HFE1600
EVALUATION DATA

DWG: IA688-53-01		
APPD	CHK	DWG
Ami P. 31-Oct-2012	Ami P. 31-Oct-2012	Sarley 28.10.2012

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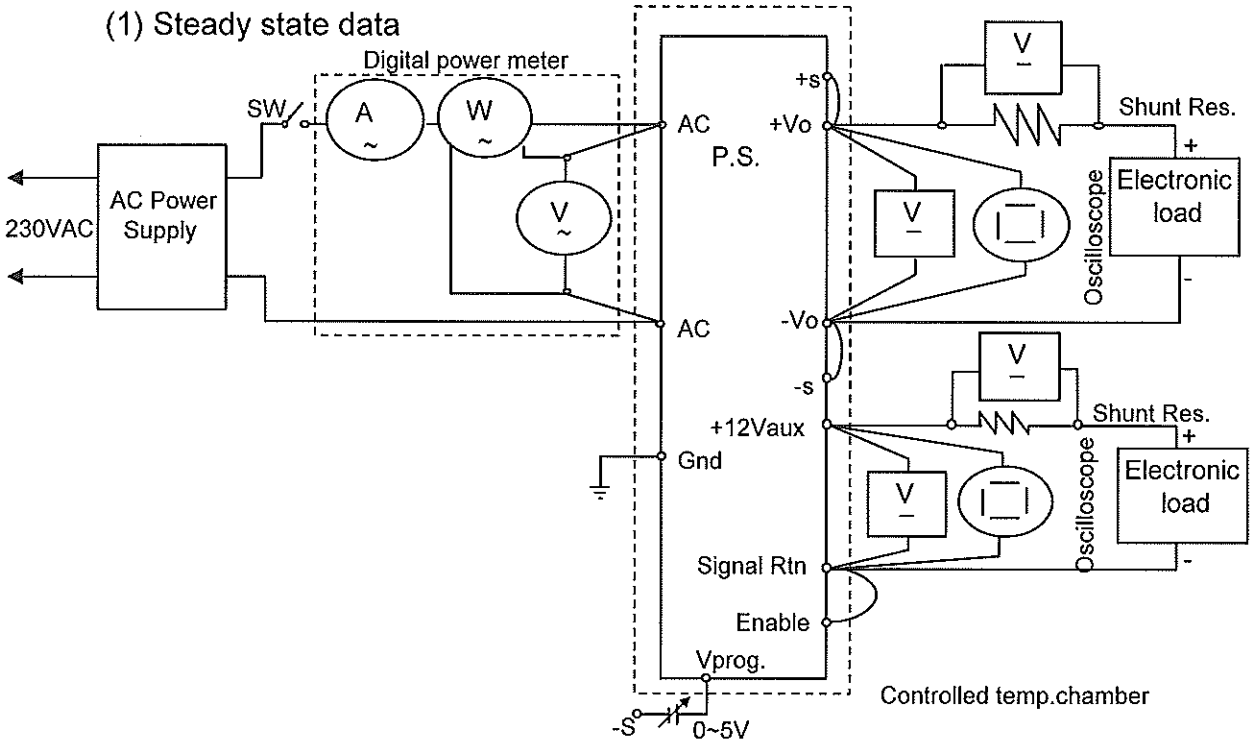
TERMINOLOGY USED

Definition

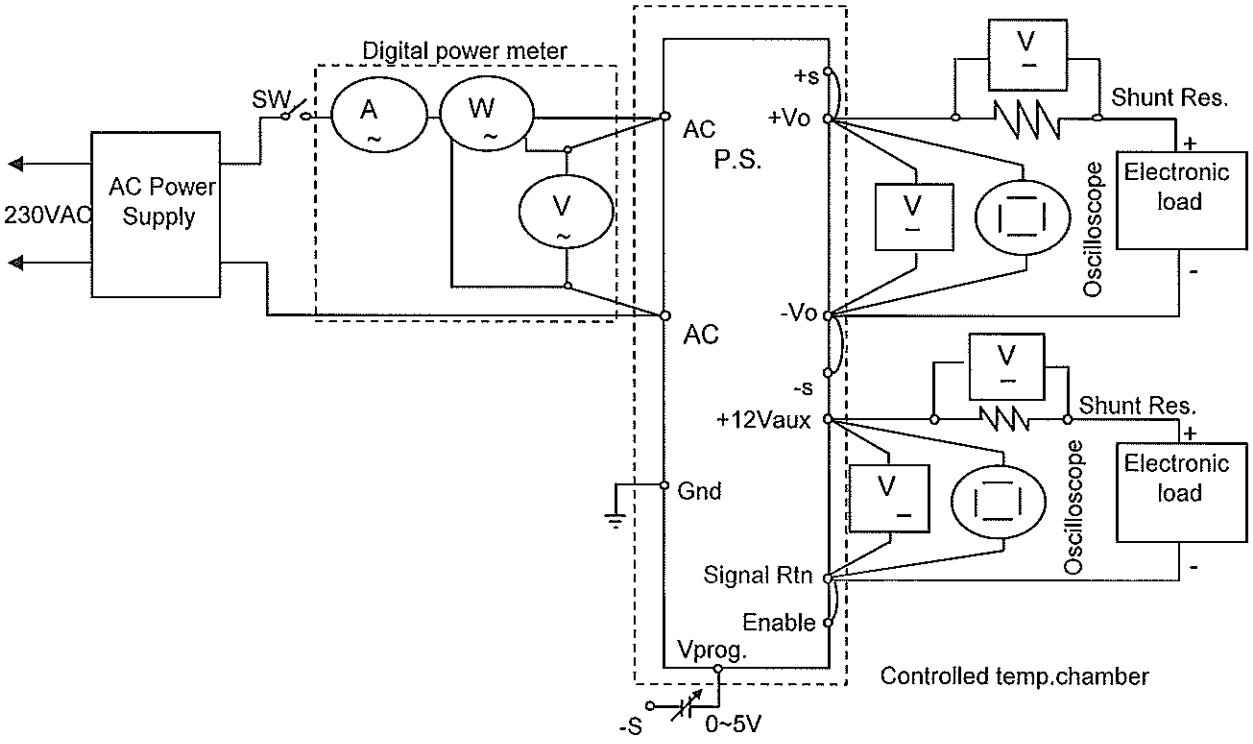
Vin	Input voltage
Vout	Output voltage
Iin	Input current
Iout	Output current
Ta	Ambient Temperature

1-1.Circuits used for determination

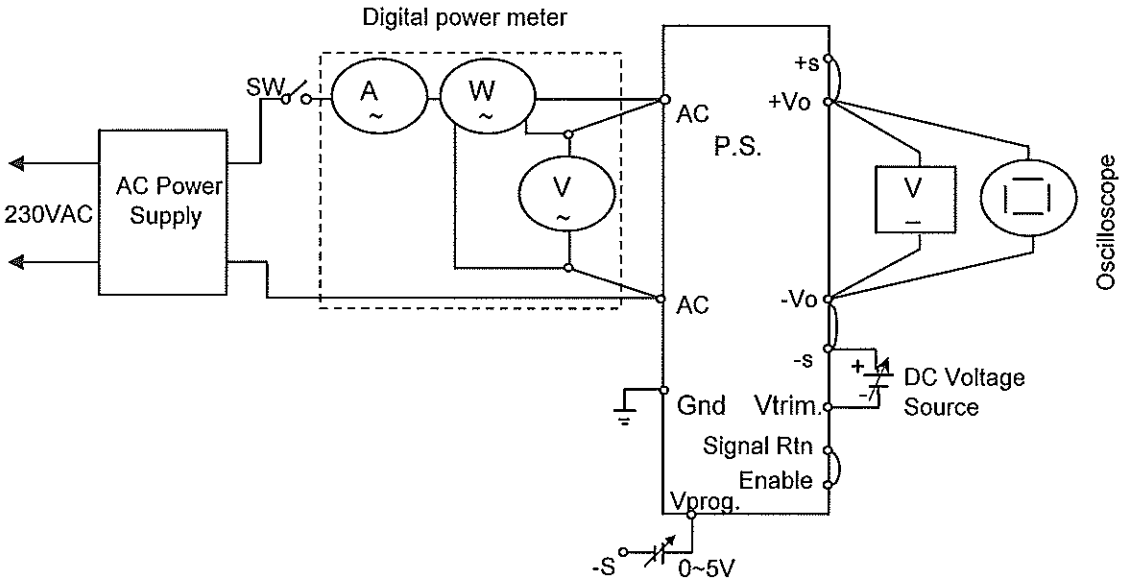
(1) Steady state data



(2) Warm up voltage drift & temperature stability



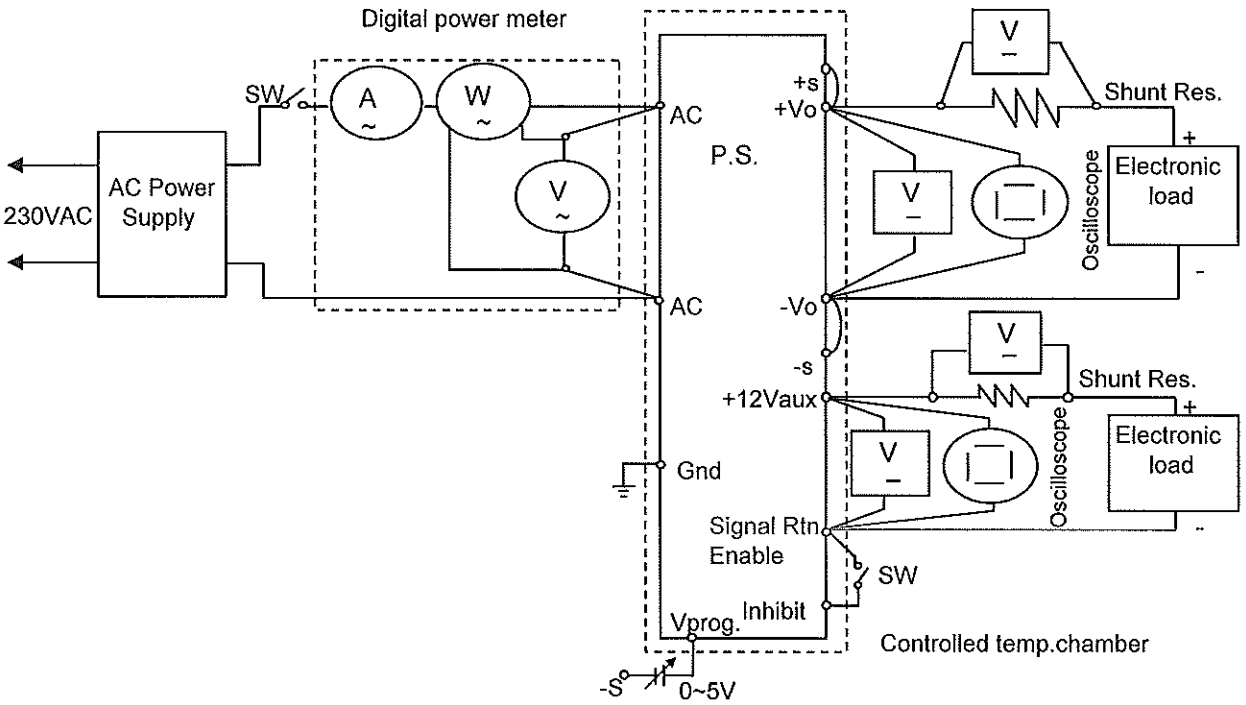
(3) Over Voltage Protection (OVP) characteristics



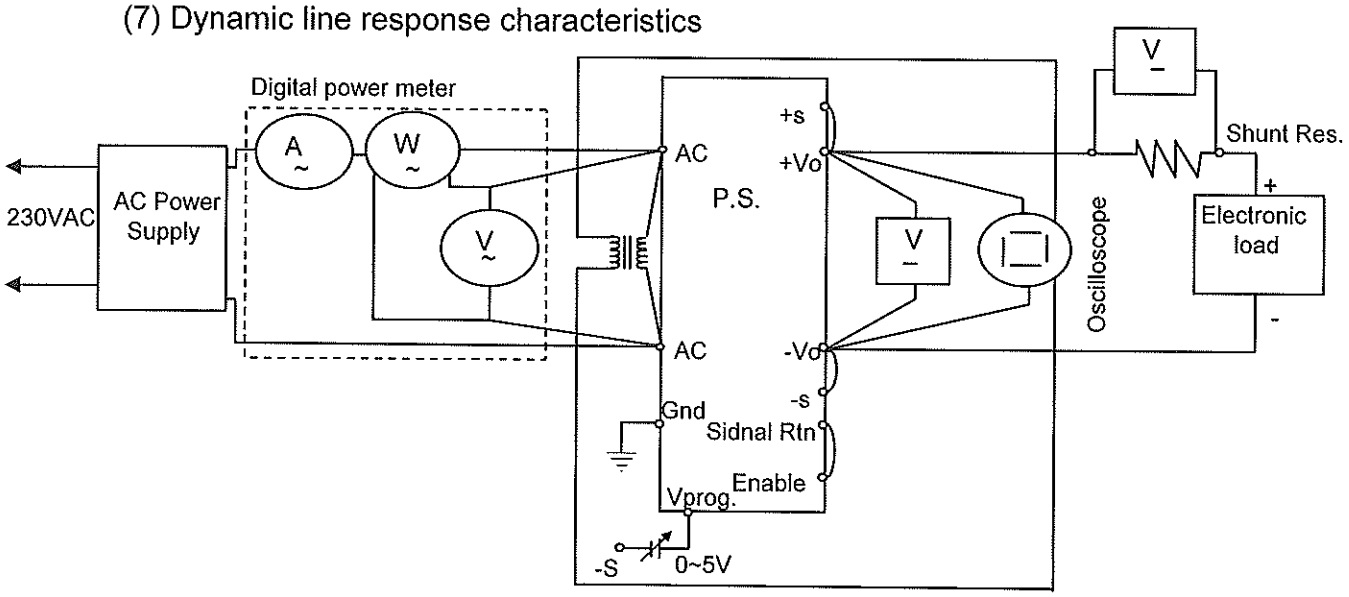
(4) Over Current Protection (OCP) characteristics

Same as item (1)

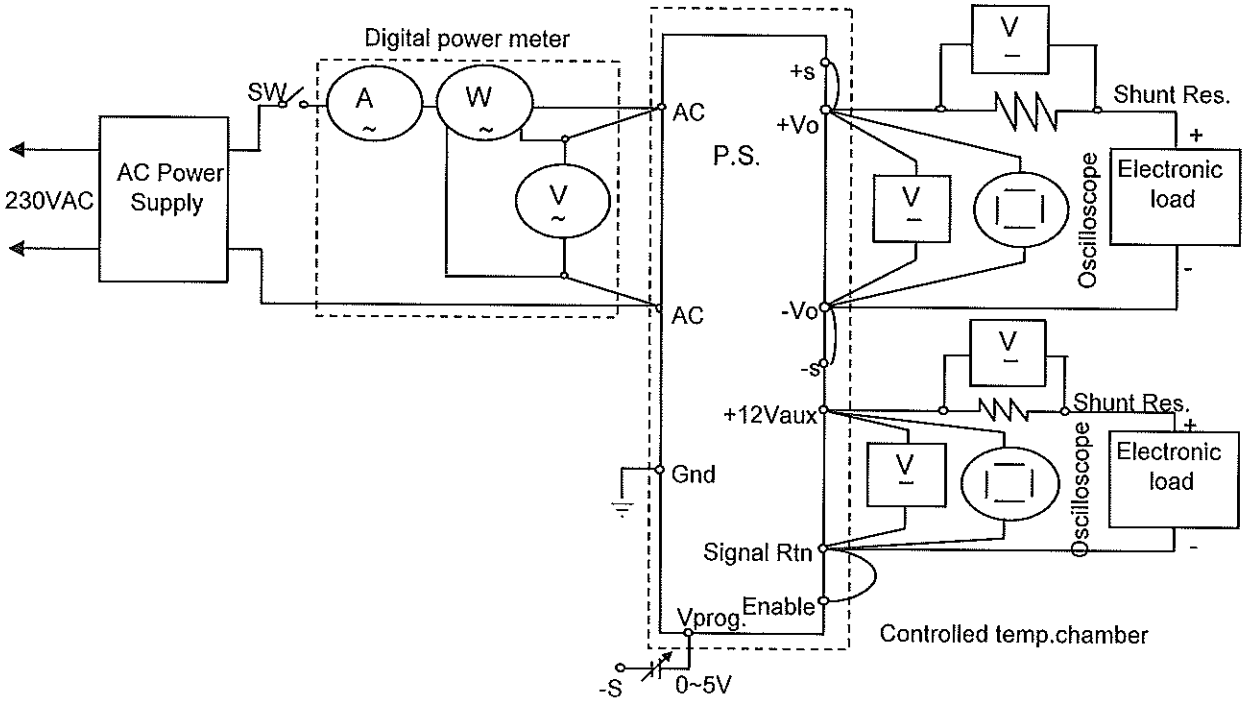
(5) (6) Output Rise & Fall Characteristics



