetic Interference characteristics

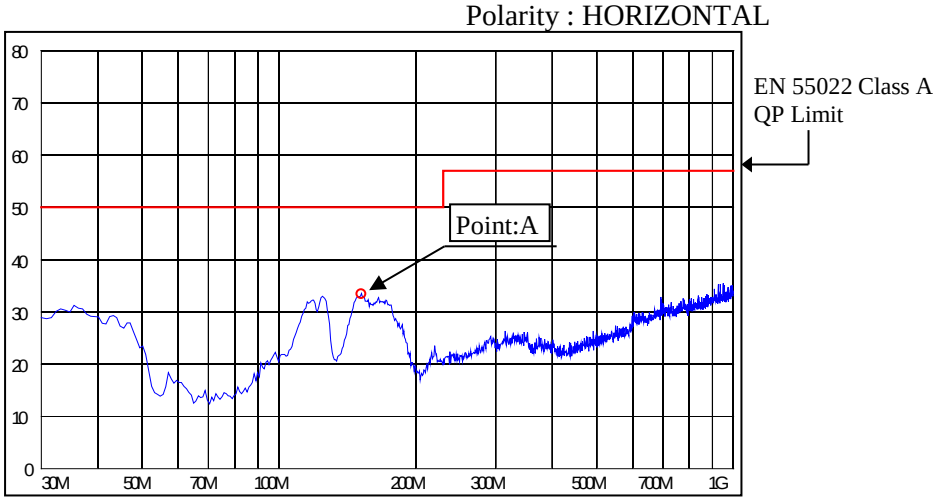
Conditions Vin : 230 VAC
Iout : 100 %
Ta : 25 ℃

Radiated Emission

24V

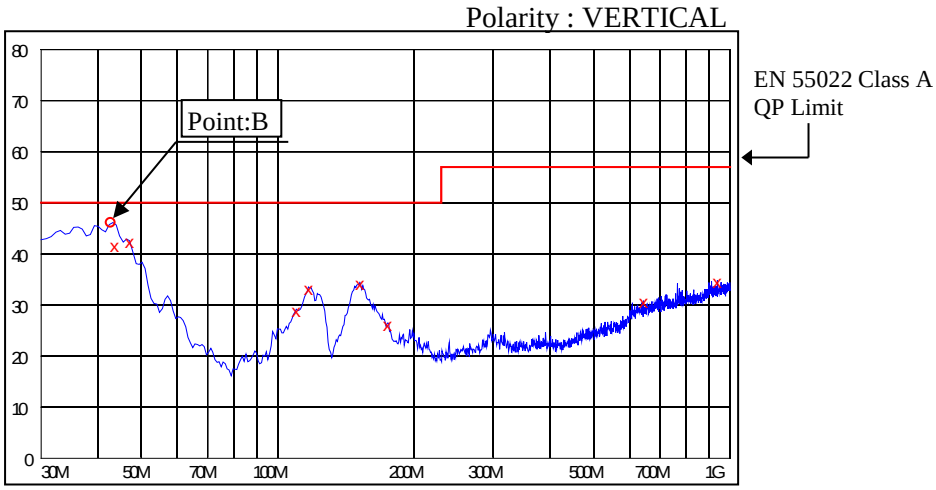
Ref. Data	Point A (160MHz) Limit (dBuV)	Measure (dBuV)
QP	50.0	35.6

Polarity : HORIZONTAL



Ref. Data	Point B (45MHz) Limit (dBuV)	Measure (dBuV)
QP	50.0	42.6

Polarity : VERTICAL



Limit of EN55011-A,VCCI-A,FCC-A are same as its EN55022 class A.