(7) Dynamic line response characteristics

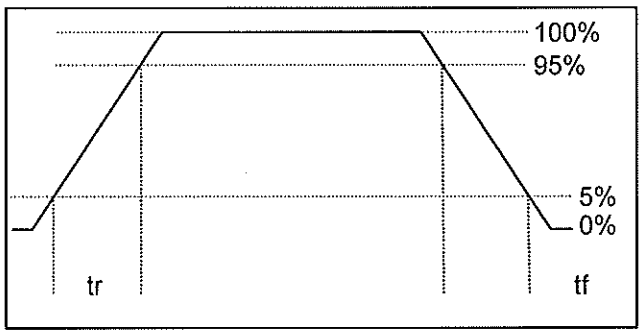


(8) Dynamic load response characteristics



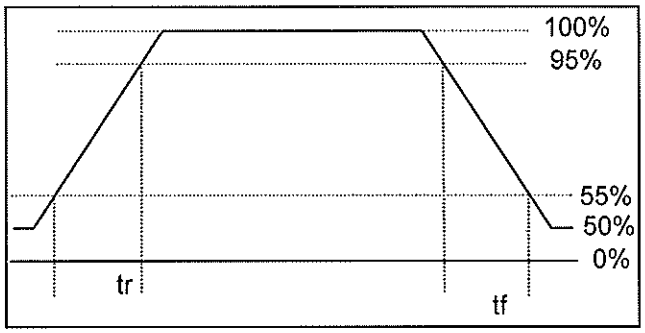
Dynamic load response characteristics

Output current waveform
Iout 0% <---> 100%



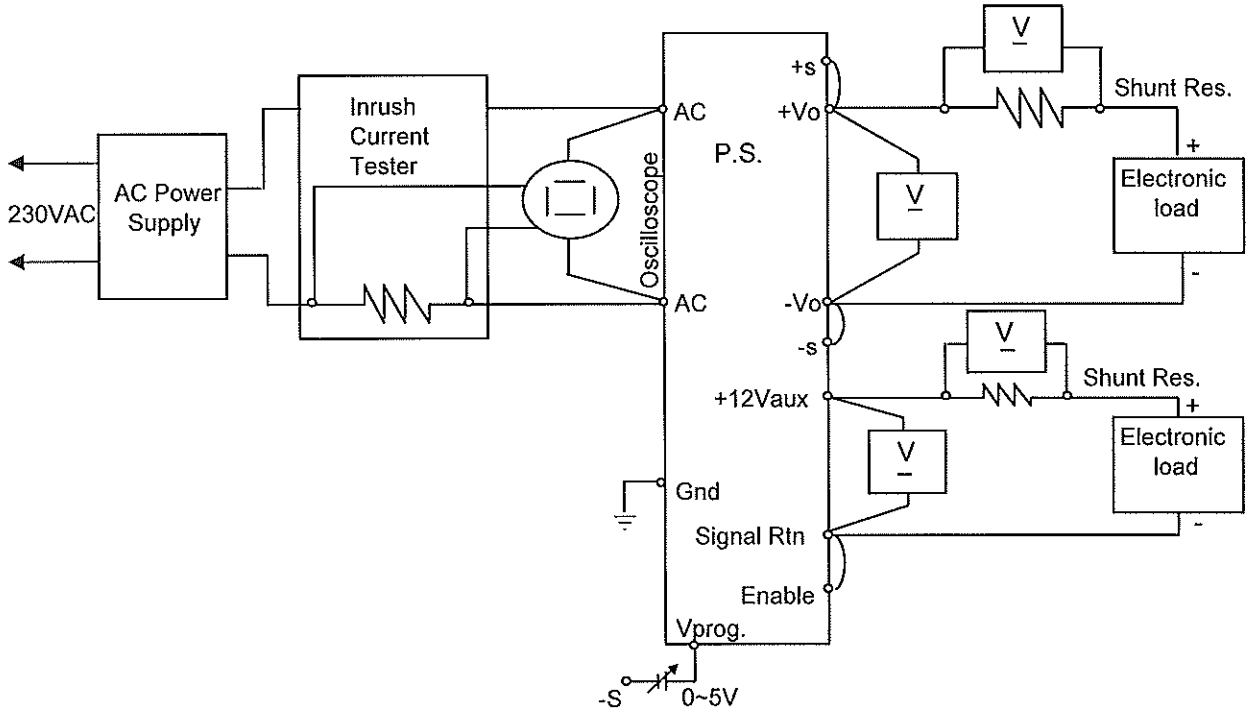
t_r = 100μs
t_f = 100μs

Output current waveform
Iout 50% <---> 100%

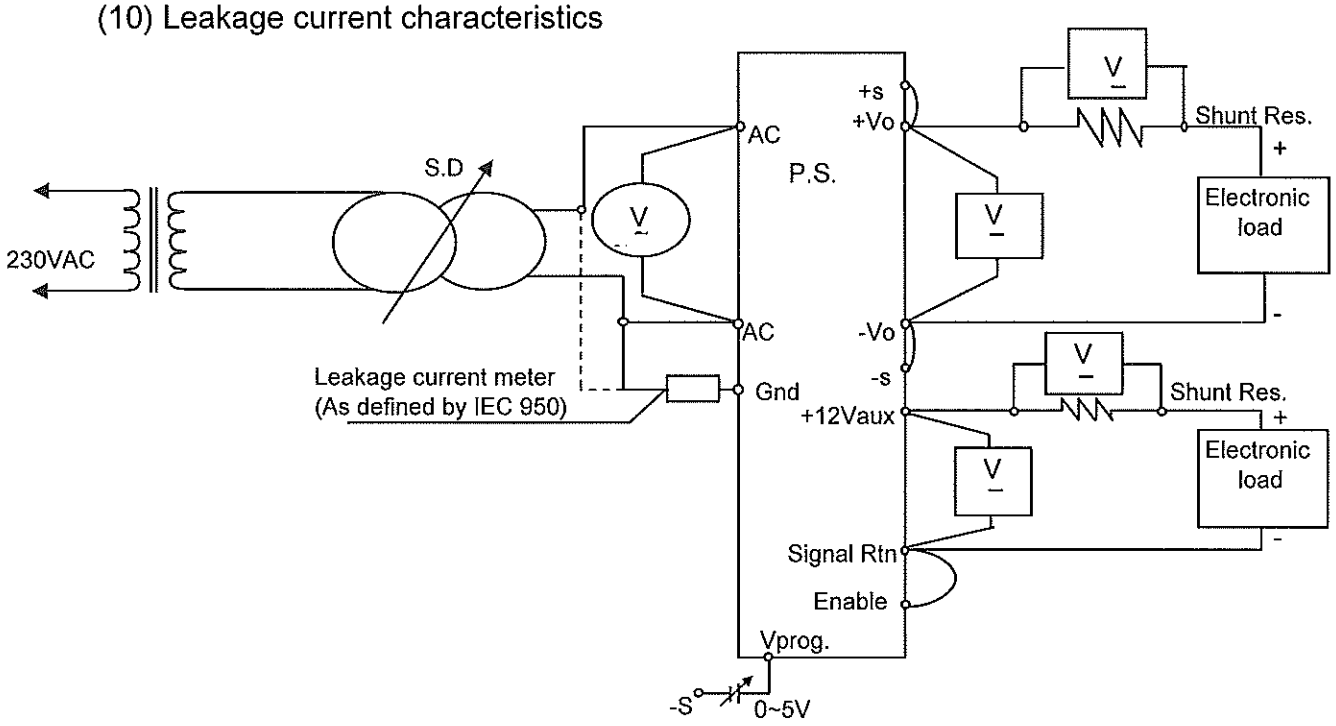


t_r = 100μs
t_f = 100μs

(9) Inrush current characteristics

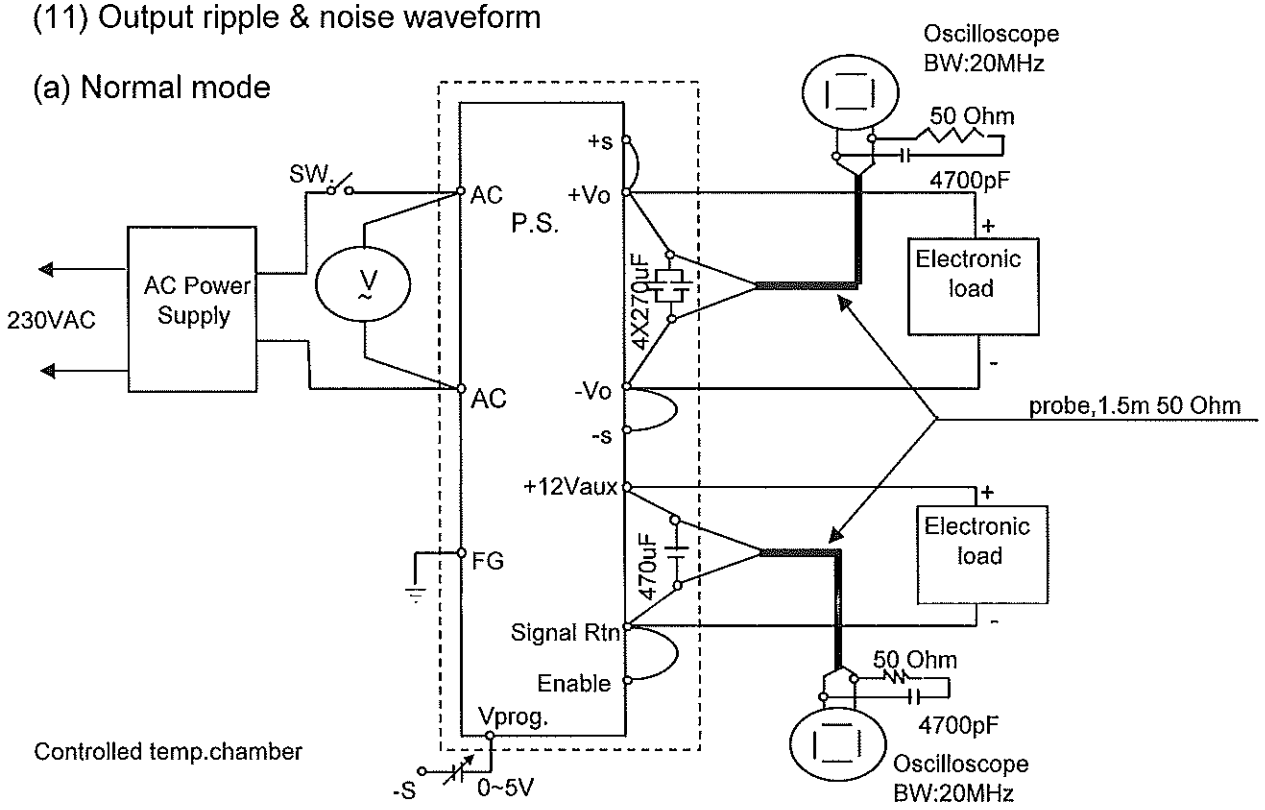


(10) Leakage current characteristics

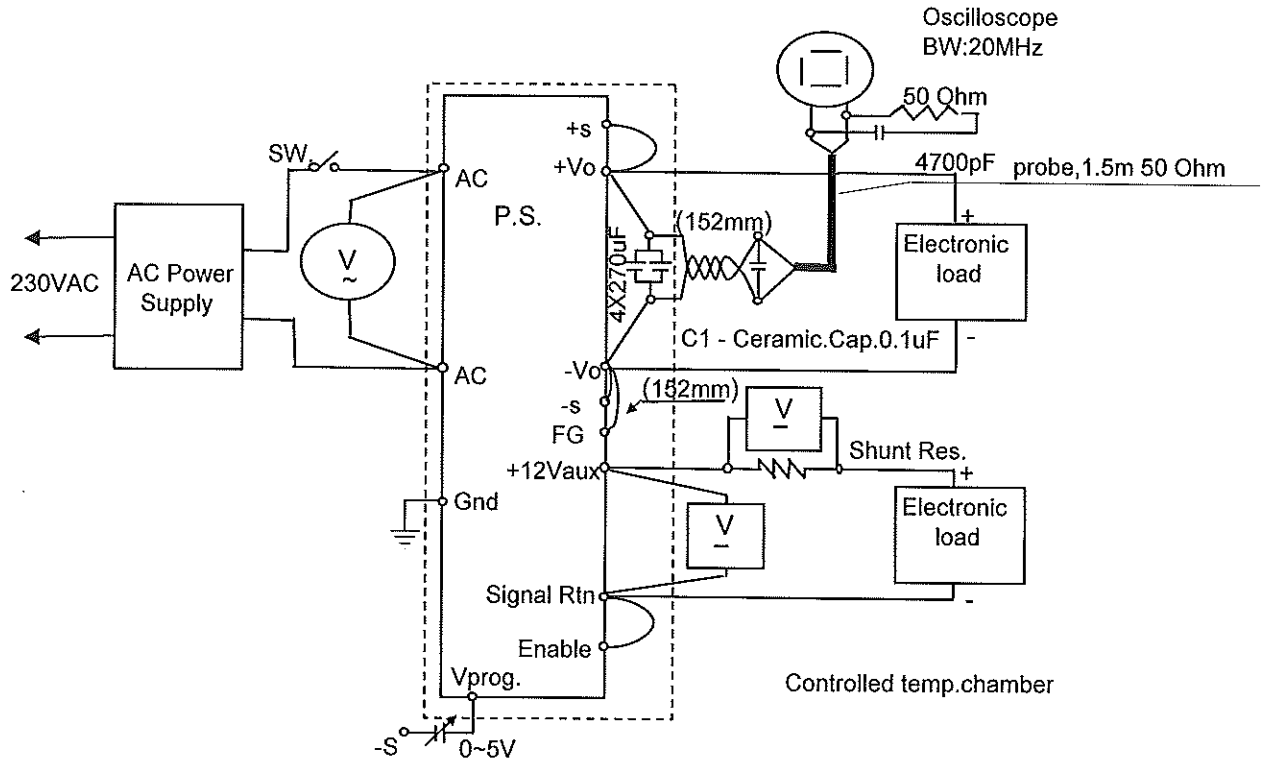


(11) Output ripple & noise waveform

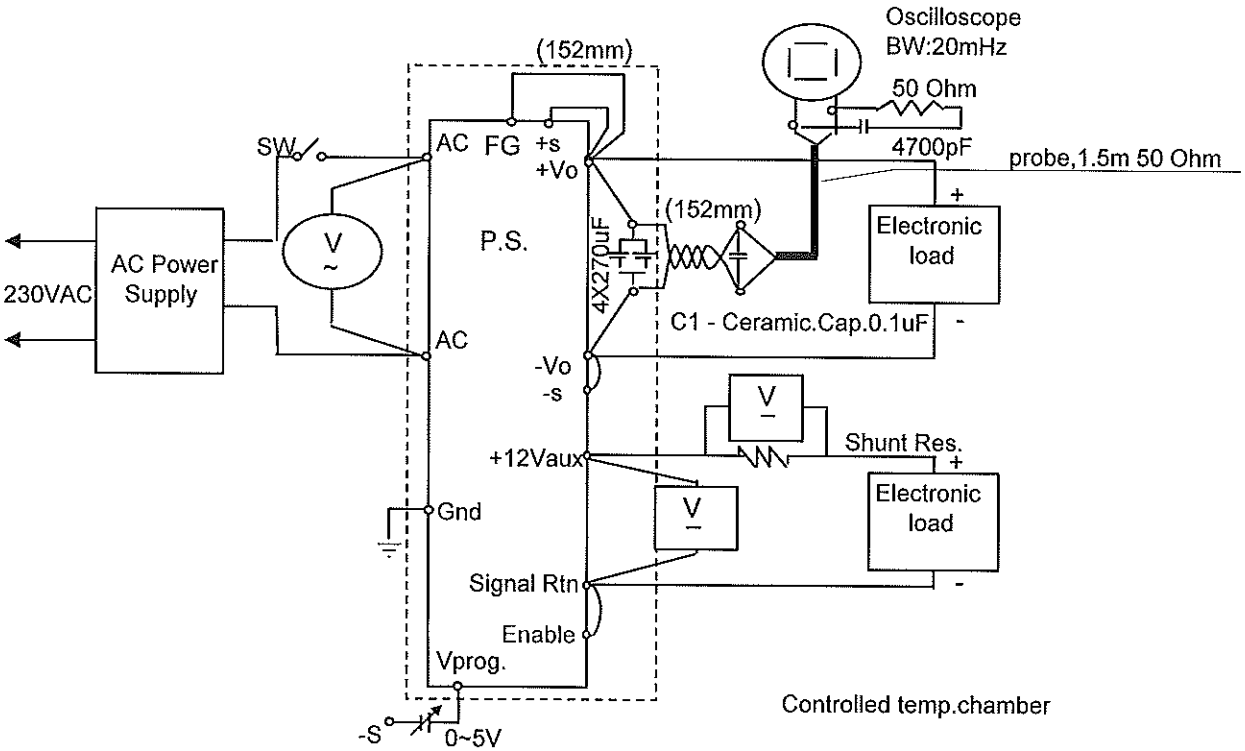
(a) Normal mode



(b) Normal and common mode -Vo Terminal grounded



(c) Normal and common mode +Vo Terminal grounded



(12) Standby current

Same as Steady state data

1-2 List of equipment used

No	EQUIPMENT USED	MANUFACTURER	MODEL No.
1	Storage oscilloscope	YOKOGAWA	DL7100
2	Storage oscilloscope	YOKOGAWA	DL1740
3	Digital multimeter	AGILENT	34401A
4	Digital power meter	YOKOGAWA	WT110
5	Autotransformer	VOLTAC	B15
6	Autotransformer	METREL	HSN 260/30
7	Electronic load	H&H	ZS6060 SC150
8	Electronic load	H&H	ZS7006
9	Electronic load	H&H	ZS7060
10	Electronic load	CHROMA	63203
11	Electronic load	CHROMA	63206
12	Controlled temp. chamber	THERMOTRON	SM-16-3800
13	Controlled temp. chamber	THERMOTRON	SE-600-6-6
14	AC Source	CHROMA	6590
15	Analyzing AC power supply	TAKASAGO	AA2000XG
16	Inrush current tester	TAKAMISAWA	PSA-210
17	Leakage current tester	HIOKI	3155
18	Current probe	YOKOGAWA	701933

2. CHARACTERISTICS

2-1. Steady state data

(1). Regulation-Line and Load, Temperature drift

12V

1.1 Regulation - Line & Load

CONDITIONS: Ta = 25°C
Iaux=0.5A

	Vin (AC)				
Io	85	100	132	Line Regulation	
0%	12.004	12.004	12.004	0	0
50%	12.002	12.002	12.002	0	0
100%	12.008	12.007	12.006	0.002	0.017
Load Regulation	0.006	0.005	0.004	ΔV(V)	(%)
	0.050	0.042	0.033	(%)	

*Note:Load at 85Vac is derated according to specification

	Vin (AC)					
Io	170	200	230	265	Line Regulation	
0%	12.000	12.000	12.001	12.001	0.001	0.008
50%	11.999	11.999	11.999	11.999	0	0
100%	12.007	12.006	12.006	12.005	0.002	0.017
Load Regulation	0.008	0.007	0.007	0.006	ΔV(V)	(%)
	0.067	0.058	0.058	0.050	(%)	

1.2 Temperature drift

	Ta			Drift (V)	PPM/°C
	-10°C	25°C	50°C		
Vo (V)	11.998	11.998	11.983	0.015	21

CONDITIONS: Vin=230VAC
Vo=12V
Io=133A
Iaux=0.5A

2-1. Steady state data

(1). Regulation-Line and Load, Temperature drift

24V

1.1 Regulation - Line & Load

CONDITIONS: Ta = 25°C
Iaux=0.5A

	Vin (AC)				
Io	85	100	132	Line Regulation	
0%	24.005	24.003	24.003	0.002	0.008
50%	23.983	23.983	23.984	0.001	0.004
100%	23.989	23.988	23.989	0.001	0.004
Load Regulation	0.022	0.020	0.019	ΔV(V)	(%)
	0.092	0.083	0.079	(%)	

*Note:Load at 85Vac is derated according to specification

	Vin (AC)					
Io	170	200	230	265	Line Regulation	
0%	24.003	24.003	24.003	24.003	0	0
50%	23.987	23.988	23.988	23.988	0.001	0.004
100%	23.999	24.001	24.002	24.003	0.004	0.017
Load Regulation	0.016	0.015	0.015	0.015	ΔV(V)	(%)
	0.067	0.063	0.063	0.063	(%)	

1.2 Temperature drift

	Ta			Drift (V)	PPM/°C
	-10°C	25°C	50°C		
Vo (V)	23.983	23.971	23.943	0.040	28

CONDITIONS: Vin=230VAC
Vo=24V
Io=67A
Iaux=0.5A

2-1. Steady state data

(1). Regulation-Line and Load, Temperature drift

32V

1.1 Regulation - Line & Load

CONDITIONS: Ta = 25°C
Iaux=0.5A

	Vin (AC)				
Io	85	100	132	Line Regulation	
0%	32.007	32.007	32.007	0	0
50%	32.011	32.010	32.009	0.001	0.002
100%	32.020	32.020	32.019	0.003	0.006
Load Regulation	0.013	0.013	0.012	ΔV(V)	(%)
	0.041	0.041	0.038	(%)	

*Note:Load at 85Vac is derated according to specification

	Vin (AC)					
Io	170	200	230	265	Line Regulation	
0%	32.007	32.007	32.007	32.007	0.001	0.002
50%	32.011	32.010	32.009	32.008	0.002	0.004
100%	32.042	32.039	32.037	32.036	0.003	0.006
Load Regulation	0.035	0.032	0.030	0.029	ΔV(V)	(%)
	0.109	0.100	0.094	0.091	(%)	

1.2 Temperature drift

	Ta			Drift (V)	PPM/°C
	-10°C	25°C	50°C		
Vo (V)	32.048	32.032	31.975	0.073	38

CONDITIONS: Vin=230VAC
Vo=48V
Io=33A
Iaux=0.5A

2-1. Steady state data

(1). Regulation-Line and Load, Temperature drift

48V

1.1 Regulation - Line & Load

CONDITIONS: Ta = 25°C
Iaux=0.5A

	Vin (AC)				
Io	85	100	132	Line Regulation	
0%	47.998	47.998	47.998	0	0
50%	48.011	48.011	48.01	0.001	0.002
100%	48.018	48.017	48.015	0.003	0.006
Load Regulation	0.020	0.019	0.017	ΔV(V)	(%)
	0.042	0.040	0.035	(%)	

*Note:Load at 85Vac is derated according to specification

	Vin (AC)					
Io	170	200	230	265	Line Regulation	
0%	47.989	47.989	47.988	47.988	0.001	0.002
50%	48.019	48.018	48.017	48.017	0.002	0.004
100%	48.041	48.04	48.039	48.038	0.003	0.006
Load Regulation	0.052	0.051	0.051	0.050	ΔV(V)	(%)
	0.108	0.106	0.106	0.104	(%)	

1.2 Temperature drift

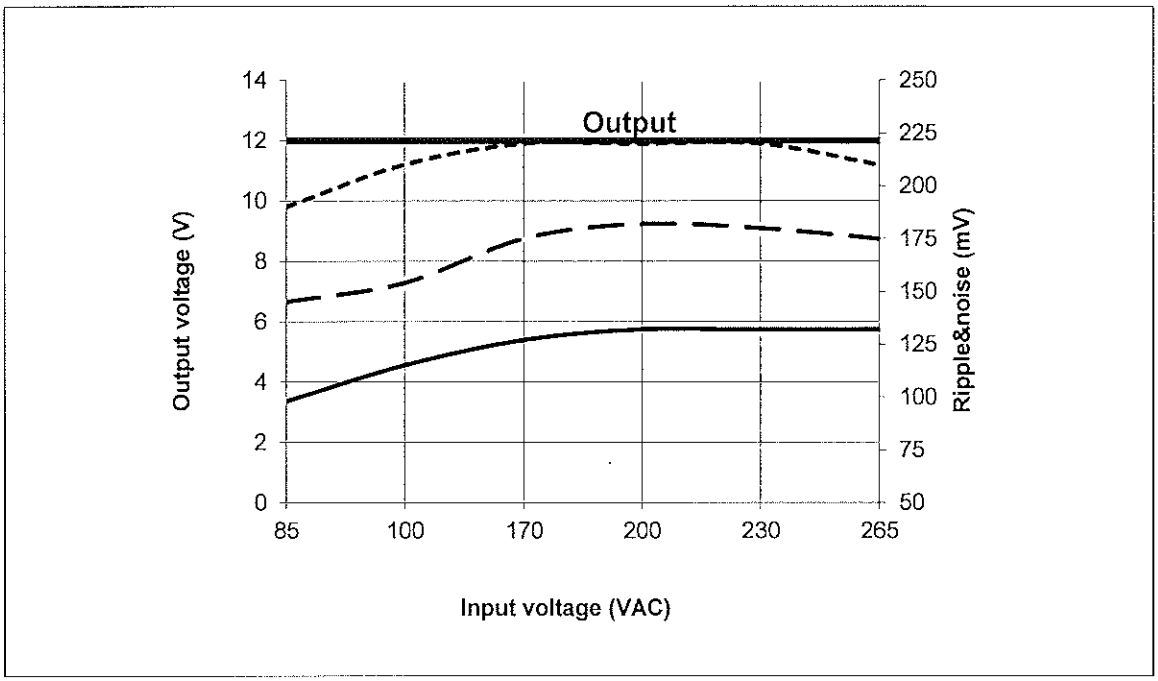
	Ta			Drift (V)	PPM/°C
	-10°C	25°C	50°C		
Vo (V)	48.243	48.180	48.052	0.191	66