2.12 Electro-Magnetic Interference characteristics

Conditions Vin : 115 VAC
Iout : 100 %
Ta : 25 ℃

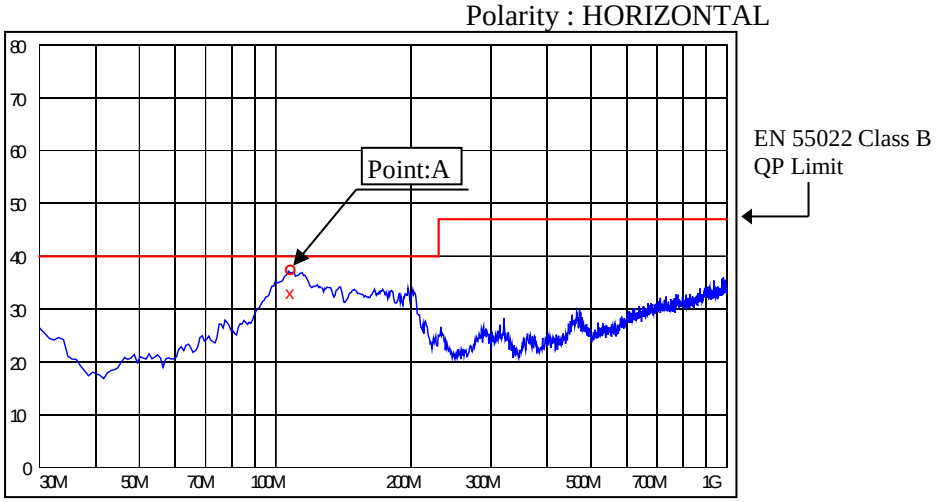
Radiated Emission

External coil :
Input : H19*13*11P DN100H(DMEGC) , 6 paired turns
Output : H19*13*11P DN100H(DMEGC) , 3 paired turns

12V

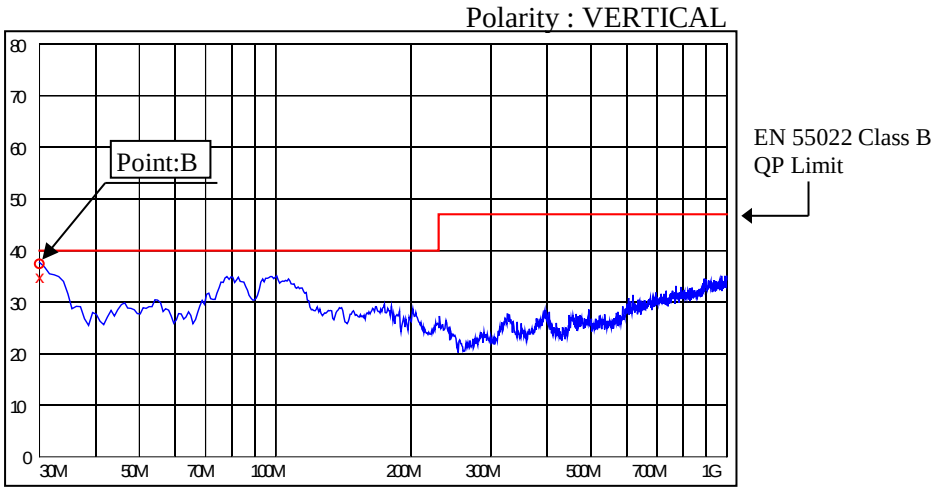
Ref. Data	Point A (107MHz) Limit (dBuV)	Measure (dBuV)
QP	40.0	33.5

Polarity : HORIZONTAL



Ref. Data	Point B (30MHz) Limit (dBuV)	Measure (dBuV)
QP	40.0	35.2

Polarity : VERTICAL



Limit of EN55011-B,VCCI-B,FCC-B are same as its EN55022 class B.

2.12 Electro-Magnetic Interference characteristics

Conditions Vin : 230 VAC
Iout : 100 %
Ta : 25 ℃

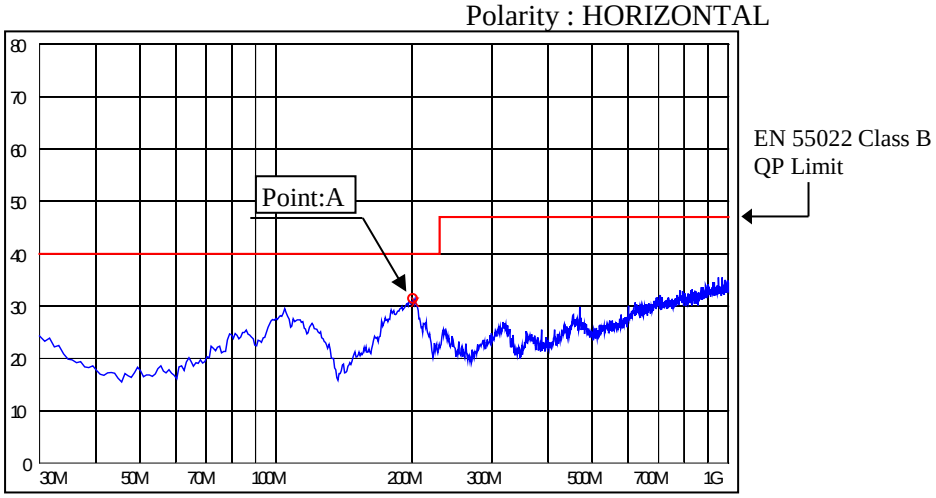
Radiated Emission

External coil :
Input : H19*13*11P DN100H(DMEGC) , 6 paired turns
Output : H19*13*11P DN100H(DMEGC) , 3 paired turns

12V

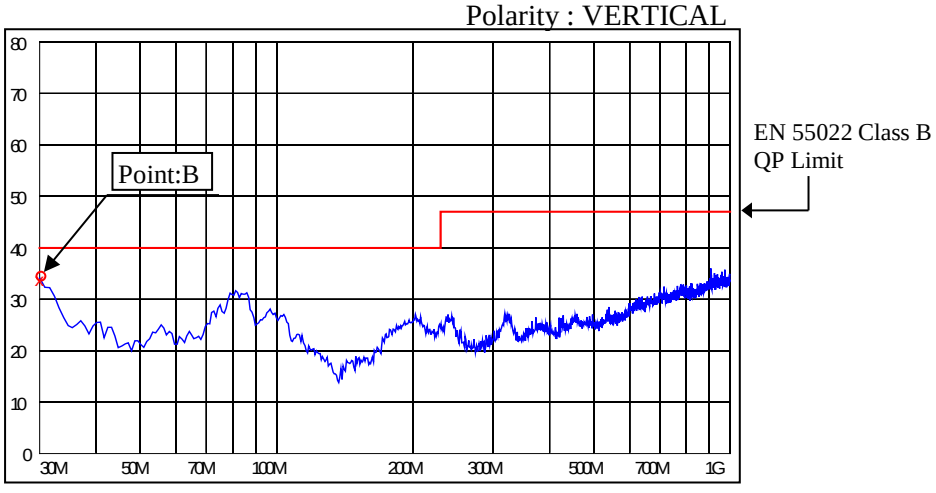
Ref. Data	Point A (200MHz) Limit (dBuV)	Measure (dBuV)
QP	40.0	31.3

Polarity : HORIZONTAL



Ref. Data	Point B (30MHz) Limit (dBuV)	Measure (dBuV)
QP	40.0	34.2

Polarity : VERTICAL



Limit of EN55011-B,VCCI-B,FCC-B are same as its EN55022 class B.

2.12 Electro-Magnetic Interference characteristics

Conditions Vin : 115 VAC
Iout : 100 %
Ta : 25 ℃

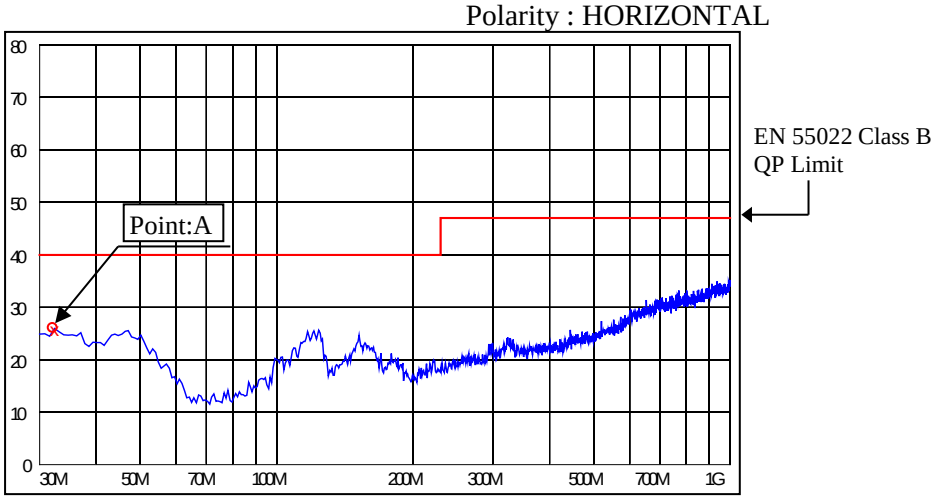
Radiated Emission

External coil :
Input : H19*13*11P DN100H(DMEGC) , 6 paired turns
Output : H19*13*11P DN100H(DMEGC) , 3 paired turns