CONDITIONS: Vin=230VAC
Vo=48V
Io=33A
Iaux=0.5A

(2). Output ripple Vs Input and Output Voltages

CONDITIONS: Iout:100%
Ta: -10°C
25°C
50°C

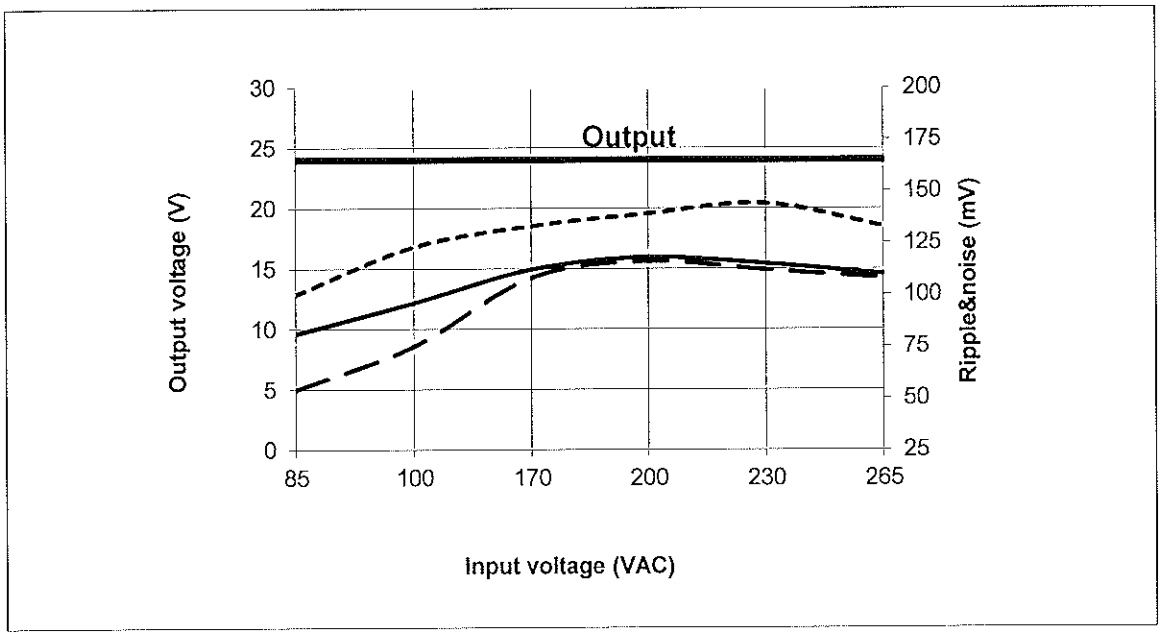
12V



(2). Output ripple Vs Input and Output Voltages

CONDITIONS: Iout:100%
Ta: -10°C
25°C
50°C

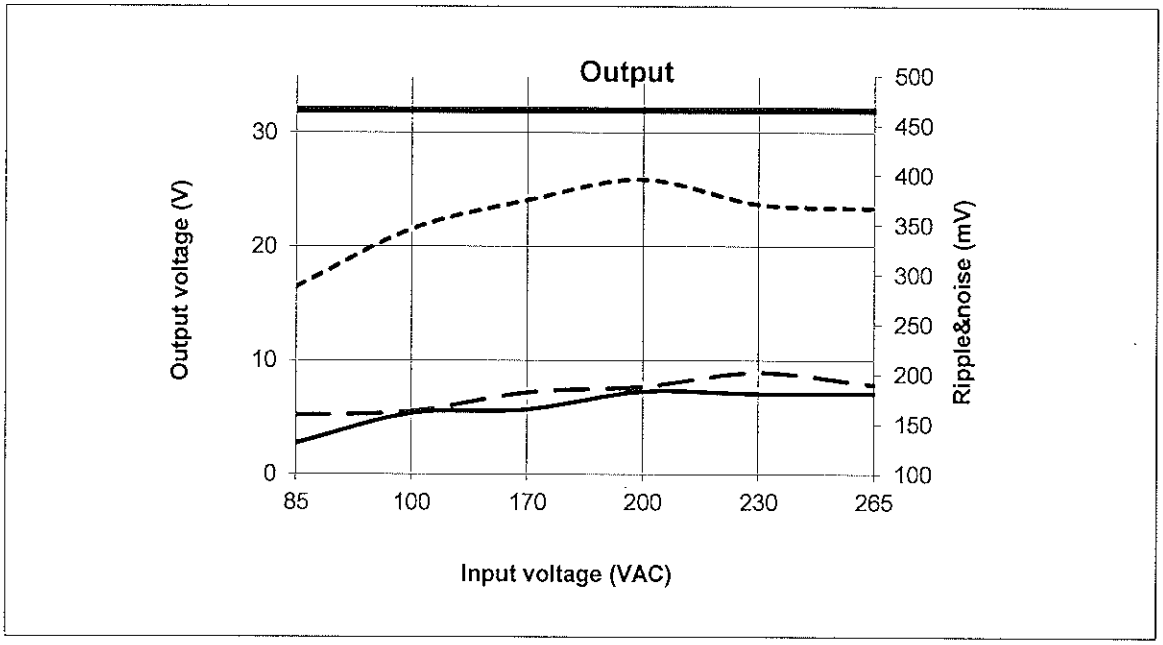
24V



(2). Output ripple Vs Input and Output Voltages

CONDITIONS: Iout:100%
Ta: -10°C
25°C
50°C

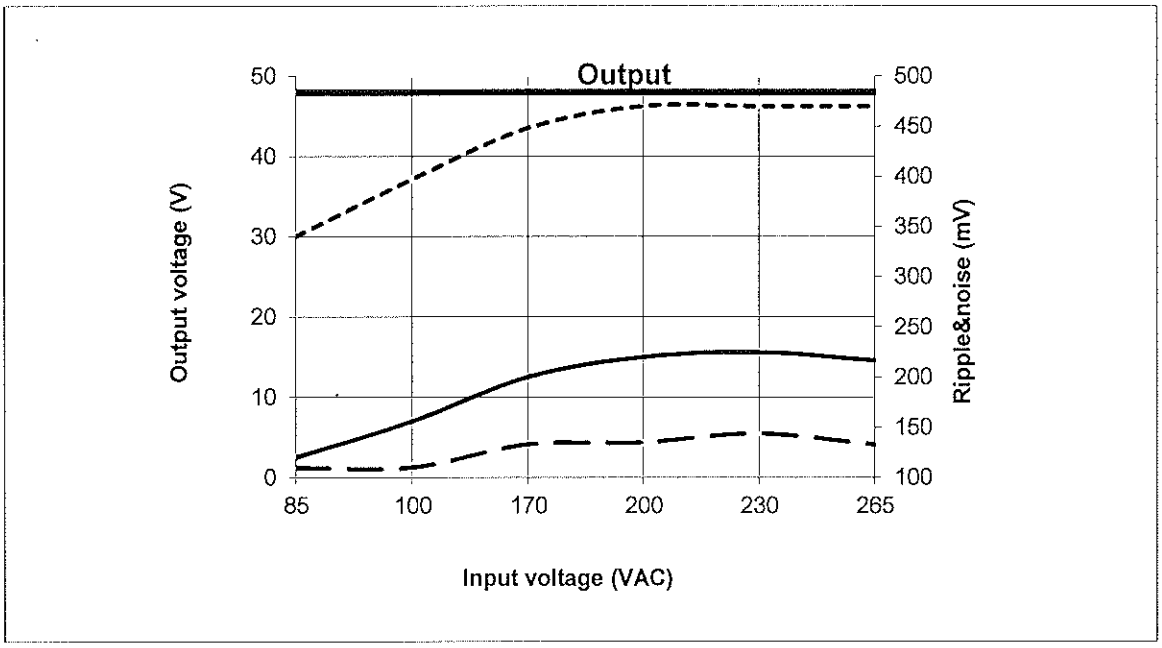
32V



(2). Output ripple Vs Input and Output Voltages

CONDITIONS: Iout:100%
Ta: -10°C
25°C
50°C

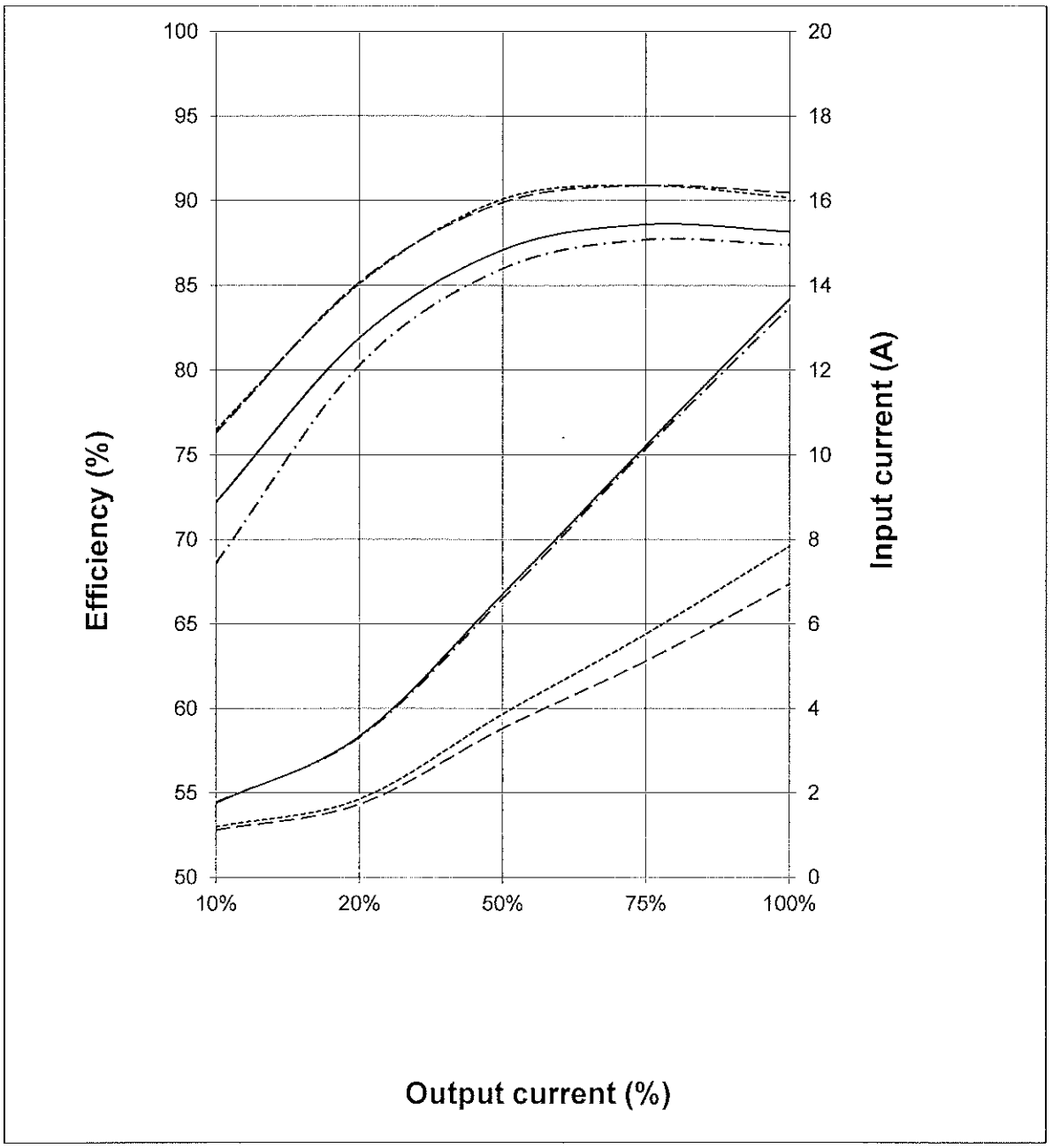
48V



(3). Efficiency and Input current vs. Output current

CONDITIONS:
Vin: 85 VAC
115 VAC
230 VAC
265 VAC
Vout:100%
Ta: 25˚C

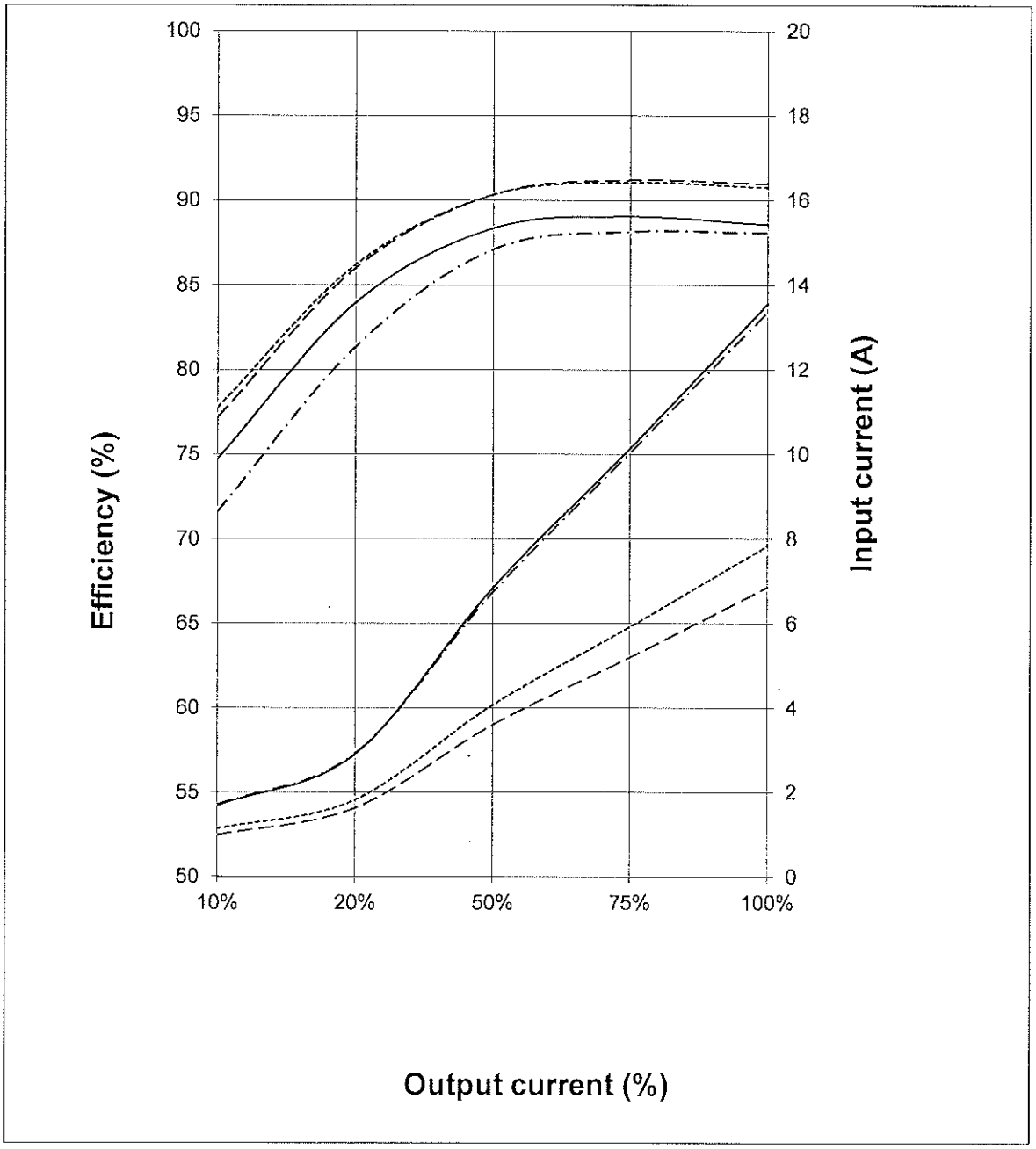
12V



(3). Efficiency and Input current vs. Output current

CONDITIONS:
Vin: 85 VAC
115 VAC
230 VAC
265 VAC
Vout:100%
Ta: 25˚C

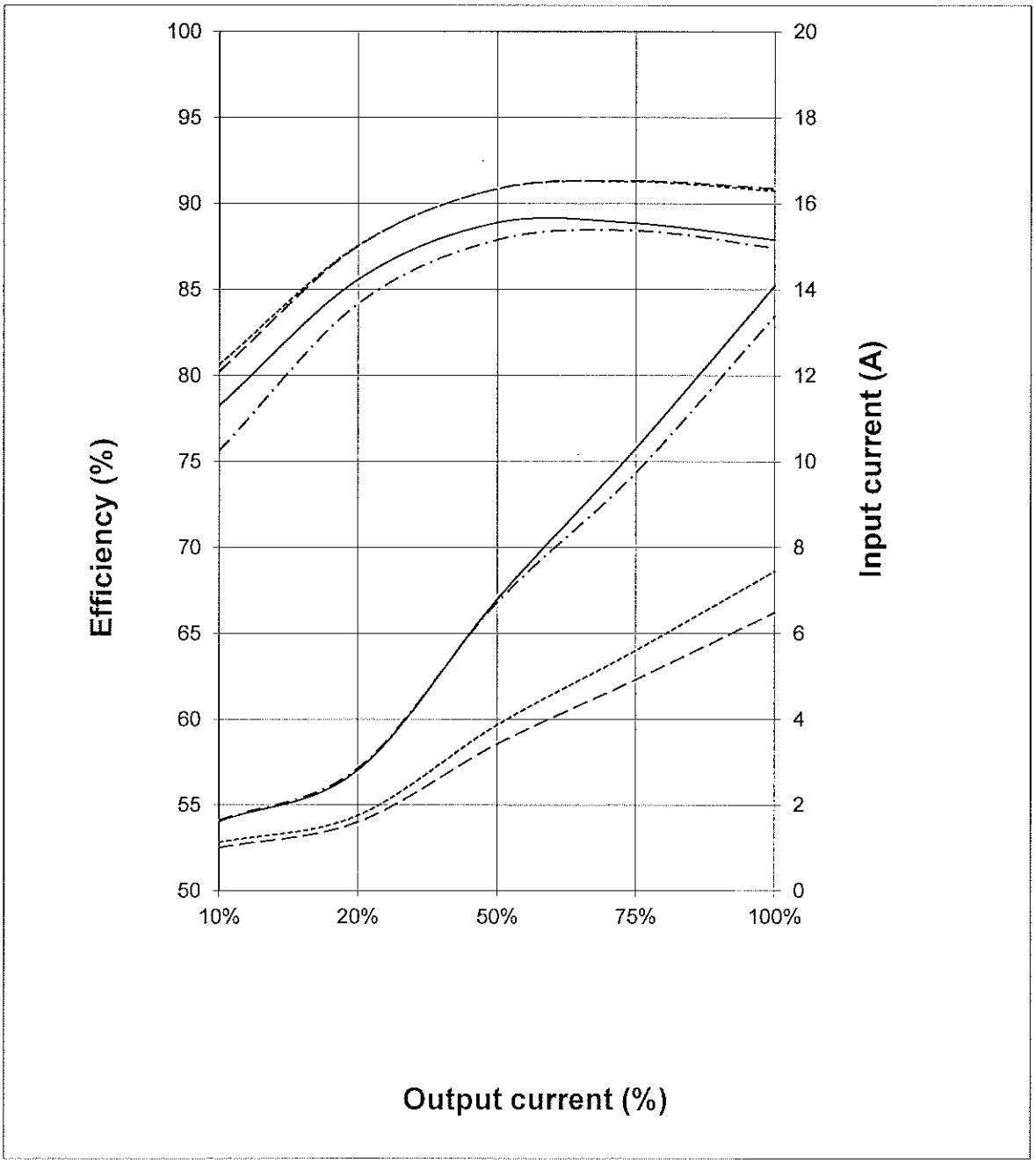
24V



(3). Efficiency and Input current vs. Output current

CONDITIONS:
Vin: 85 VAC
115 VAC
230 VAC
265 VAC
Vout:100%
Ta: 25˚C

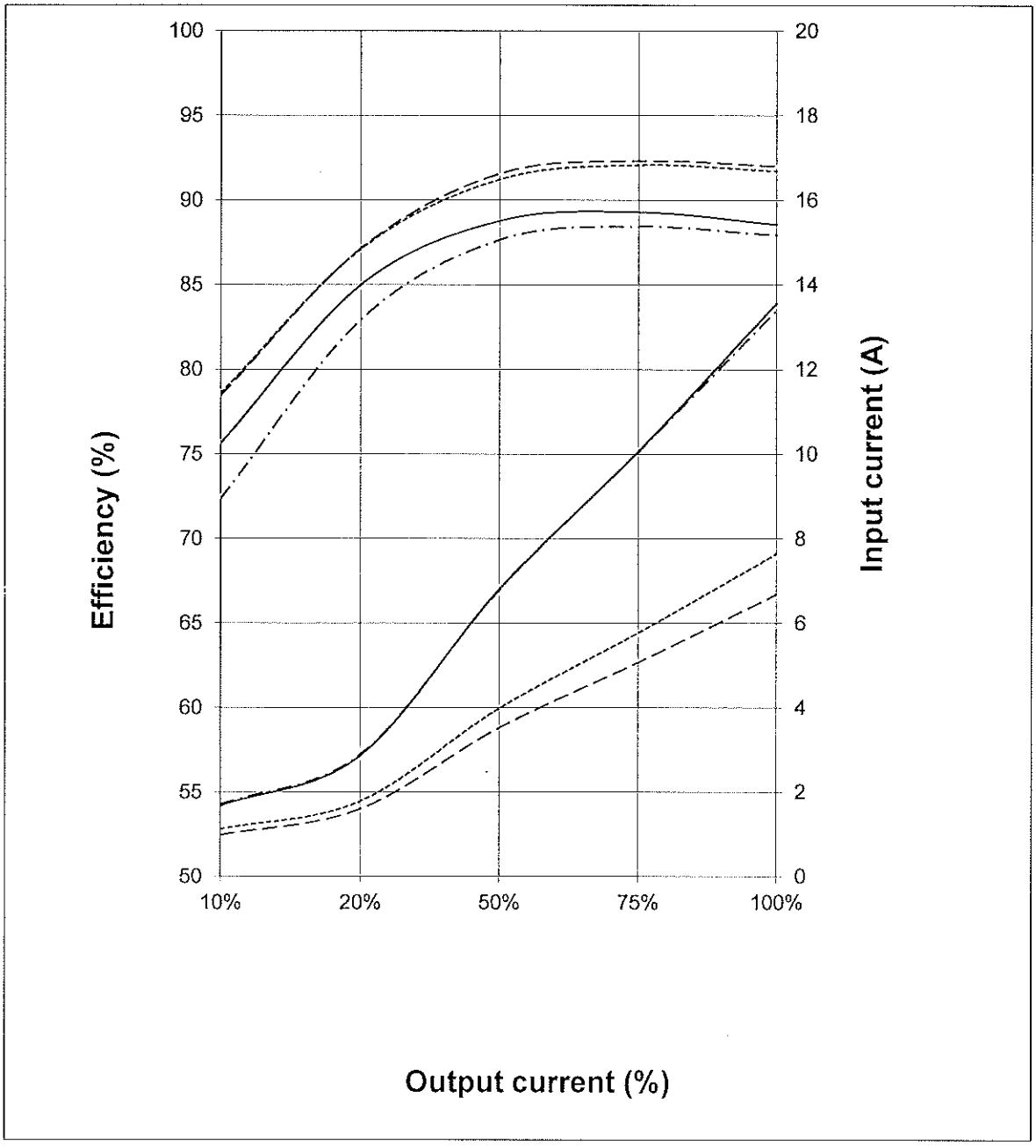
32V



(3). Efficiency and Input current vs. Output current

CONDITIONS: Vin: 85 VAC
115 VAC
230 VAC
265 VAC
Vout:100%
Ta: 25°C

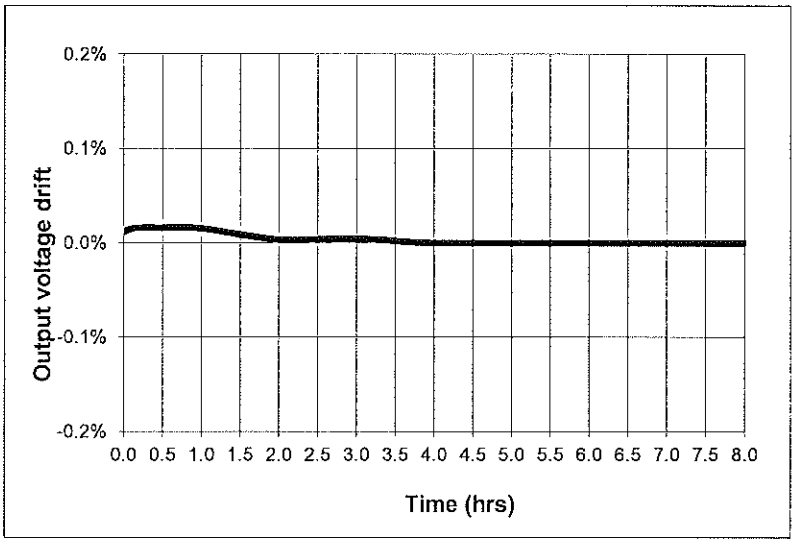
48V



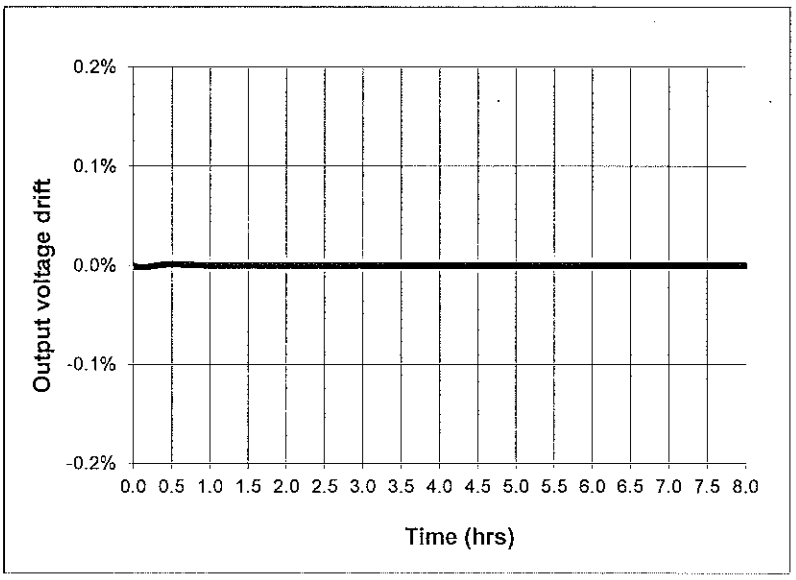
2.2. Warm up voltage drift characteristics