24V

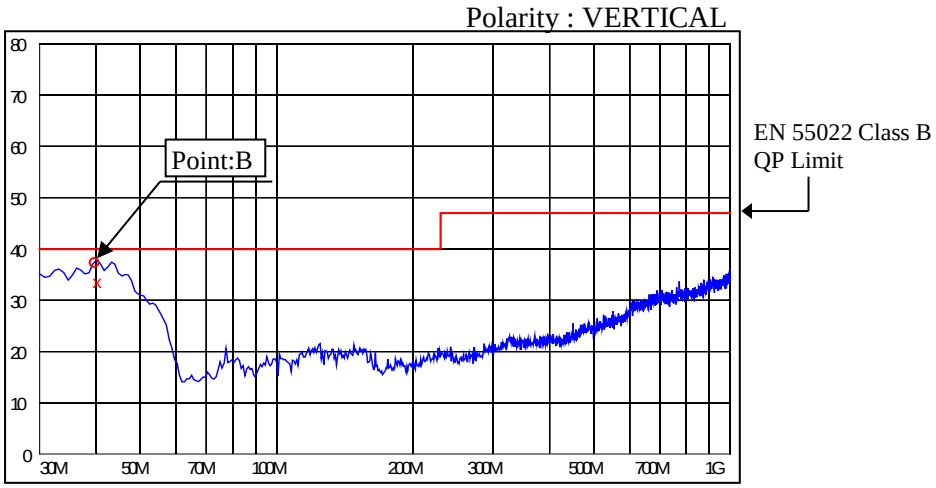
Ref. Data	Point A (32MHz) Limit (dBuV)	Measure (dBuV)
QP	40.0	25.9

Polarity : HORIZONTAL



Ref. Data	Point B (40MHz) Limit (dBuV)	Measure (dBuV)
QP	40.0	33.8

Polarity : VERTICAL



Limit of EN55011-B,VCCI-B,FCC-B are same as its EN55022 class B.

2.12 Electro-Magnetic Interference characteristics

Conditions Vin : 230 VAC
Iout : 100 %
Ta : 25 ℃

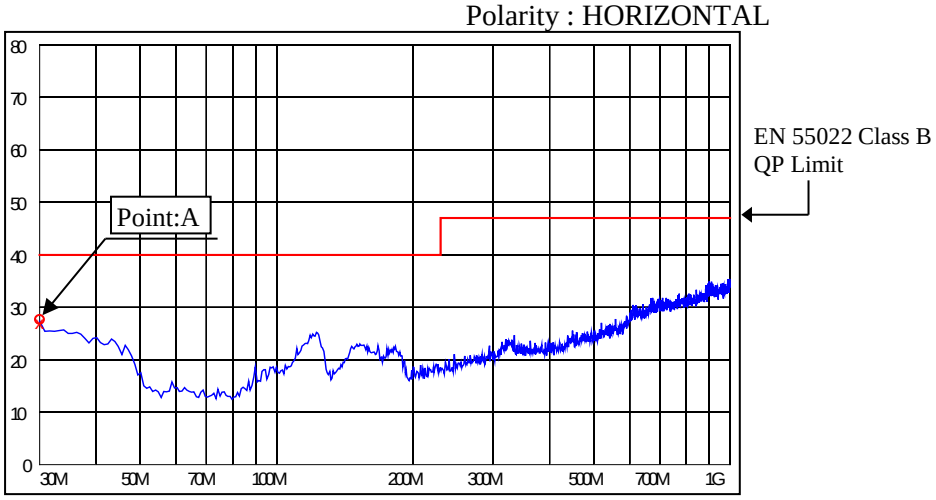
Radiated Emission

External coil :
Input : H19*13*11P DN100H(DMEGC) , 6 paired turns
Output : H19*13*11P DN100H(DMEGC) , 3 paired turns