CONDITIONS: Vin: 230Vac
Iout: 100%
Ta = 25°C

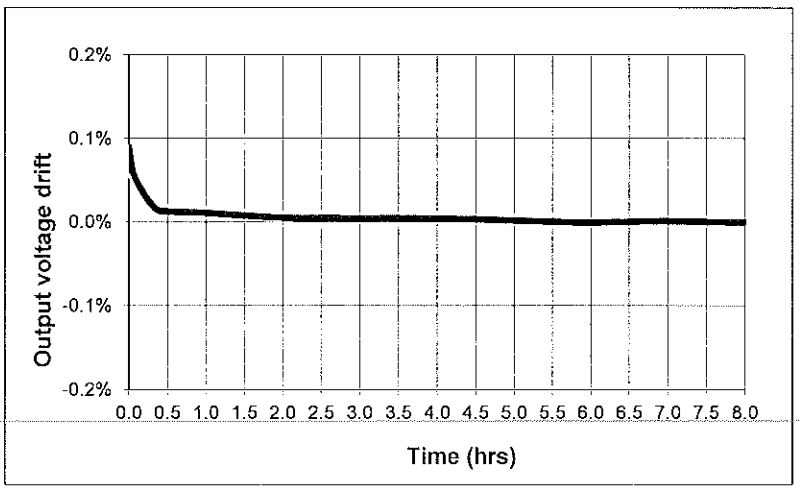
12V



24V



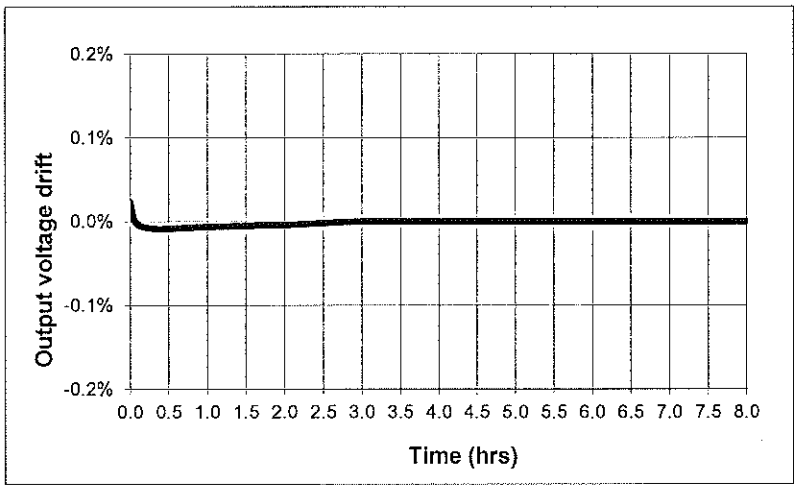
32V



2.2. Warm up voltage drift characteristics

CONDITIONS: Vin: 230Vac
Iout: 100%
Ta = 25°C

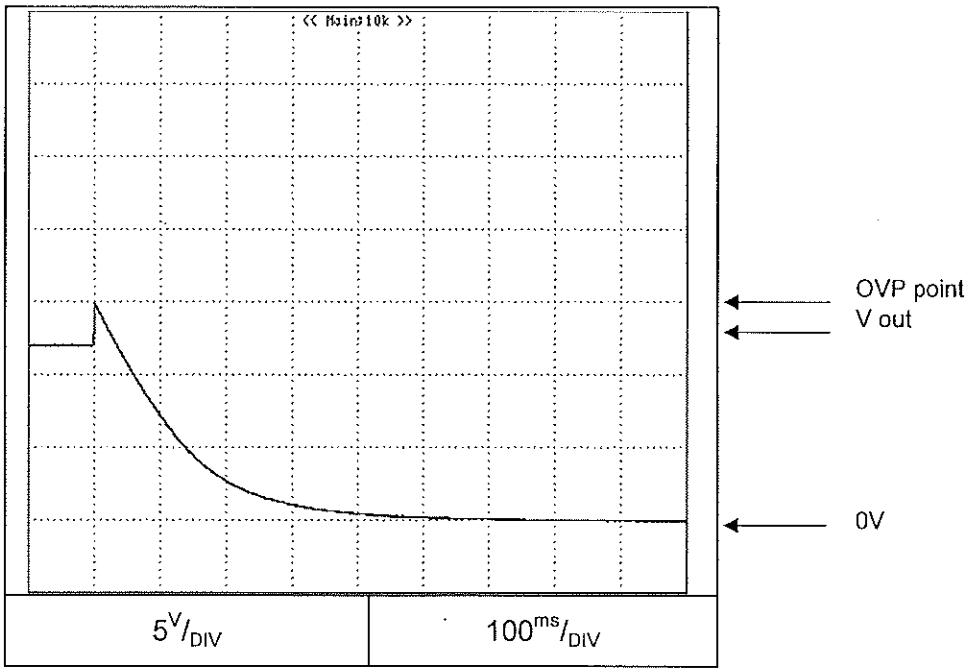
48V



2.3. Over Voltage protection (OVP) characteristics

CONDITIONS: Vin: 230Vac
Vout: 12Vdc
Iout: 0%
Ta = 25°C

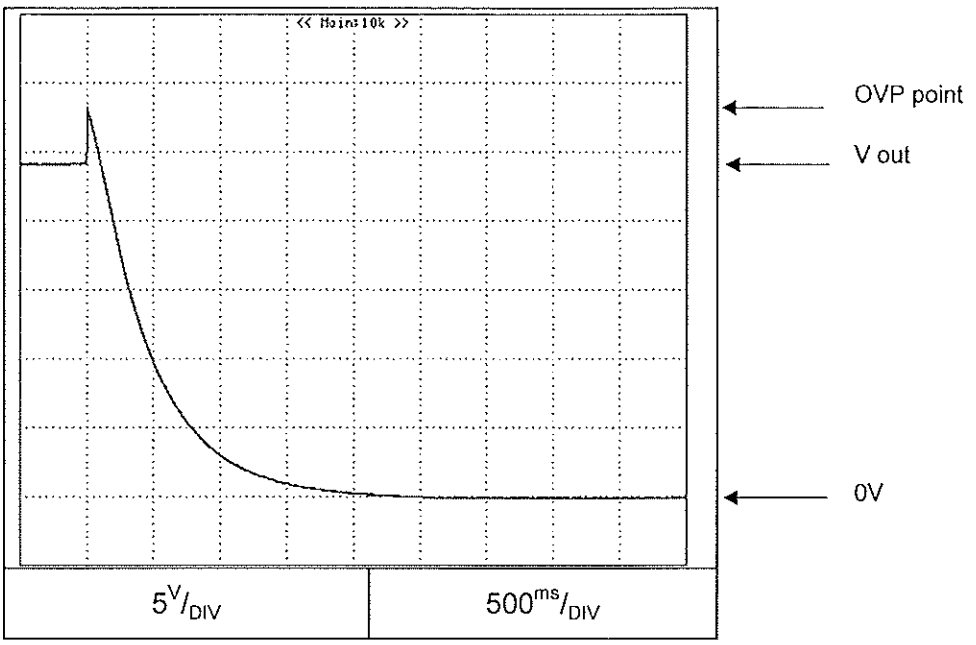
12V



2.3. Over Voltage protection (OVP) characteristics

CONDITIONS: Vin: 230Vac
Vout: 24Vdc
Iout: 0%
Ta = 25°C

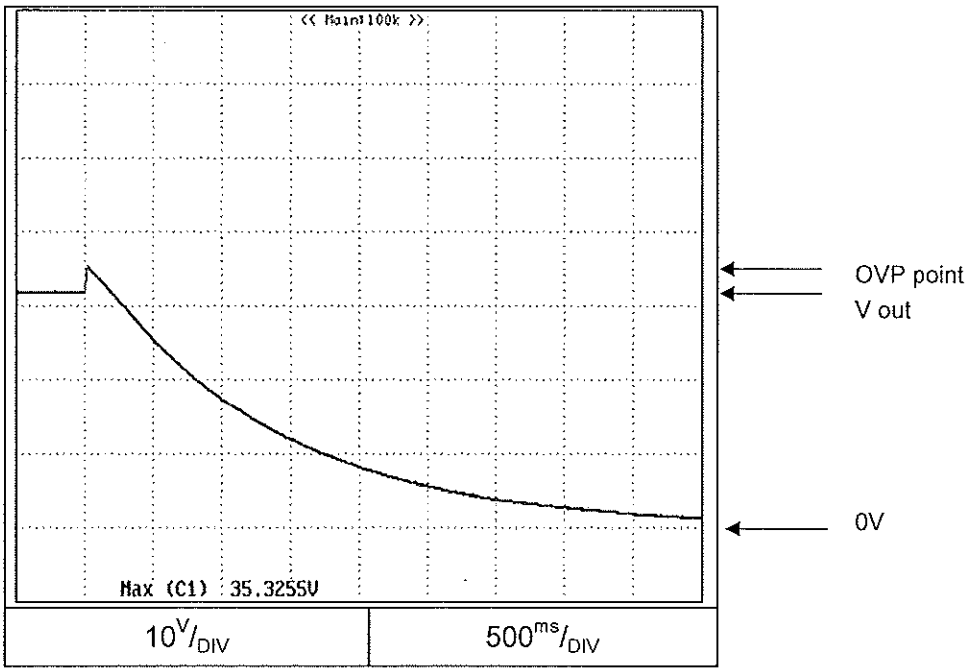
24V



2.3. Over Voltage protection (OVP) characteristics

CONDITIONS: Vin: 230Vac
Vout: 32Vdc
Iout: 0%
Ta = 25°C

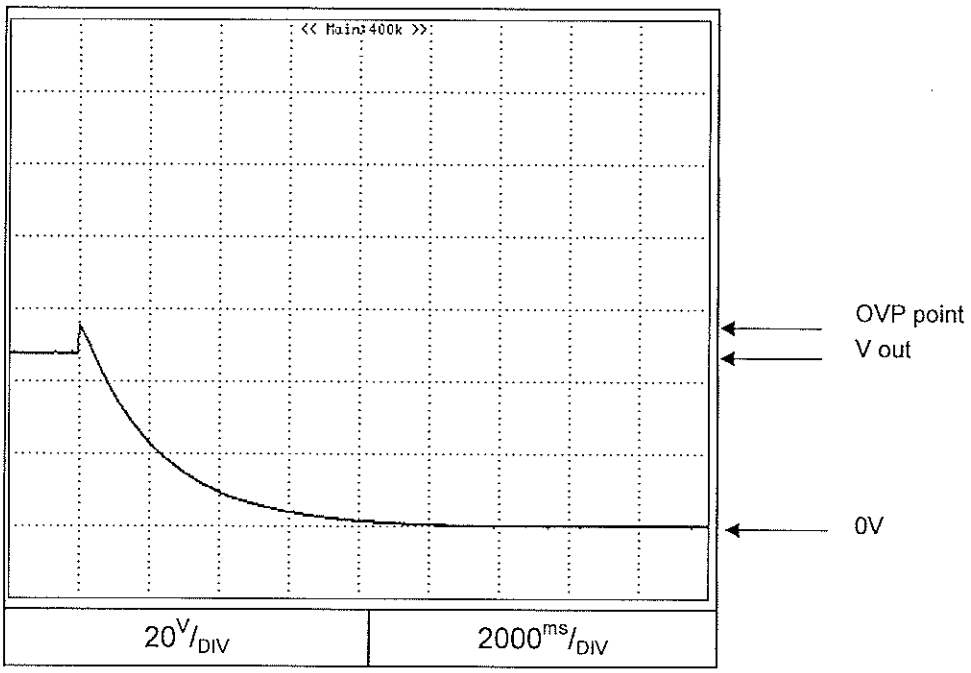
32V



2.3. Over Voltage protection (OVP) characteristics

CONDITIONS: Vin: 230Vac
Vout: 48Vdc
Iout: 0%
Ta = 25°C

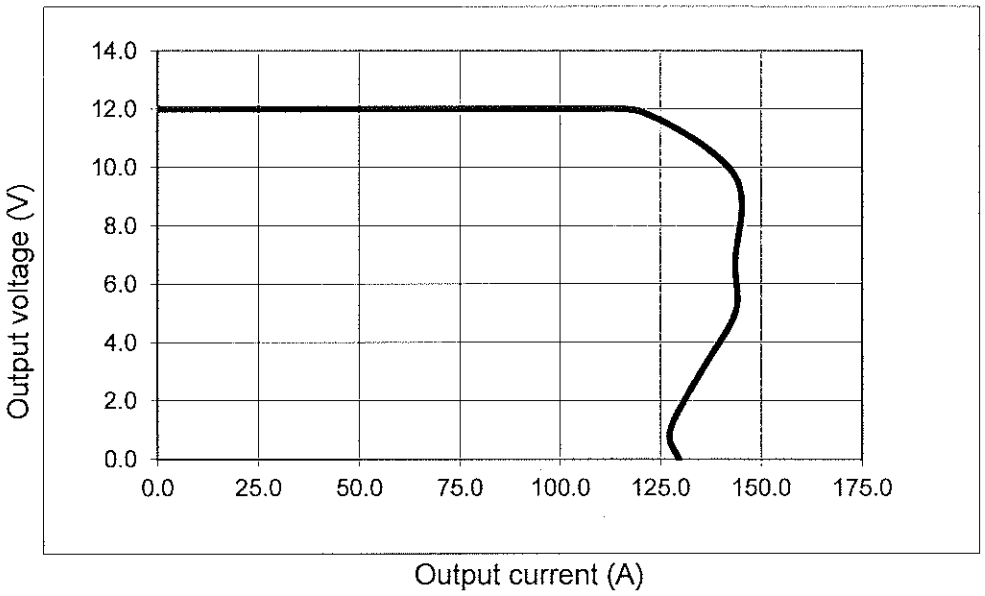
48V



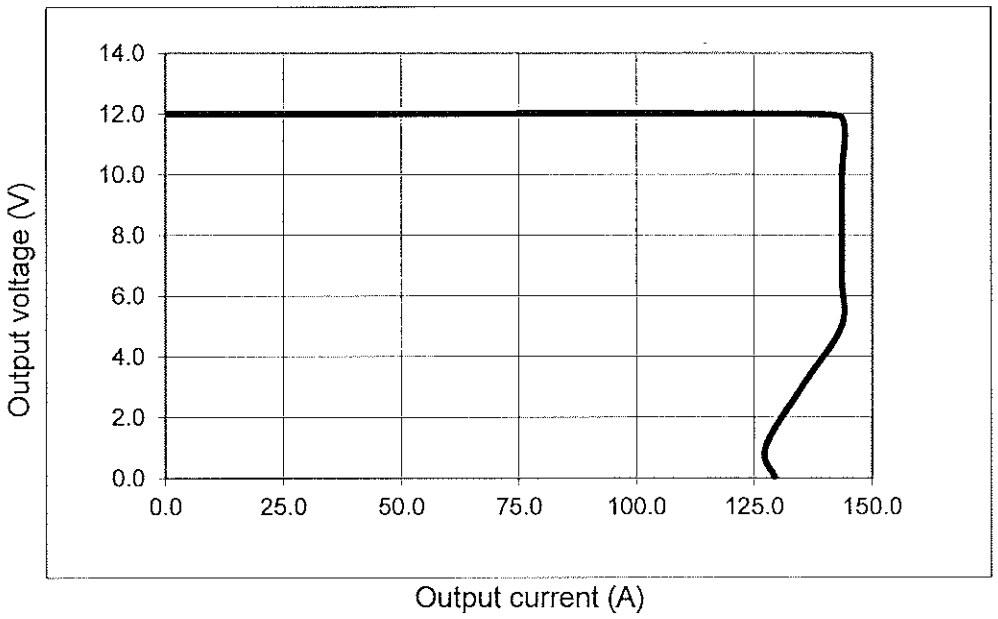
2.4. Over Current protection (OCP) characteristics

CONDITIONS: Vin: 115Vac
Ta = 25°C

12V



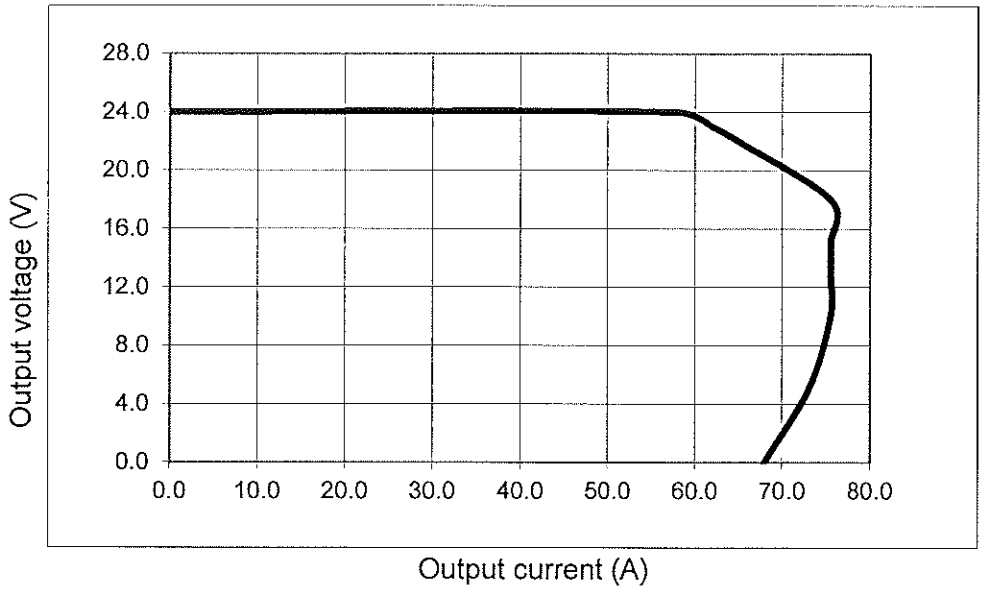
CONDITIONS: Vin: 230Vac
Ta = 25°C



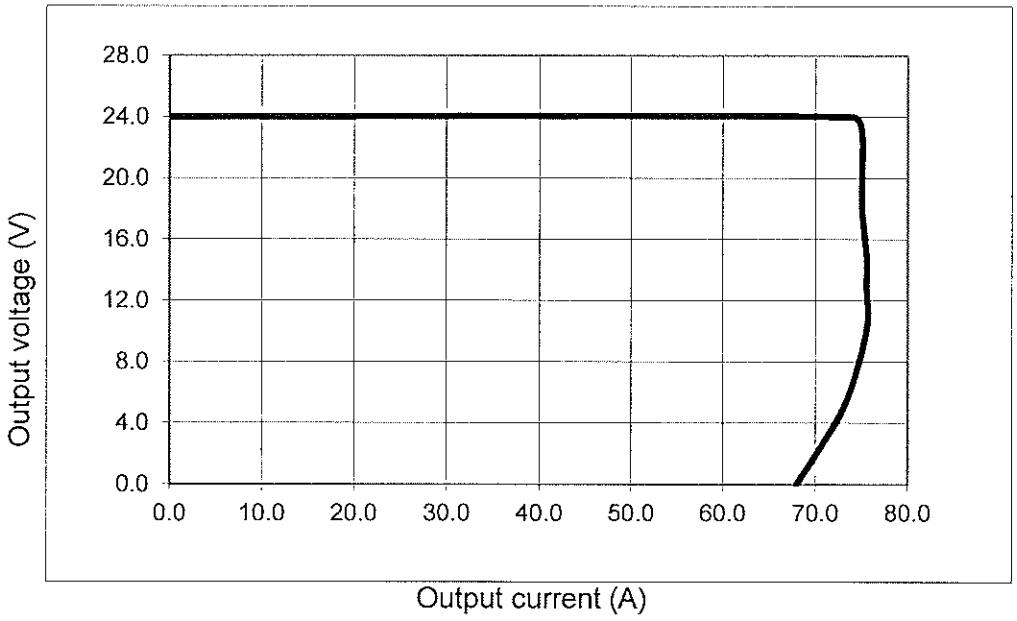
2.4. Over Current protection (OCP) characteristics

24V

CONDITIONS: Vin: 115Vac
Ta = 25°C



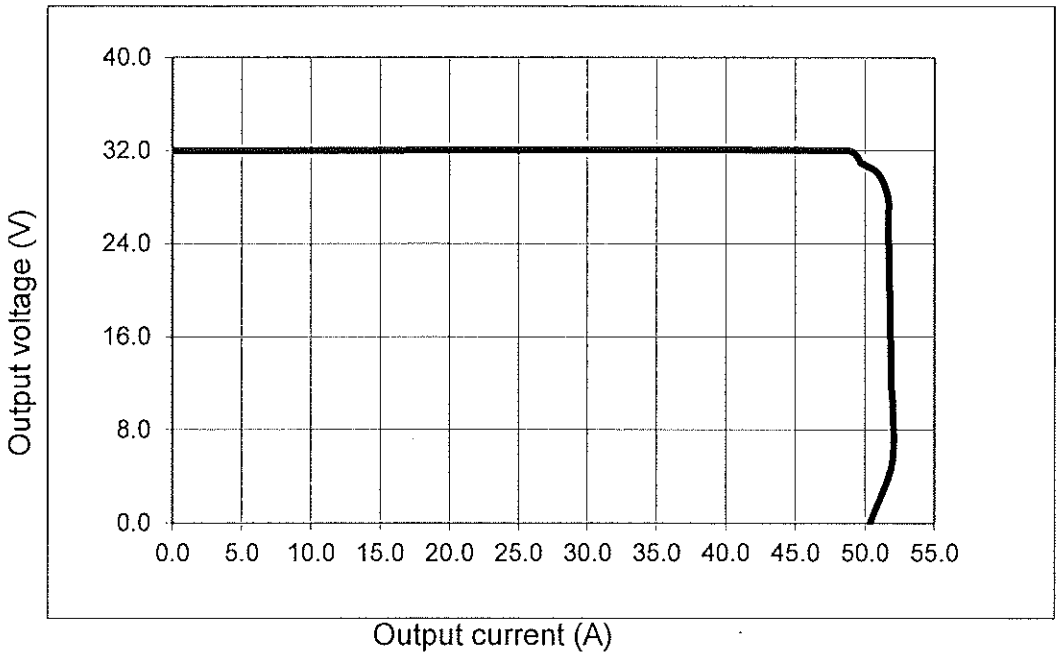
CONDITIONS: Vin: 230Vac
Ta = 25°C



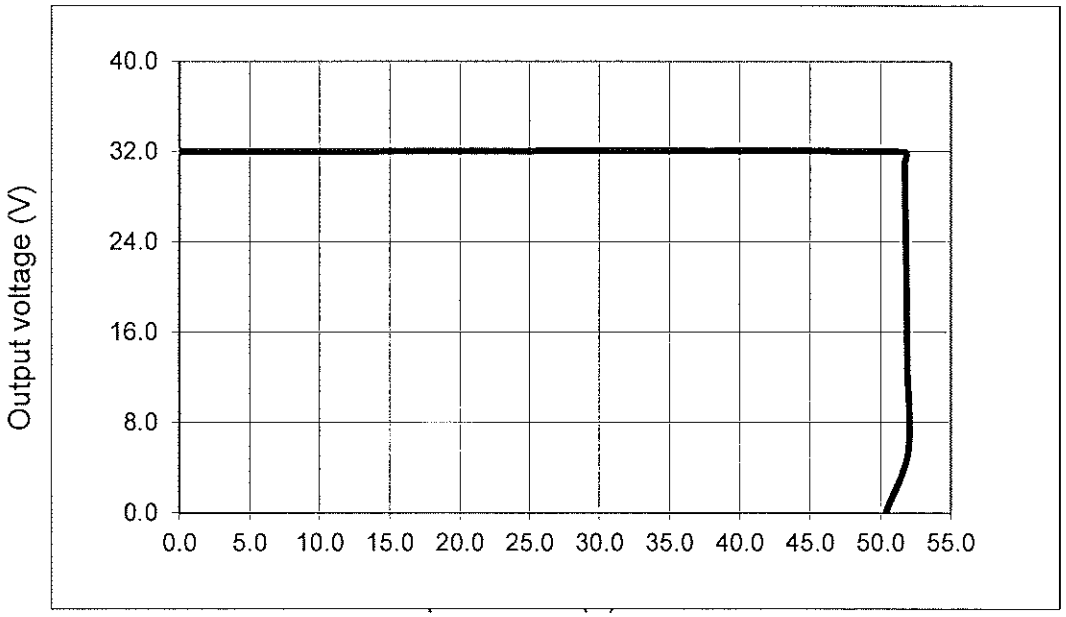
2.4. Over Current protection (OCP) characteristics

CONDITIONS: Vin: 115Vac
Ta = 25°C

32V



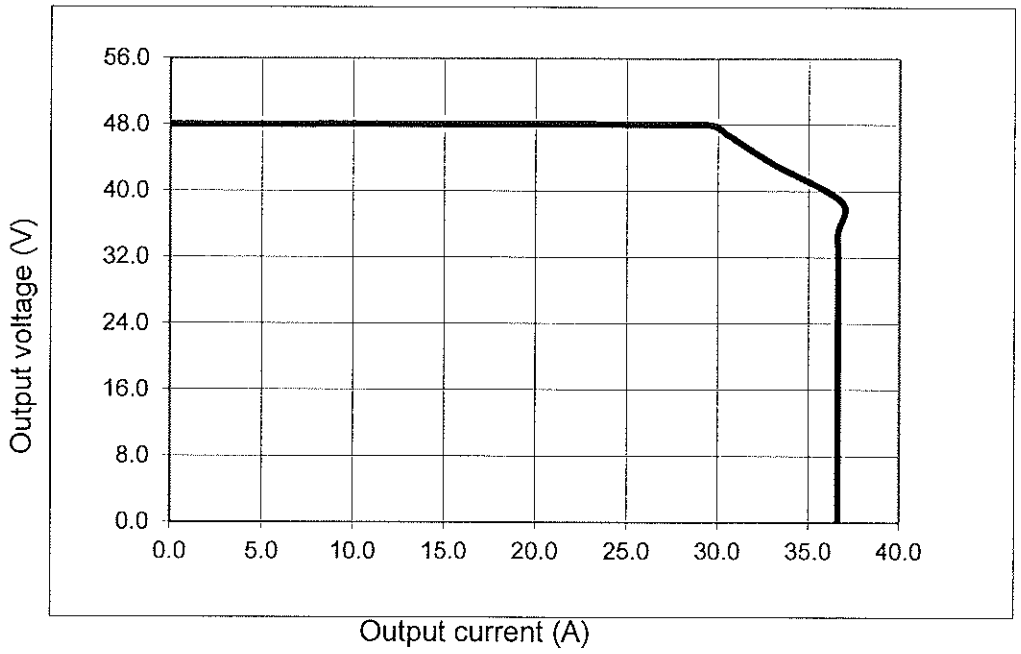
CONDITIONS: Vin: 230Vac
Ta = 25°C



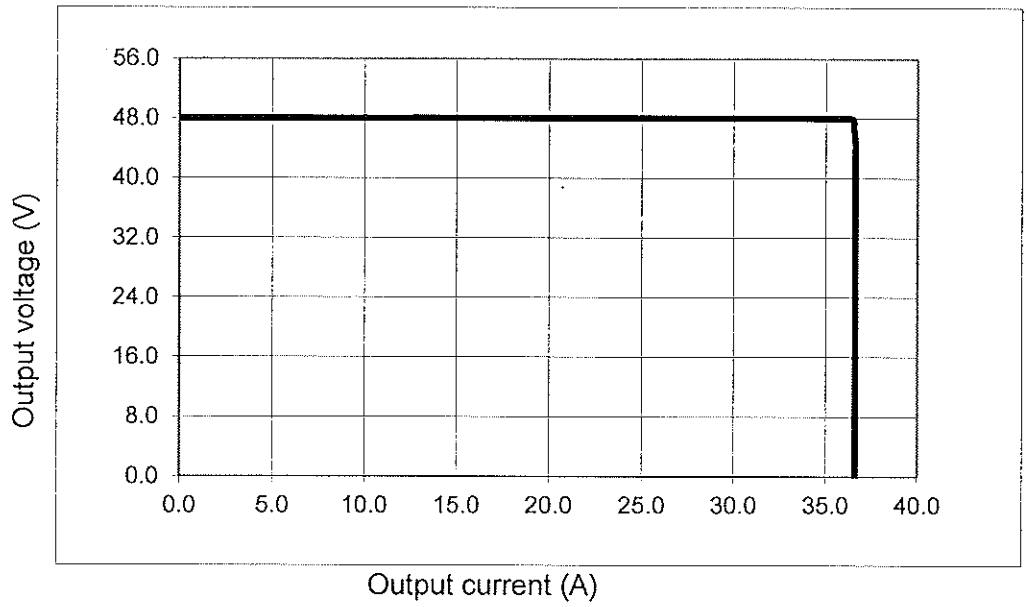
2.4. Over Current protection (OCP) characteristics