24V

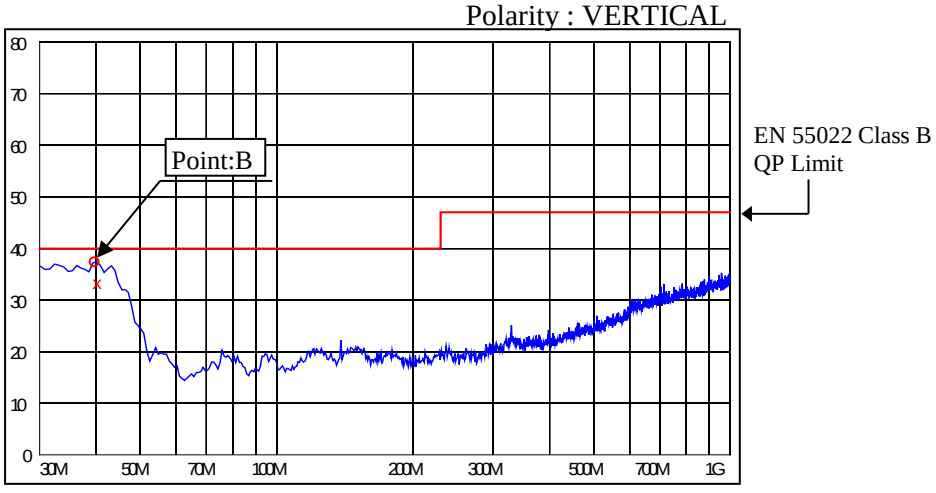
Ref. Data	Point A (32MHz) Limit (dBuV)	Measure (dBuV)
QP	40.0	25.9

Polarity : HORIZONTAL



Ref. Data	Point B (40MHz) Limit (dBuV)	Measure (dBuV)
QP	40.0	33.8

Polarity : VERTICAL



Limit of EN55011-B,VCCI-B,FCC-B are same as its EN55022 class B.