48V

CONDITIONS: Vin: 115Vac
Ta = 25°C



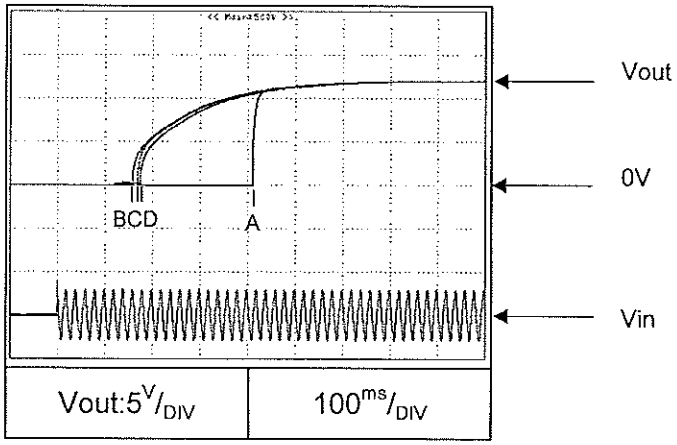
CONDITIONS: Vin: 230Vac
Ta = 25°C



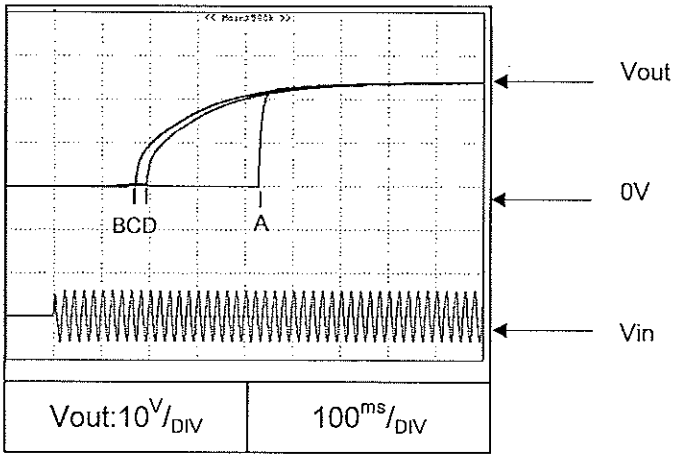
2.5. Output rise characteristics

CONDITIONS: Vin: 85 VAC (A)
115 VAC (B)
230 VAC (C)
265 VAC (D)
Iout: 0%
Ta: 25°C

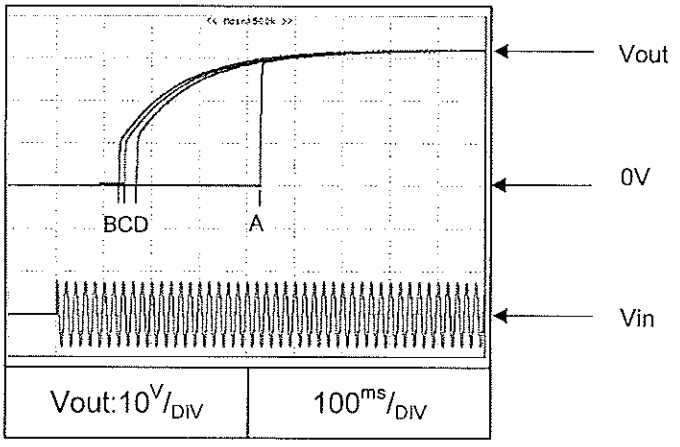
12V



24V



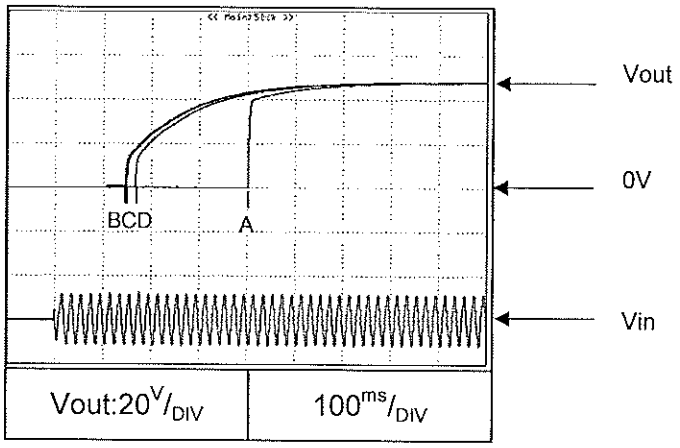
32V



2.5. Output rise characteristics

CONDITIONS: Vin: 85 VAC (A)
115 VAC (B)
230 VAC (C)
265 VAC (D)
Iout: 0%
Ta: 25˚C

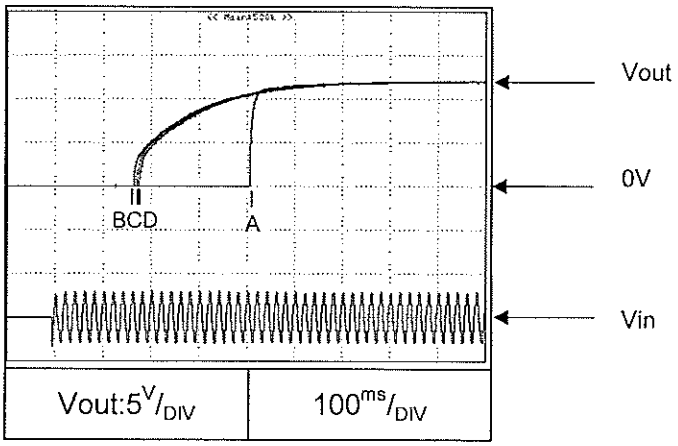
48V



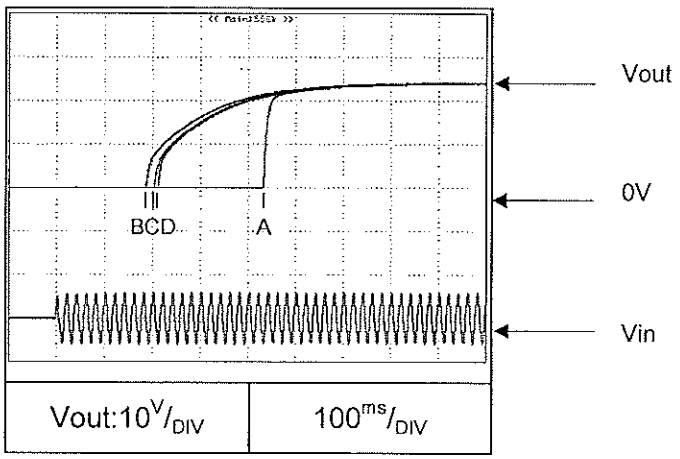
2.5. Output rise characteristics

CONDITIONS: Vin: 85 VAC (A)
115 VAC (B)
230 VAC (C)
265 VAC (D)
Iout: 100%
Ta: 25˚C

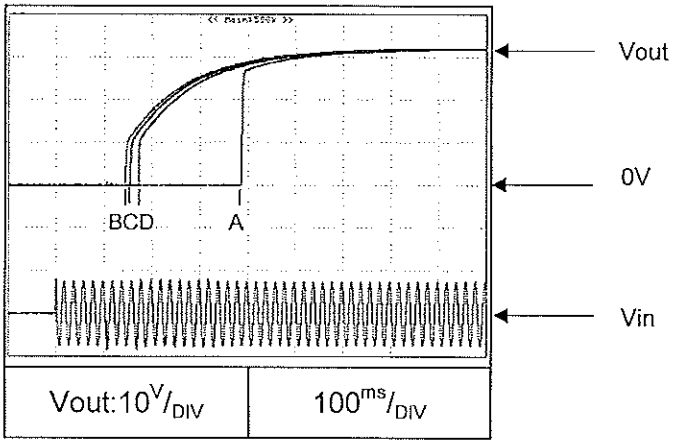
12V



24V



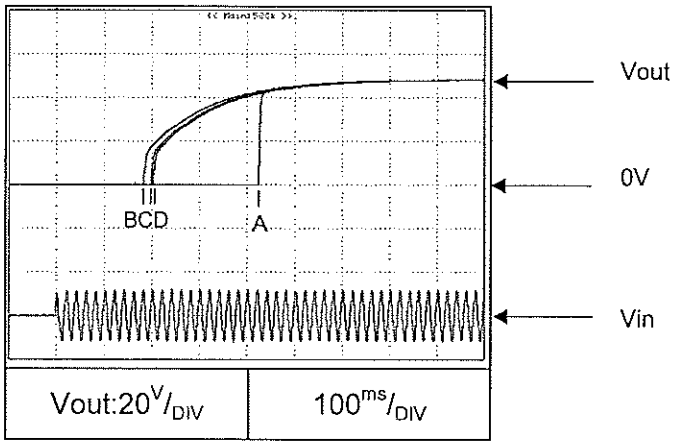
32V



2.5. Output rise characteristics

CONDITIONS: Vin: 85 VAC (A)
115 VAC (B)
230 VAC (C)
265 VAC (D)
Iout: 100%
Ta: 25˚C

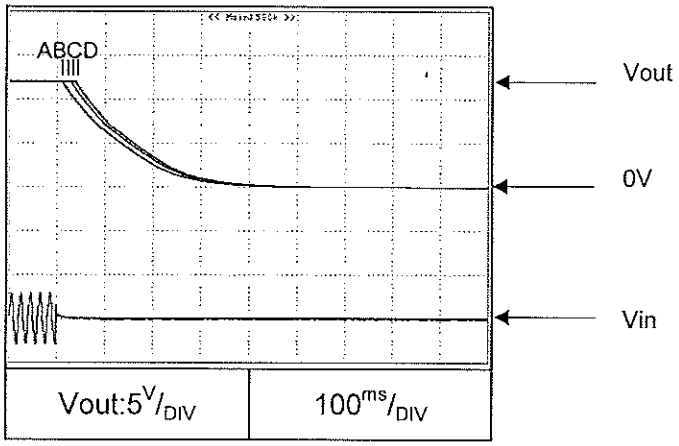
48V



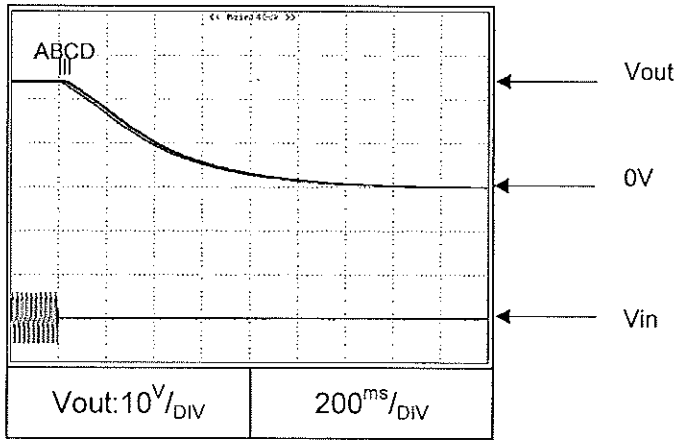
2.6. Output fall characteristics

CONDITIONS: Vin: 85 VAC (A)
115 VAC (B)
230 VAC (C)
265 VAC (D)
Iout: 0%
Ta: 25°C

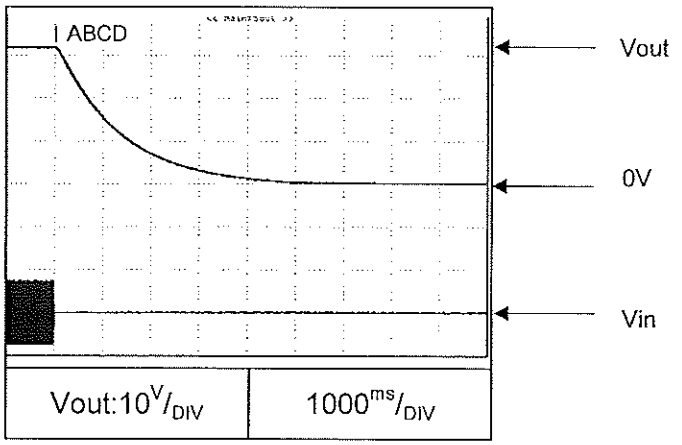
12V



24V



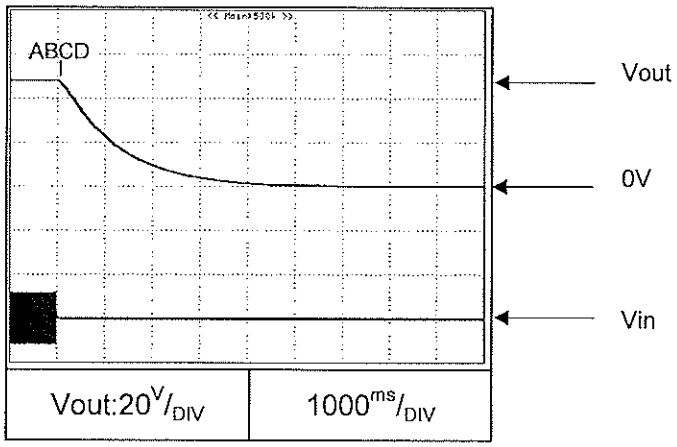
32V



2.6. Output fall characteristics

CONDITIONS: Vin: 85 VAC (A)
115 VAC (B)
230 VAC (C)
265 VAC (D)
Iout: 0%
Ta: 25˚C

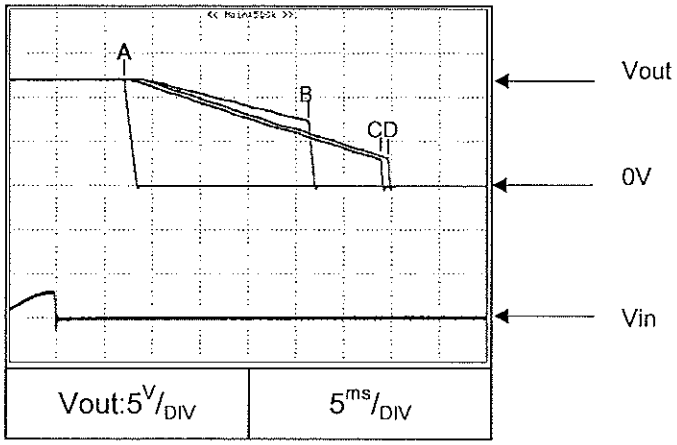
48V



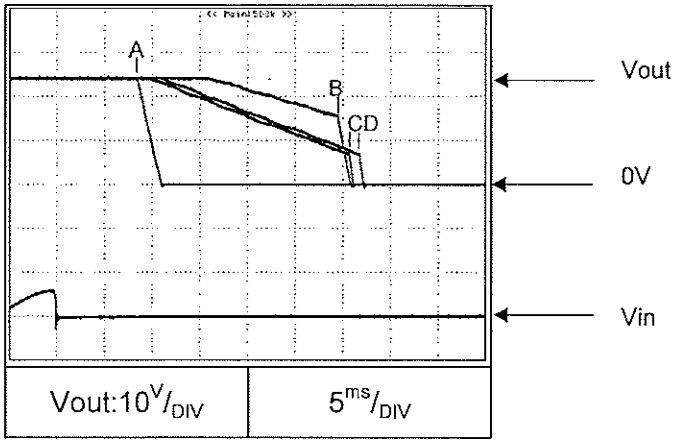
2.6. Output fall characteristics

CONDITIONS: Vin: 85 VAC (A)
115 VAC (B)
230 VAC (C)
265 VAC (D)
Iout: 100%
Ta: 25°C

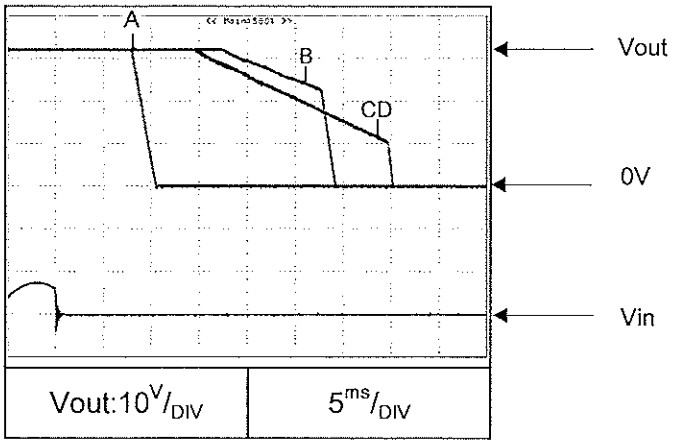
12V



24V



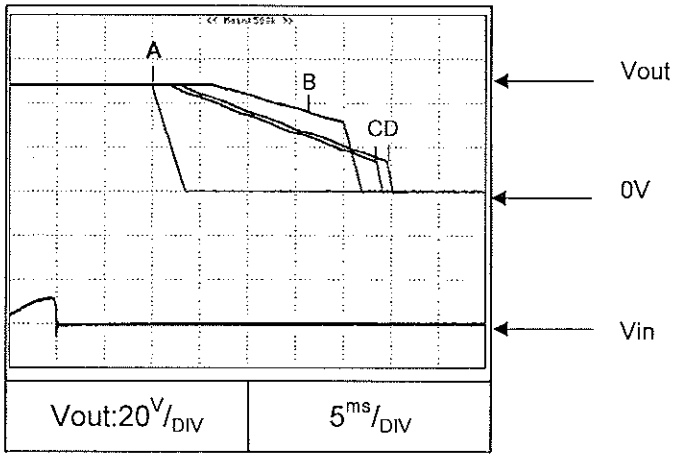
32V



2.6. Output fall characteristics

CONDITIONS: Vin: 85 VAC (A)
115 VAC (B)
230 VAC (C)
265 VAC (D)
Iout: 100%
Ta: 25˚C

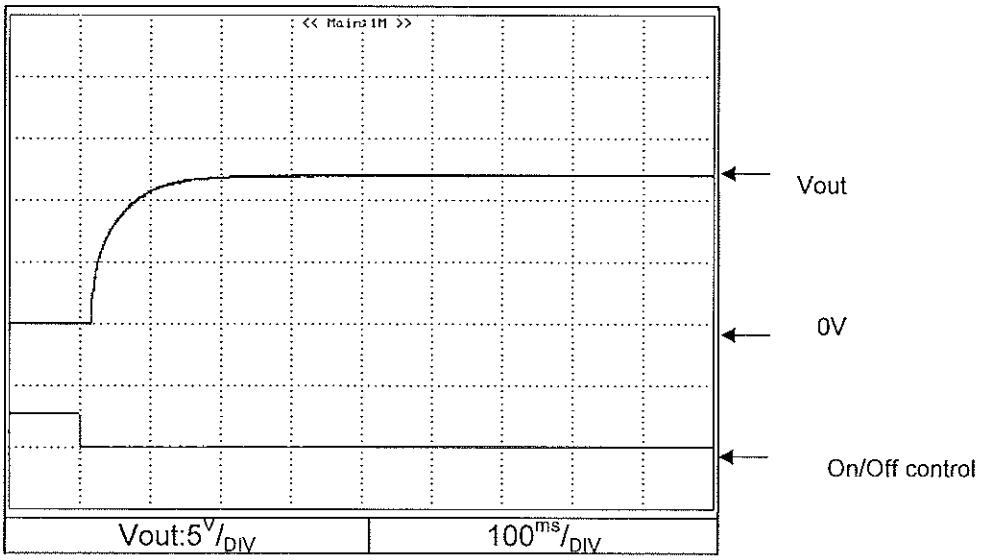
48V



2.7. Output rise characteristics with On/Off control

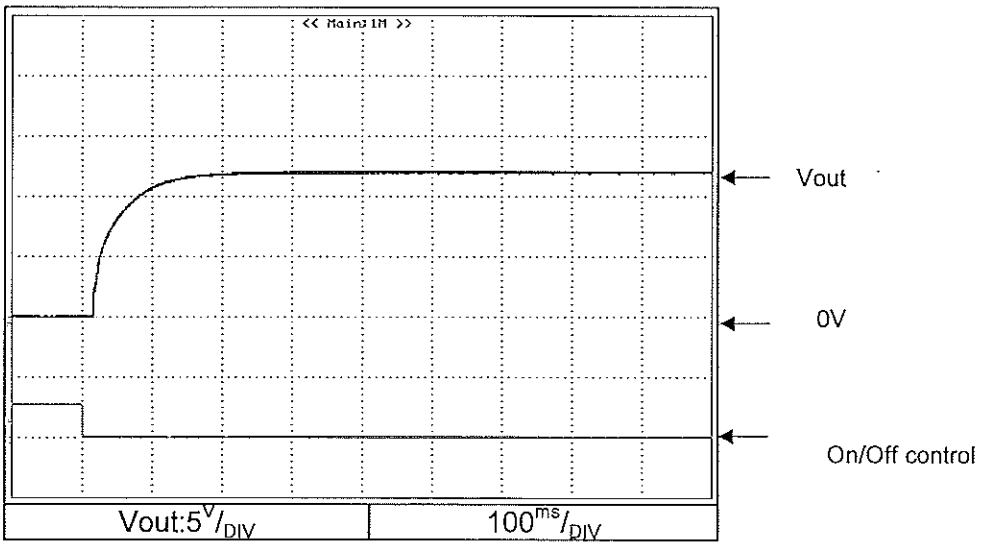
CONDITIONS: Vin: 115 VAC
Iout: 100%
Ta: 25°C

12V



CONDITIONS: Vin: 230 VAC
Iout: 100%
Ta: 25°C

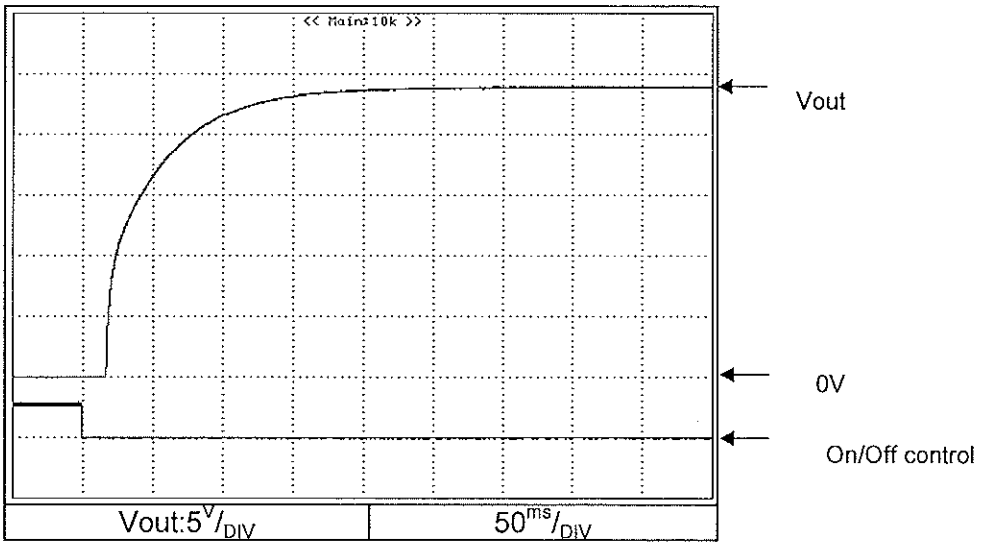
12V



2.7. Output rise characteristics with On/Off control

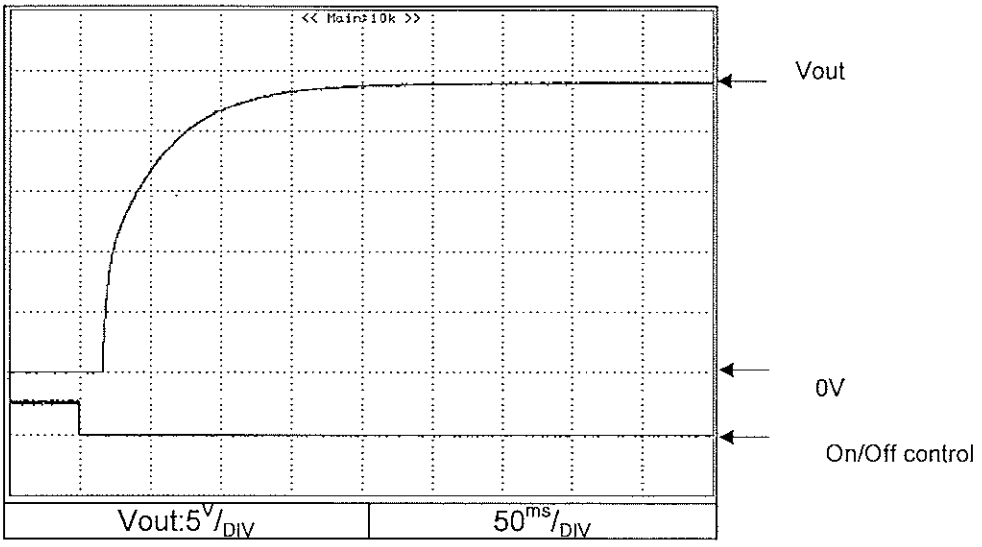
CONDITIONS: Vin: 115 VAC
Iout: 100%
Ta: 25°C

24V



CONDITIONS: Vin: 230 VAC
Iout: 100%
Ta: 25°C

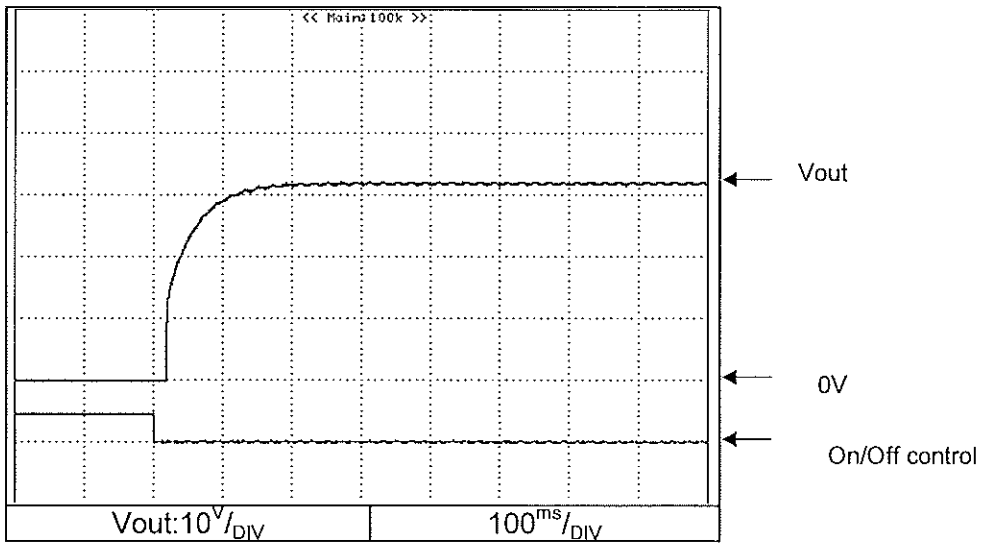
24V



2.7. Output rise characteristics with On/Off control

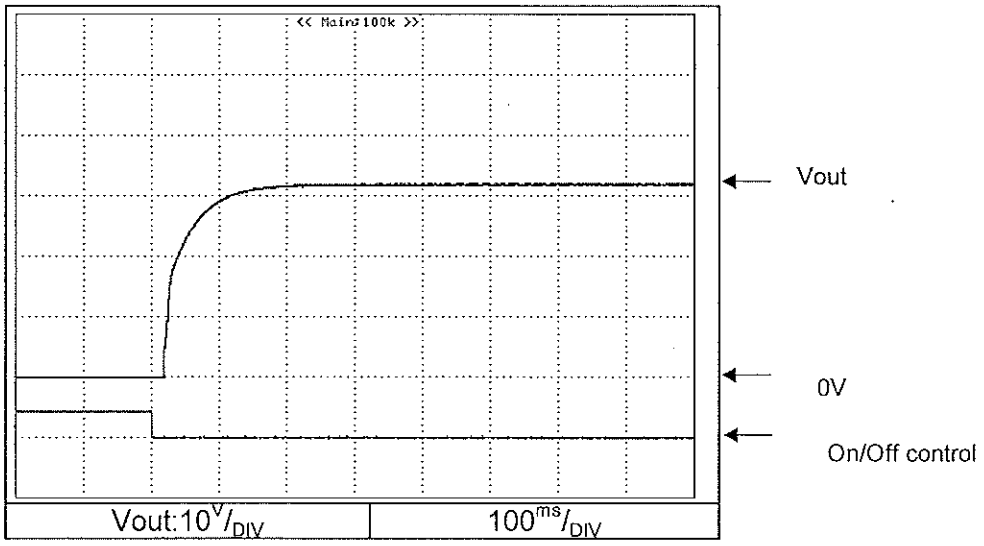
CONDITIONS: Vin: 115 VAC
Iout: 100%
Ta: 25˚C

32V



CONDITIONS: Vin: 230 VAC
Iout: 100%
Ta: 25˚C

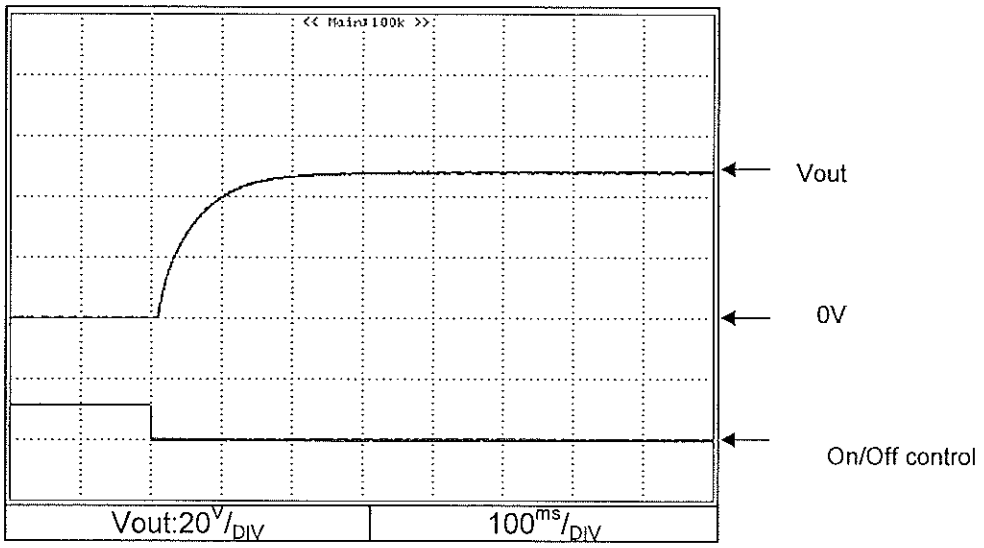
32V



2.7. Output rise characteristics with On/Off control

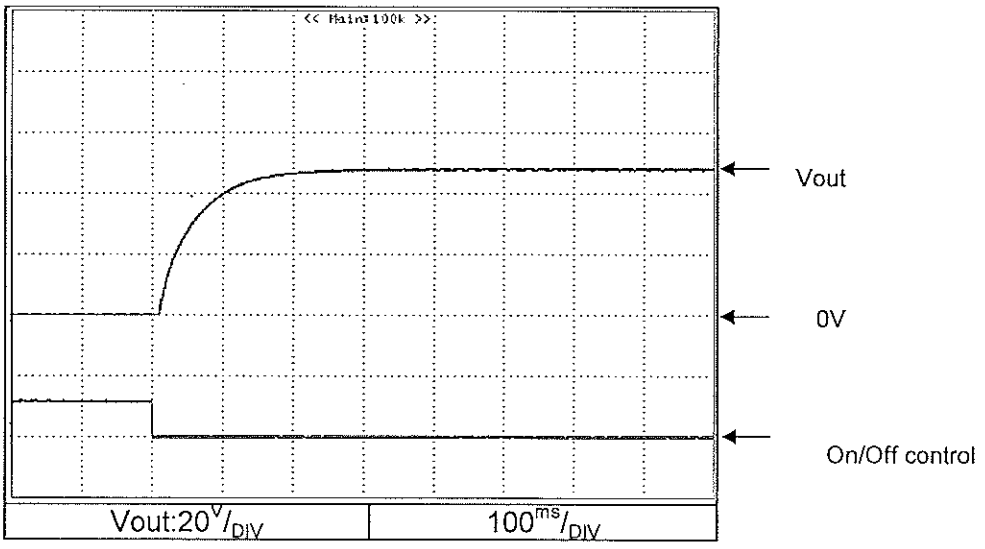
CONDITIONS: Vin: 115 VAC
Iout: 100%
Ta: 25˚C

48V



CONDITIONS: Vin: 230 VAC
Iout: 100%
Ta: 25˚C

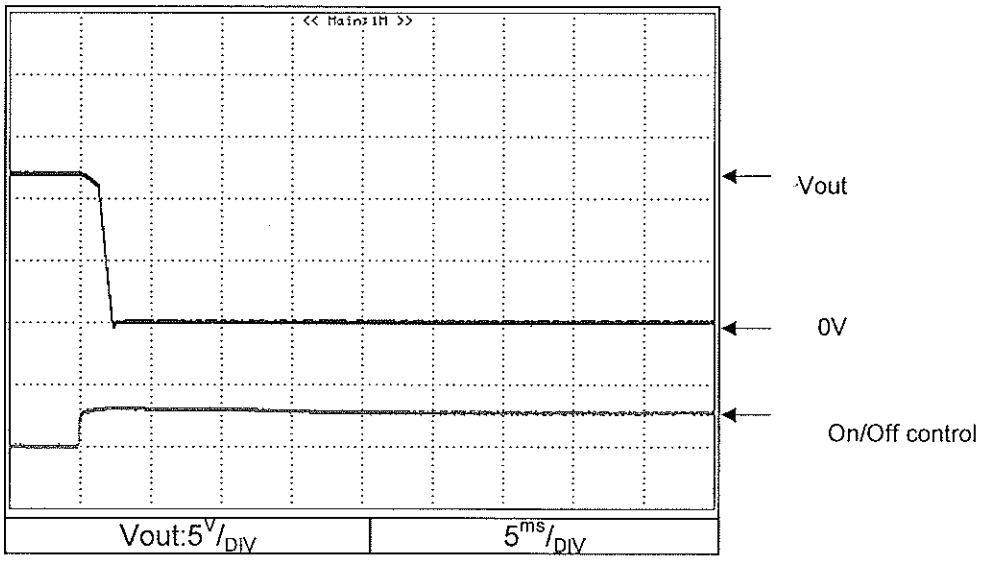
48V



2.8. Output fall characteristics with On/Off control

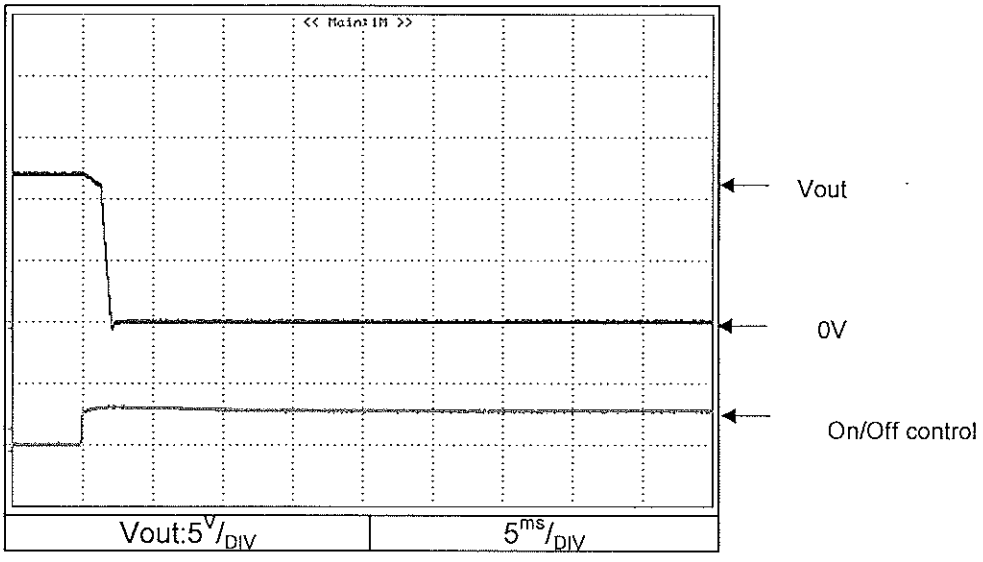
CONDITIONS: Vin: 115 VAC
Iout: 100%
Ta: 25°C

12V



CONDITIONS: Vin: 230 VAC
Iout: 100%
Ta: 25°C

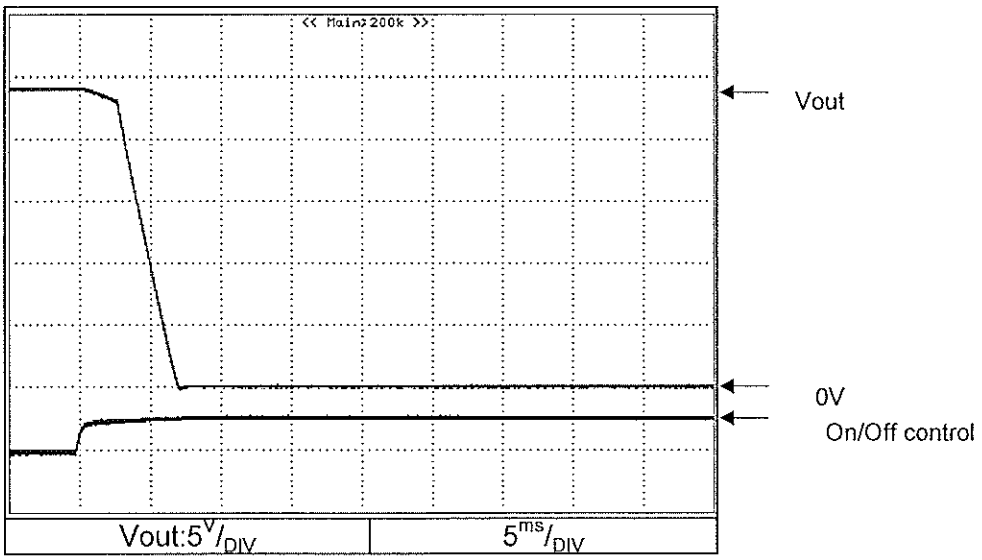
12V



2.8. Output fall characteristics with On/Off control

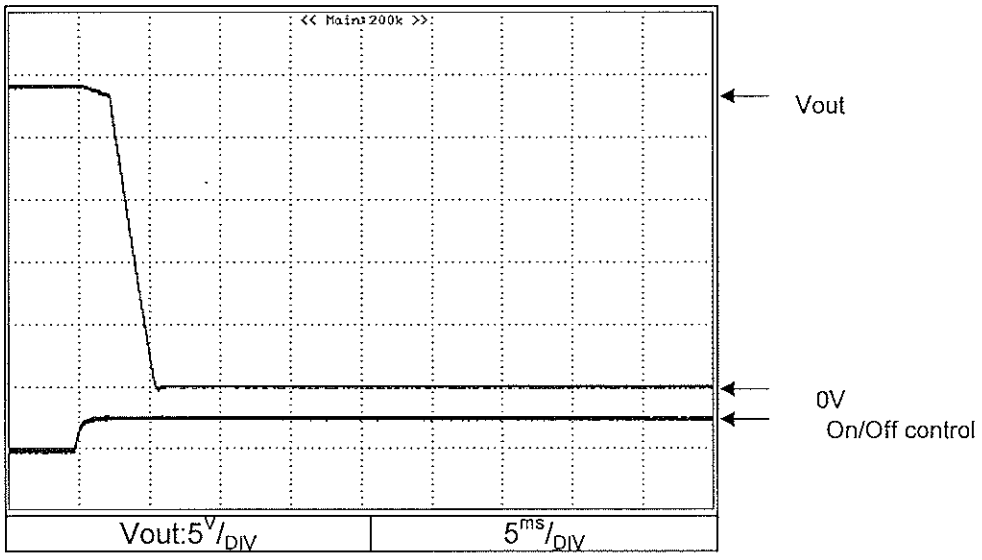
CONDITIONS: Vin: 115 VAC
Iout: 100%
Ta: 25˚C

24V



CONDITIONS: Vin: 230 VAC
Iout: 100%
Ta: 25˚C

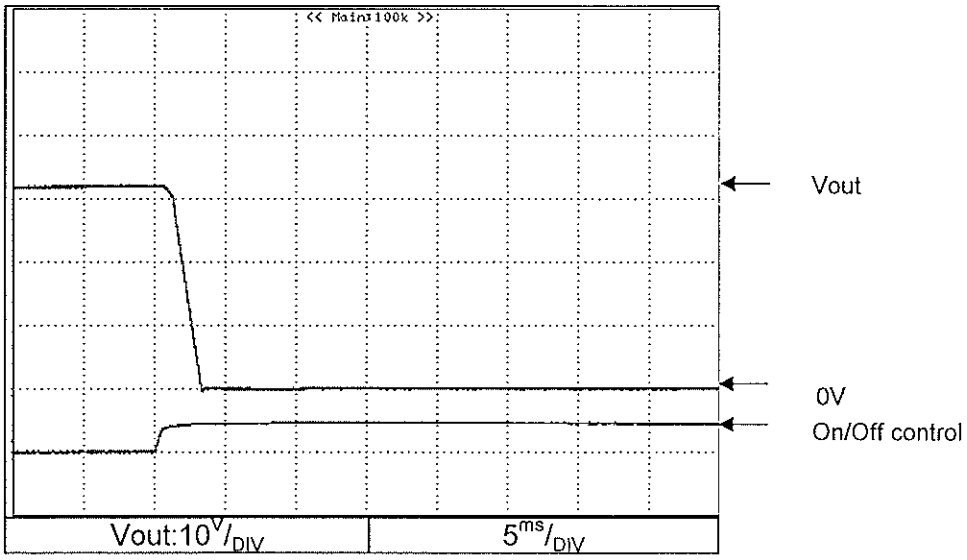
24V



2.8. Output fall characteristics with On/Off control

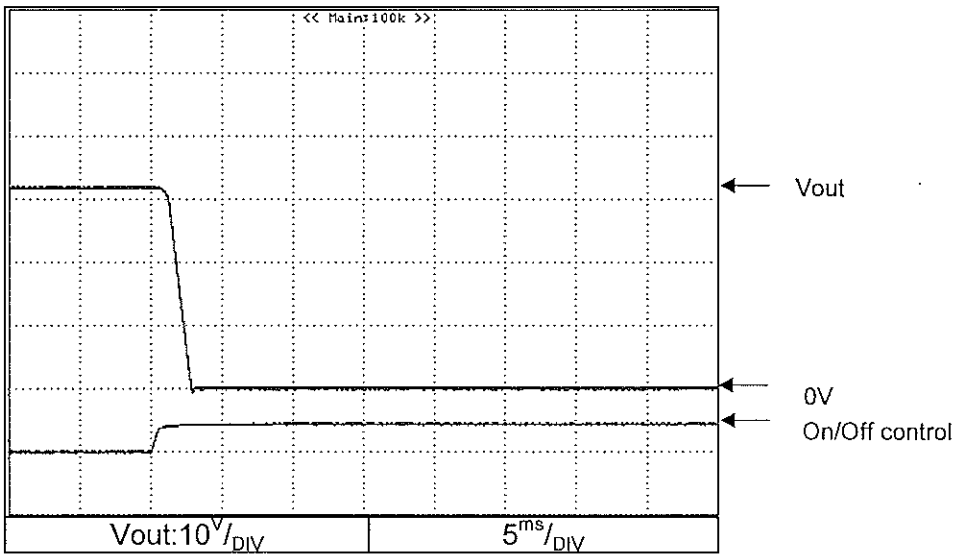
CONDITIONS: Vin: 115 VAC
Iout: 100%
Ta: 25°C

32V



CONDITIONS: Vin: 230 VAC
Iout: 100%
Ta: 25°C

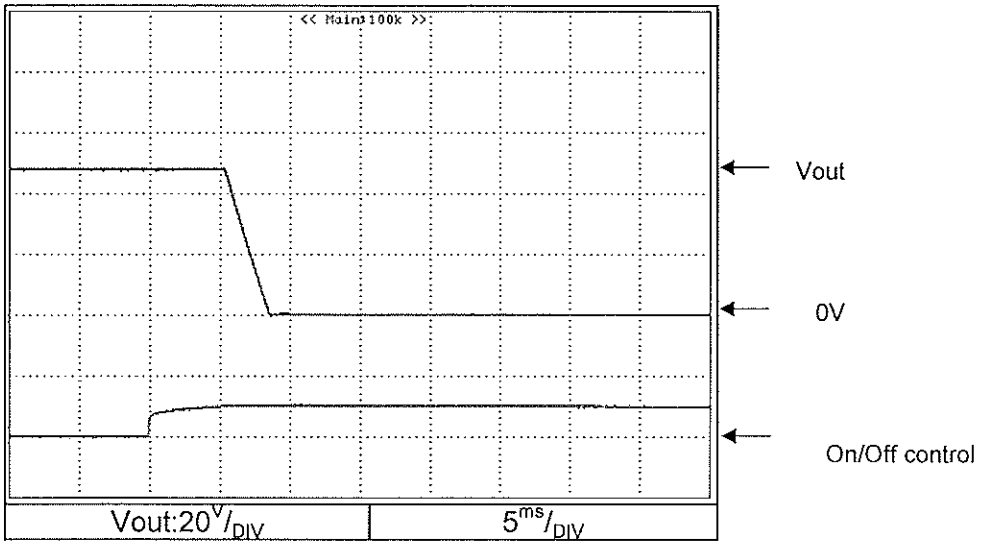
32V



2.8. Output fall characteristics with On/Off control

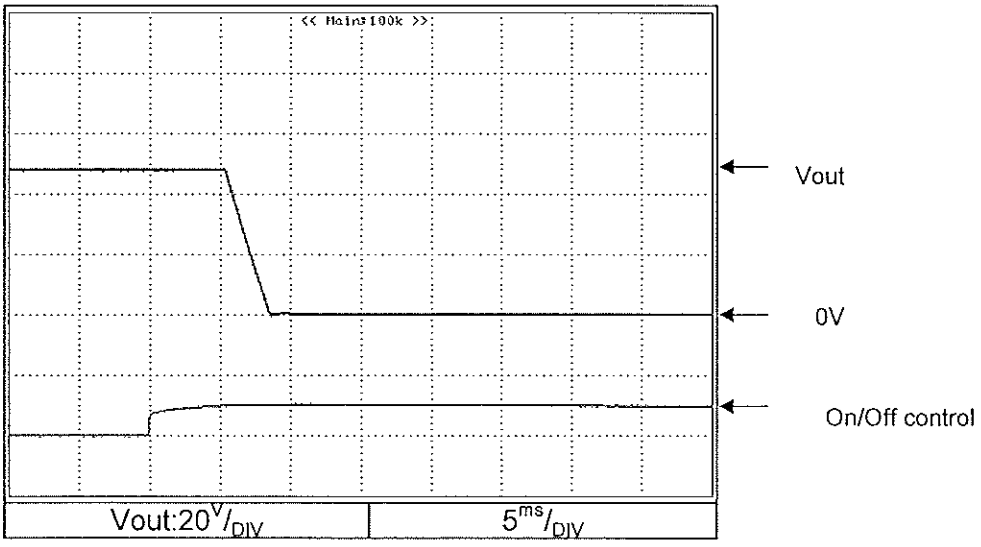
CONDITIONS: Vin: 115 VAC
Iout: 100%
Ta: 25°C