2.13 Limit power source (UL1310 class2)

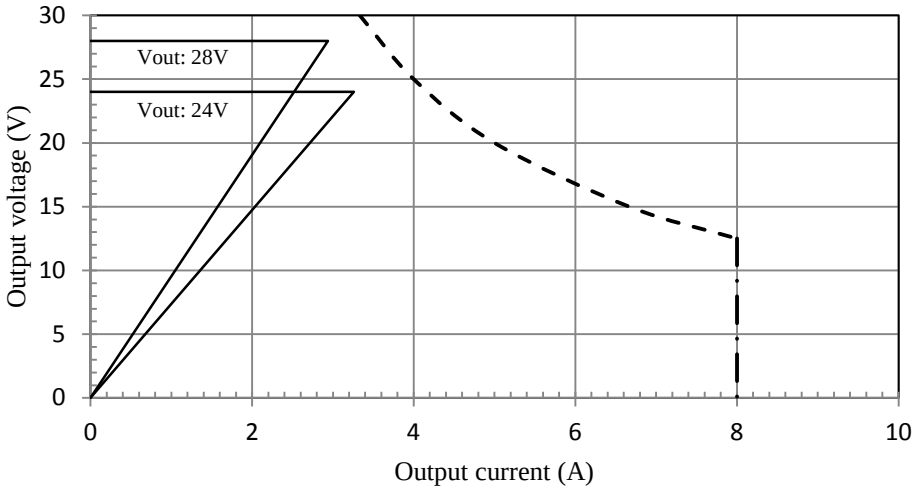
Conditions Vin : 115 VAC
Ta : 25 ℃

Limit of 100W
Limit of 8A
Output voltage vs. Output current

24V

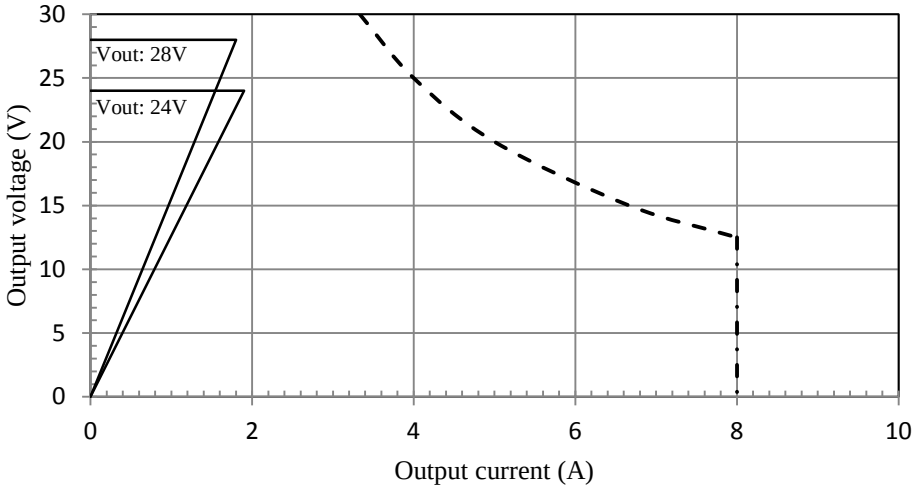
O.C.P condition

Basic protection function - Over current protection.



Single fault condition

Disable over current protection function by shorting the current sense resistor.



2.13 Limit power source (UL1310 class2)

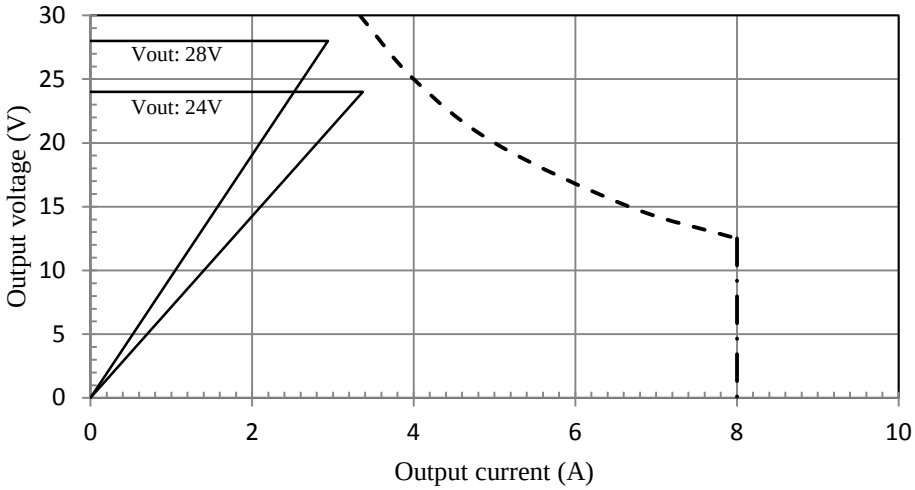
Conditions Vin : 230 VAC
Ta : 25 ℃

Limit of 100W
Limit of 8A
Output voltage vs. Output current

24V

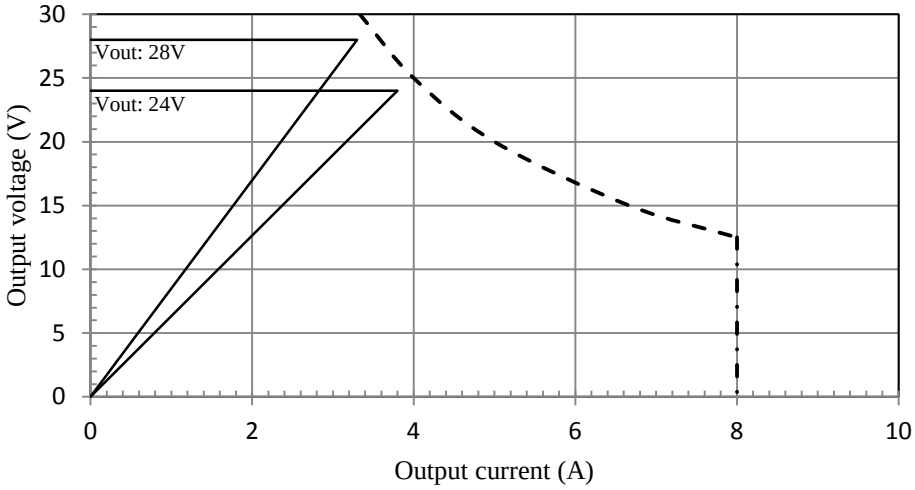
O.C.P condition

Basic protection function - Over current protection.



Single fault condition

Disable over current protection function by shorting the current sense resistor.



2.14 Harmonic current characteristics

Conditions Vin : 230 VAC
Iout : 100 %
Ta : 25 ℃