48V



CONDITIONS: Vin: 230 VAC
Iout: 100%
Ta: 25°C

48V

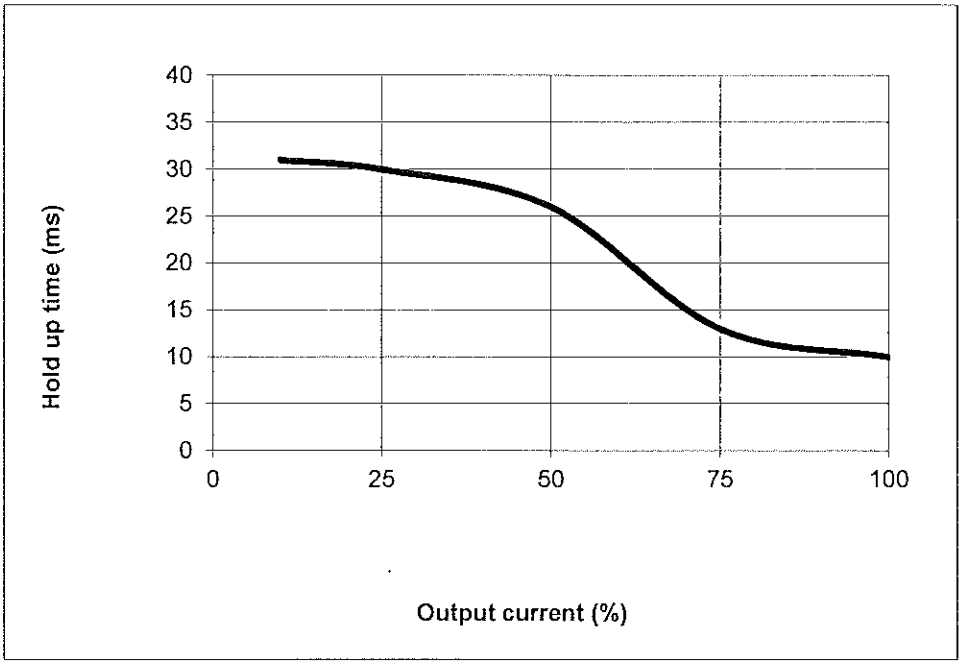


2.9. Hold up time characteristics

CONDITIONS: Vout: 100%
Ta: 25˚C

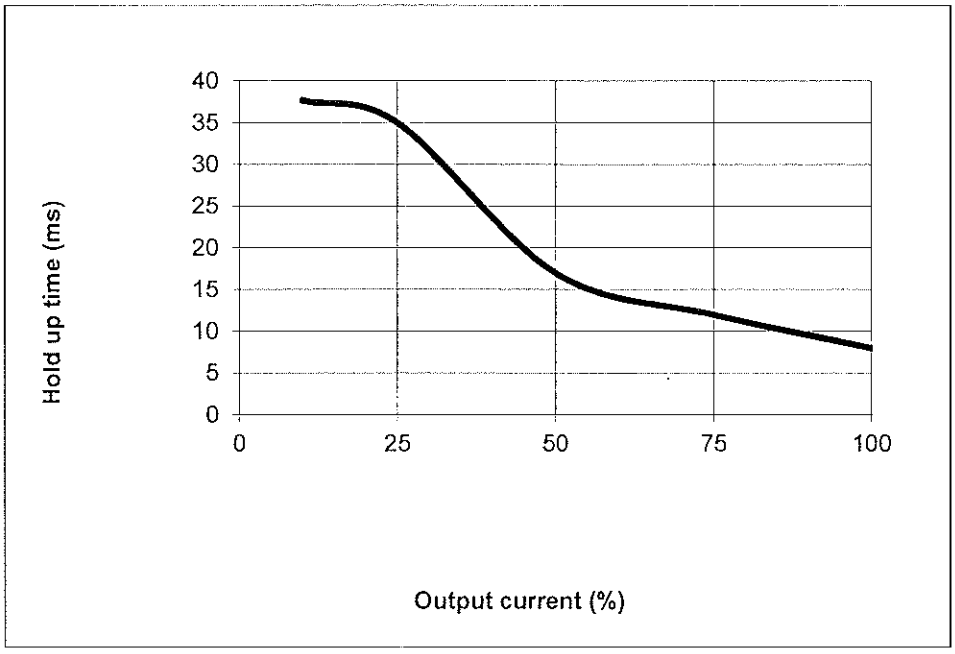
Vin: 115 VAC

12V



Vin: 230 VAC

12V

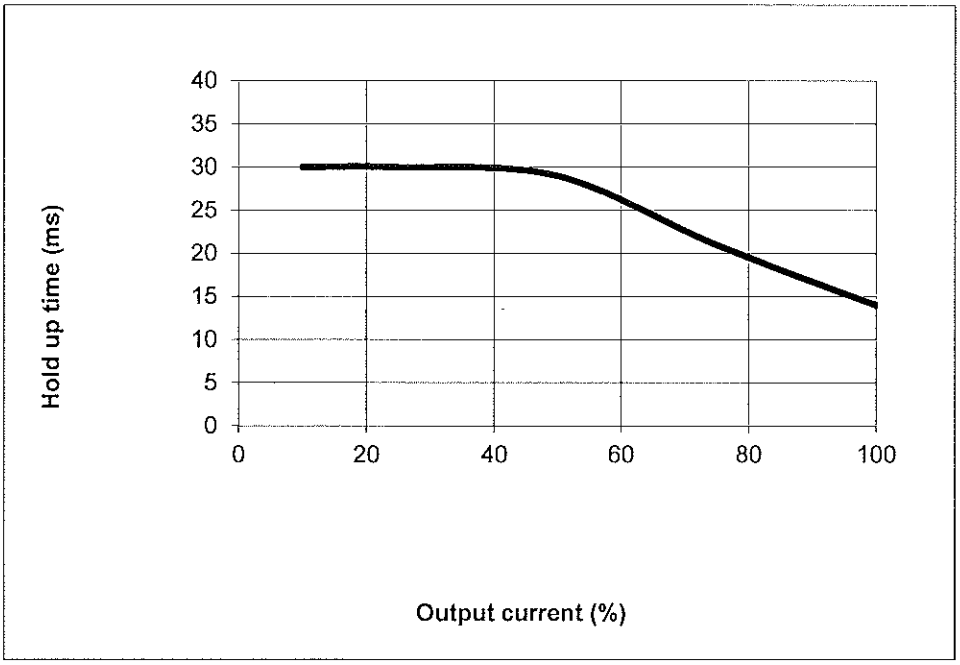


2.9. Hold up time characteristics

CONDITIONS: Vout: 100%
Ta: 25°C

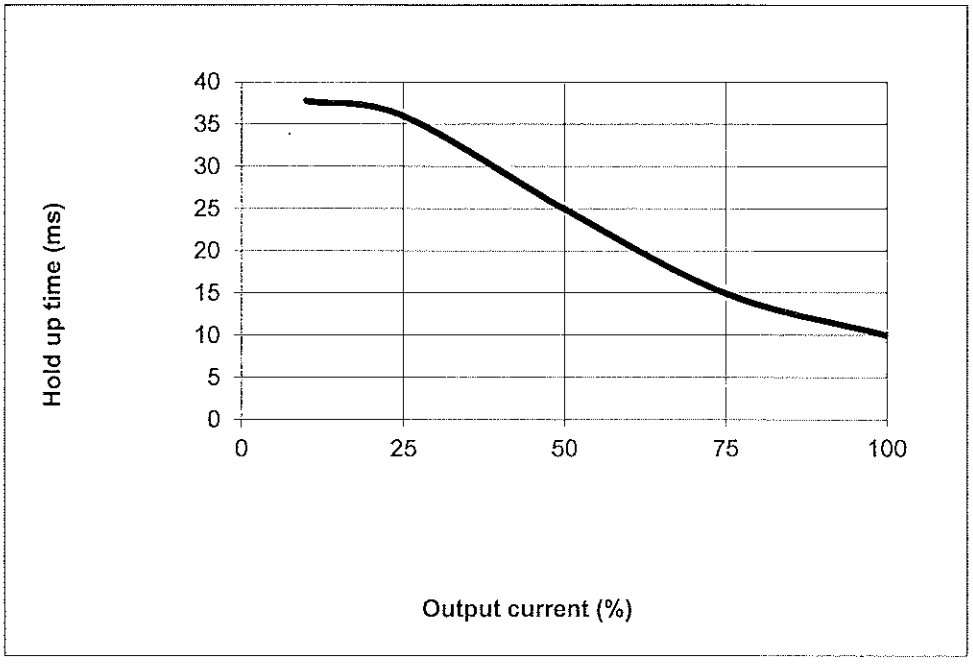
Vin: 115 VAC

24V



Vin: 230 VAC

24V

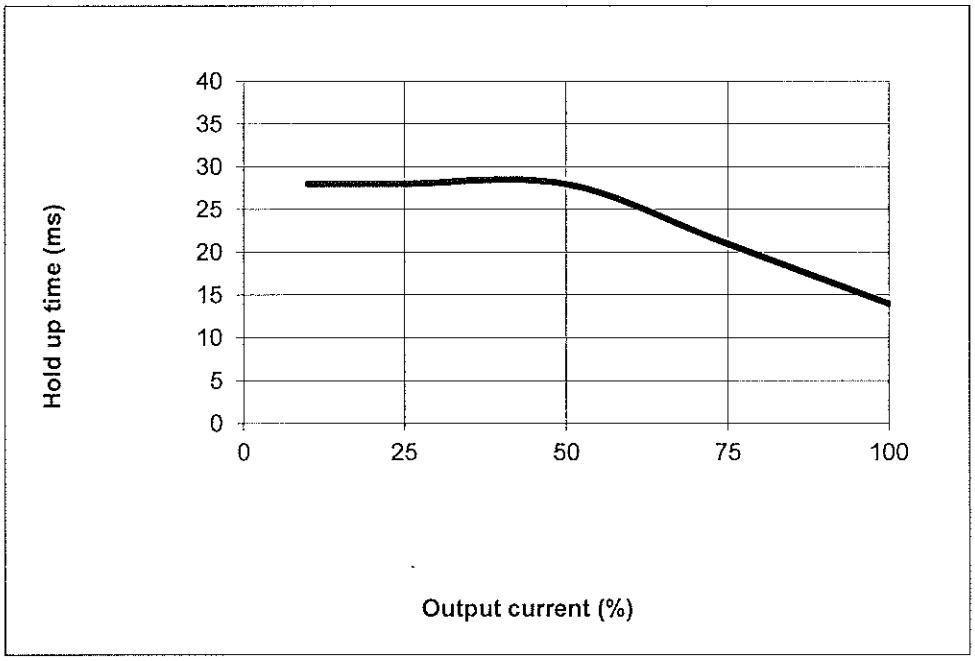


2.9. Hold up time characteristics

CONDITIONS: Vout: 100%
Ta: 25˚C

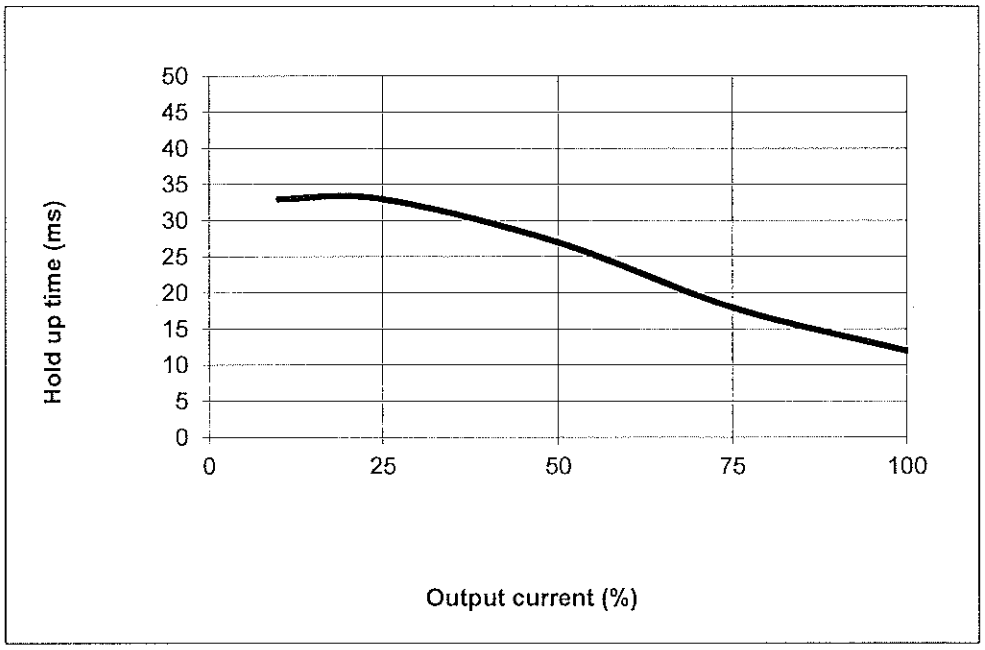
Vin: 115 VAC

32V



Vin: 230 VAC

32V

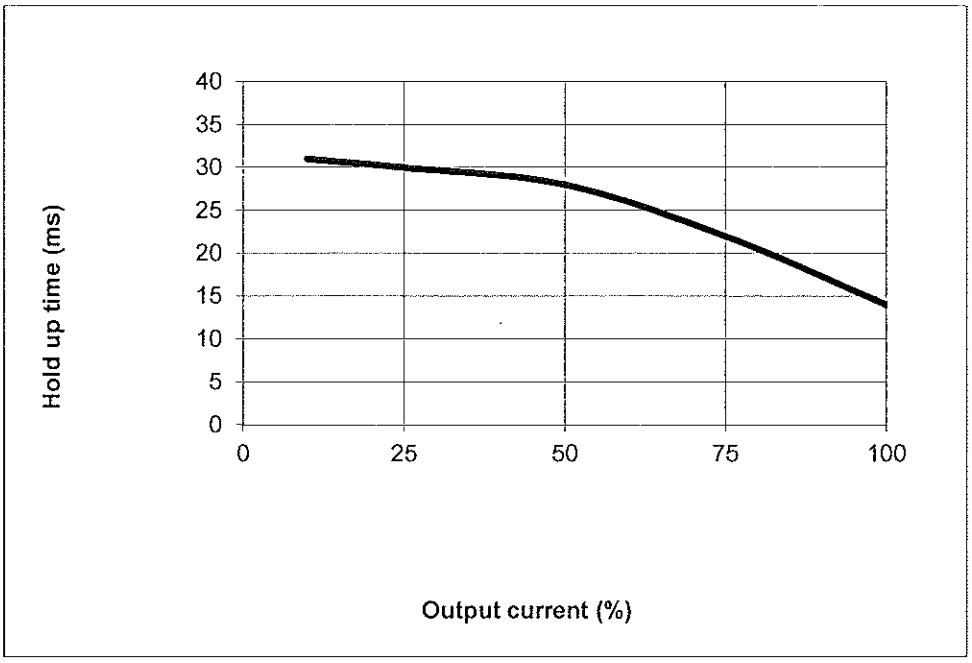


2.9. Hold up time characteristics

CONDITIONS: Vout: 100%
Ta: 25°C

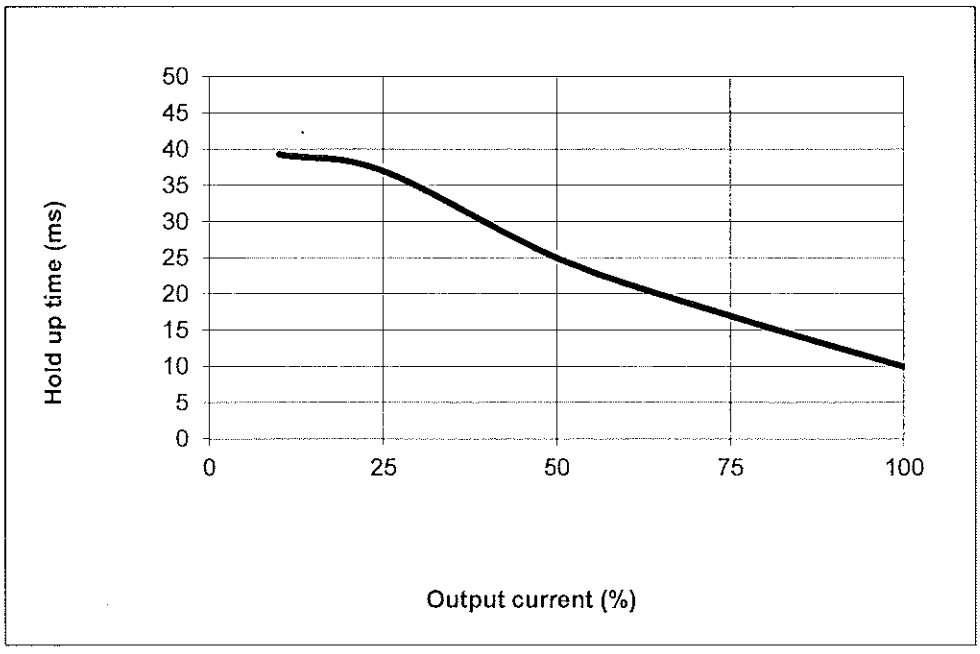
Vin: 115 VAC

48V



Vin: 230 VAC

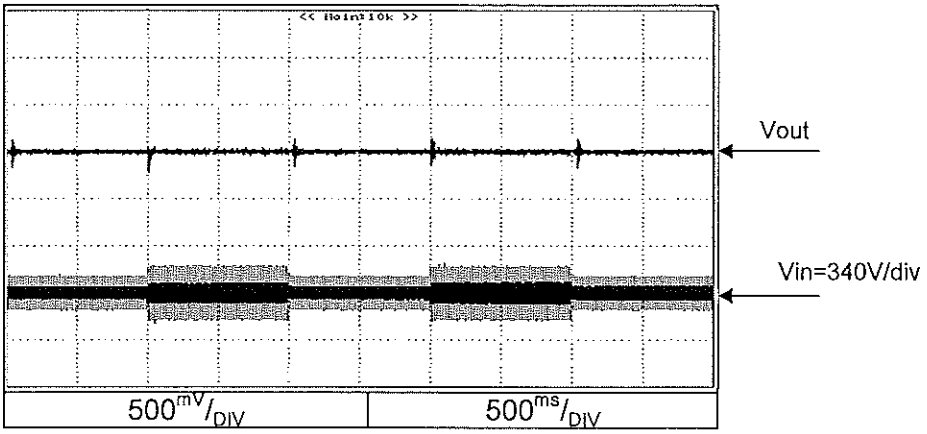
48V



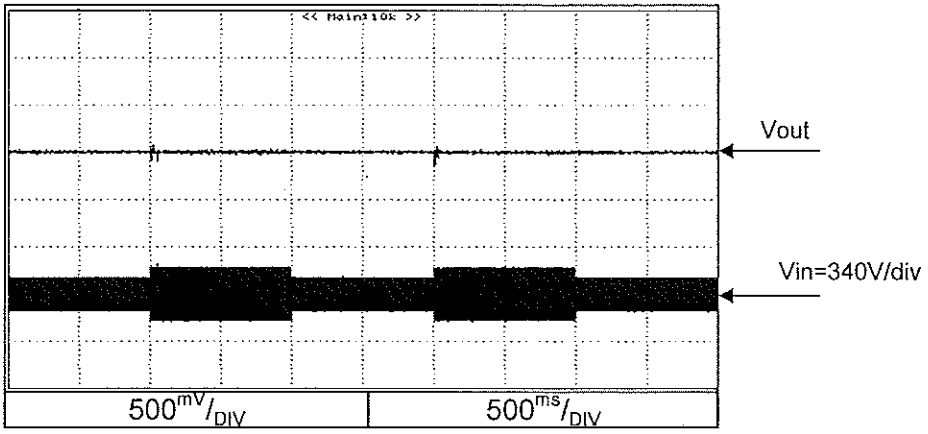
2.10. Dynamic line response characteristics

CONDITIONS: Vin: 85V↔132V
Iout: 100%
Ta: 25°C

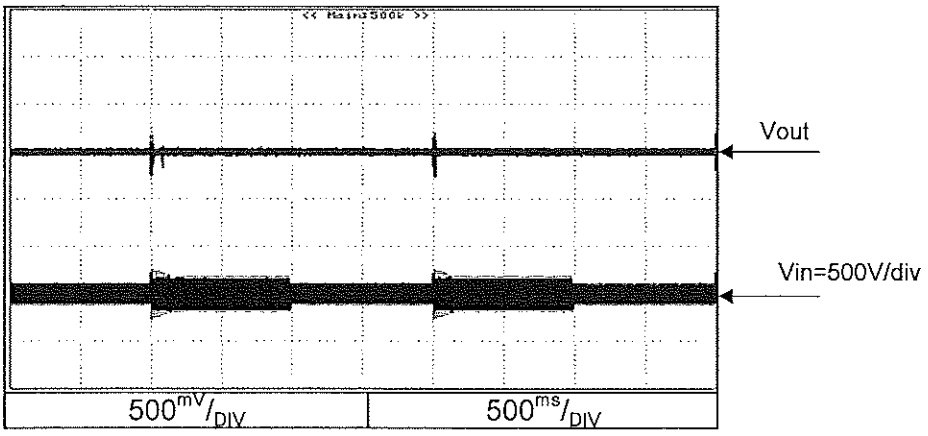
12V



24V



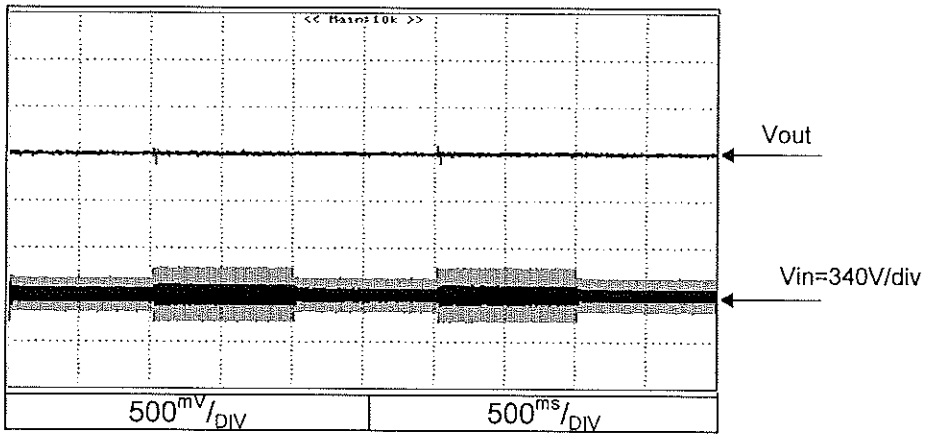
32V



2.10. Dynamic line response characteristics

CONDITIONS: Vin: 85V↔132V
Iout: 100%
Ta: 25°C

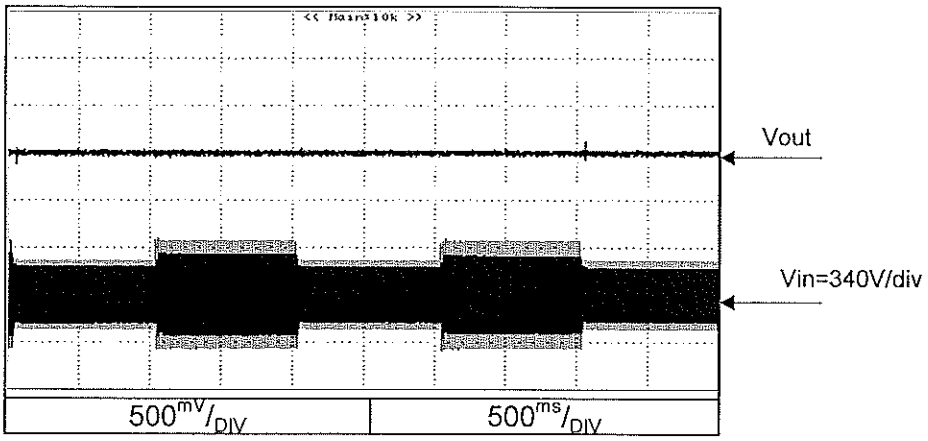
48V



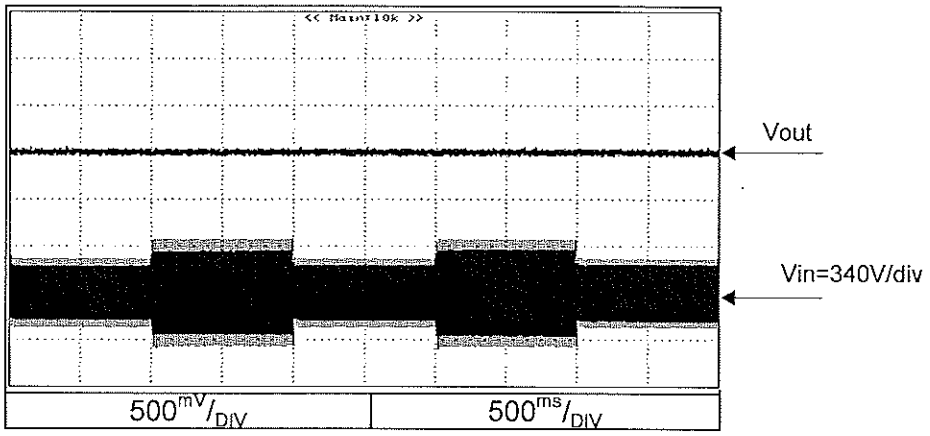
2.10. Dynamic line response characteristics

CONDITIONS: Vin: 170V↔265V
Iout: 100%
Ta: 25°C

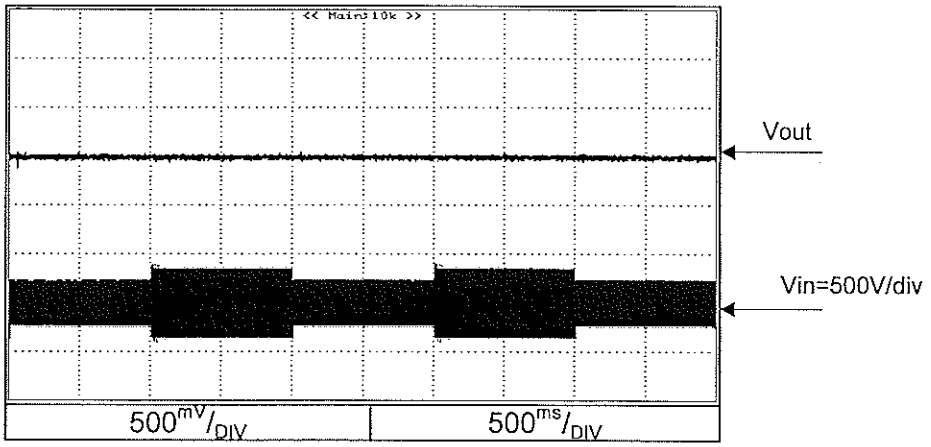
12V



24V



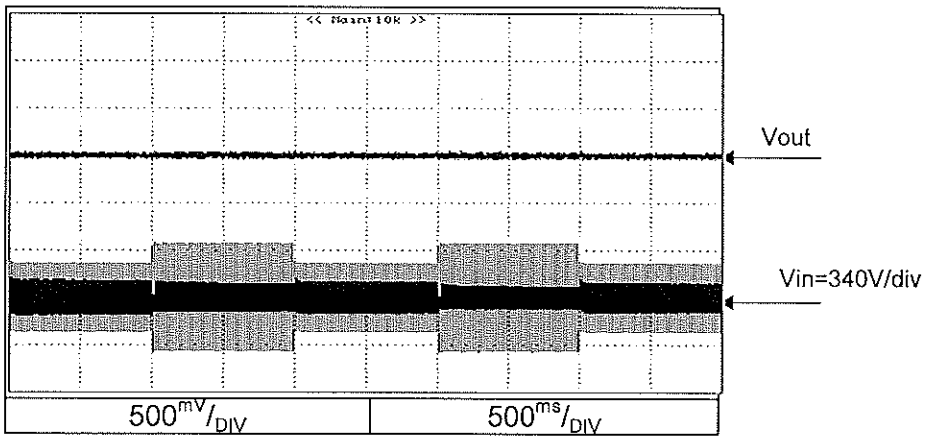
32V



2.10. Dynamic line response characteristics

CONDITIONS: Vin: 170V↔265V
Iout: 100%
Ta: 25°C

48V

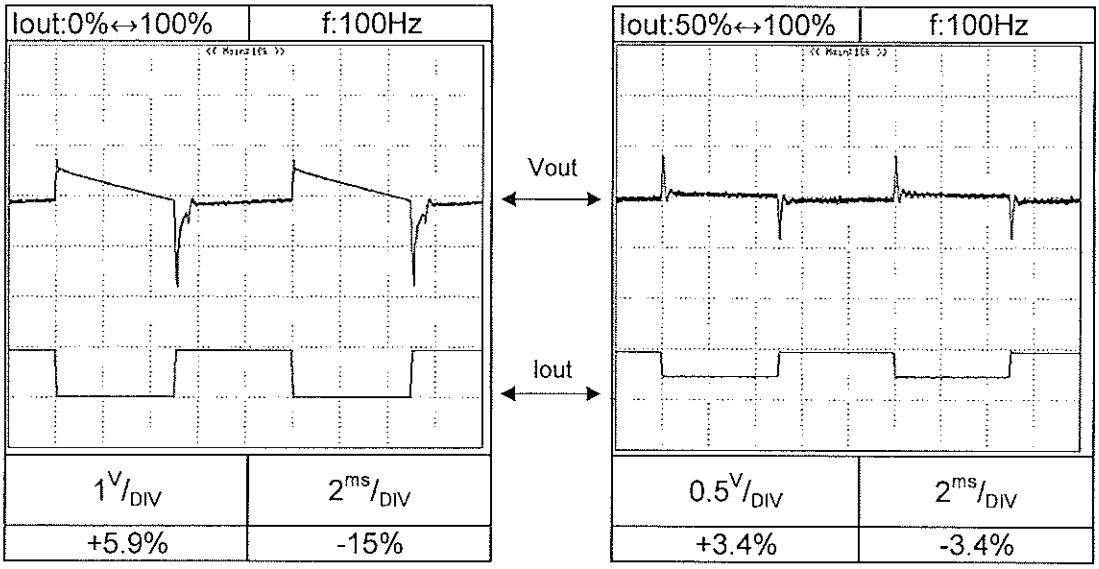


2.11. Dynamic load response characteristics

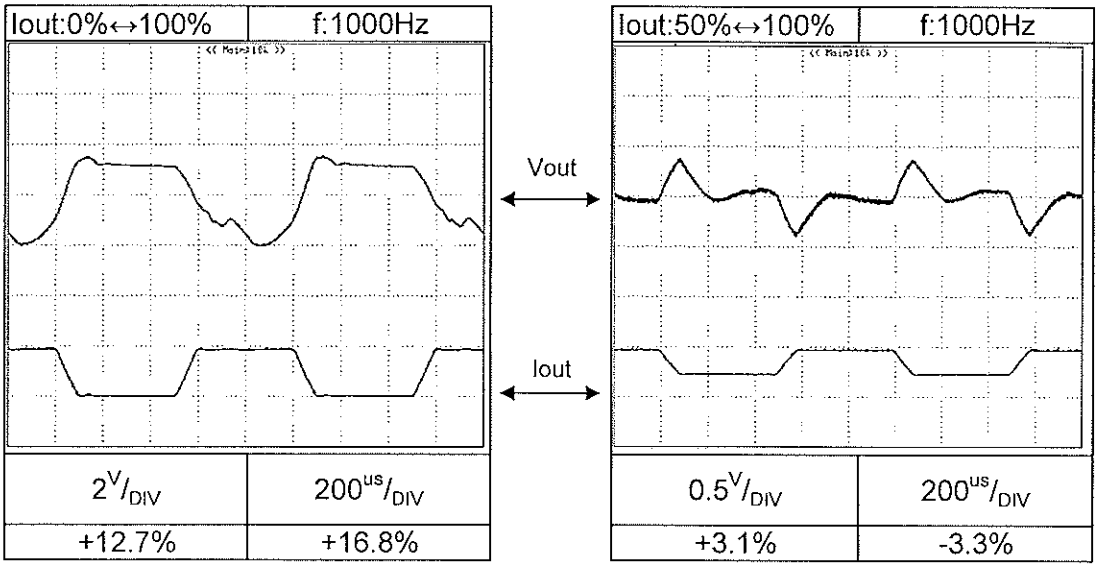
CONDITIONS: Vin: 230VAC
Vout: 100%
Ta: 25°C
Load current: tr=tf=100uS

12V

f=100Hz



f=1kHz

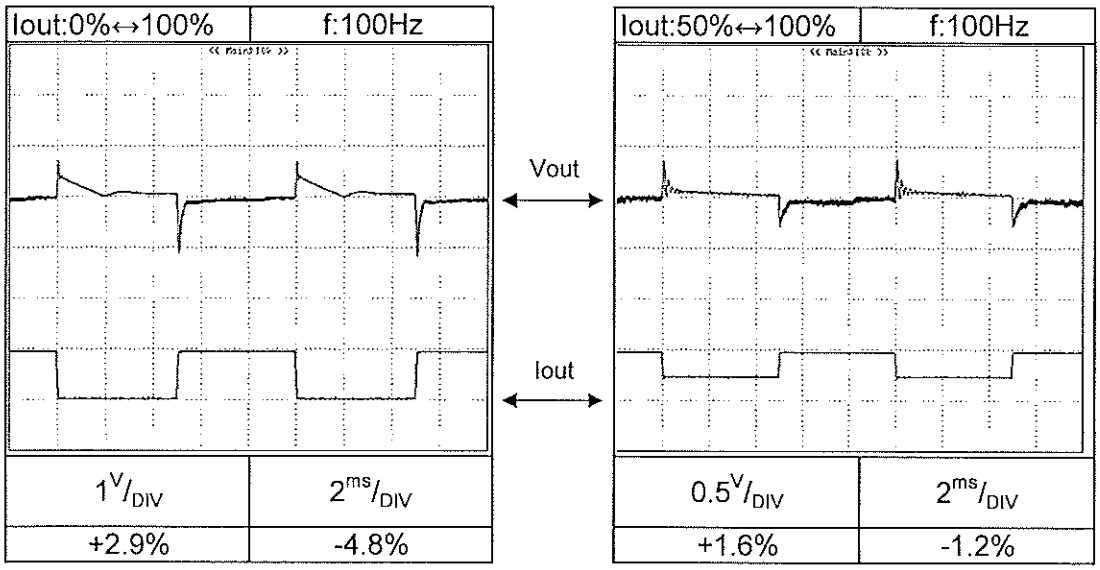


2.11. Dynamic load response characteristics

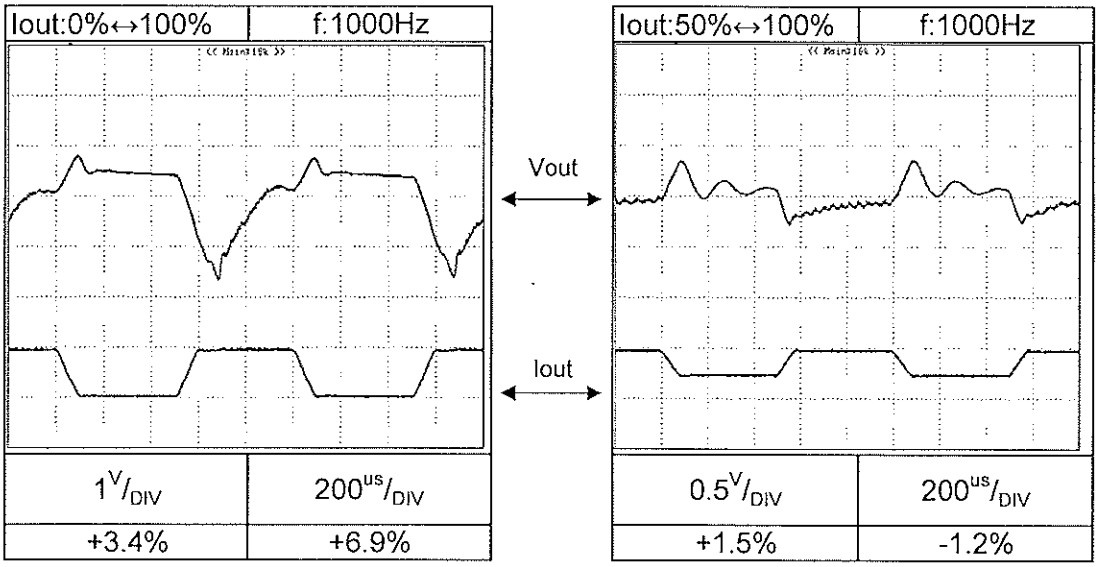
CONDITIONS: Vin: 230VAC
Vout: 100%
Ta: 25°C
Load current: tr=tf=100uS

24V

f=100Hz



f=1kHz

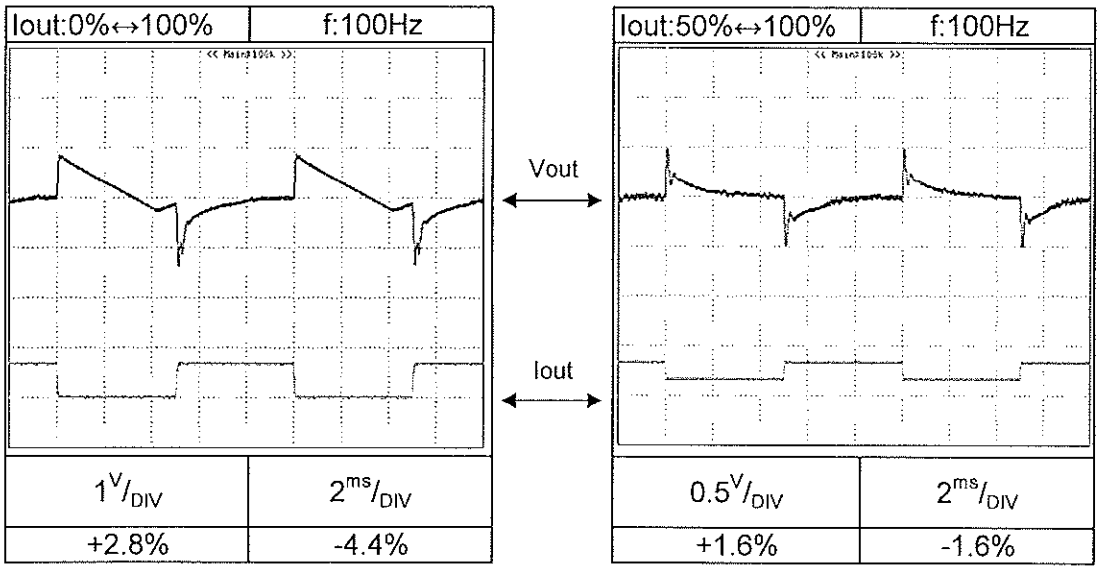


2.11. Dynamic load response characteristics

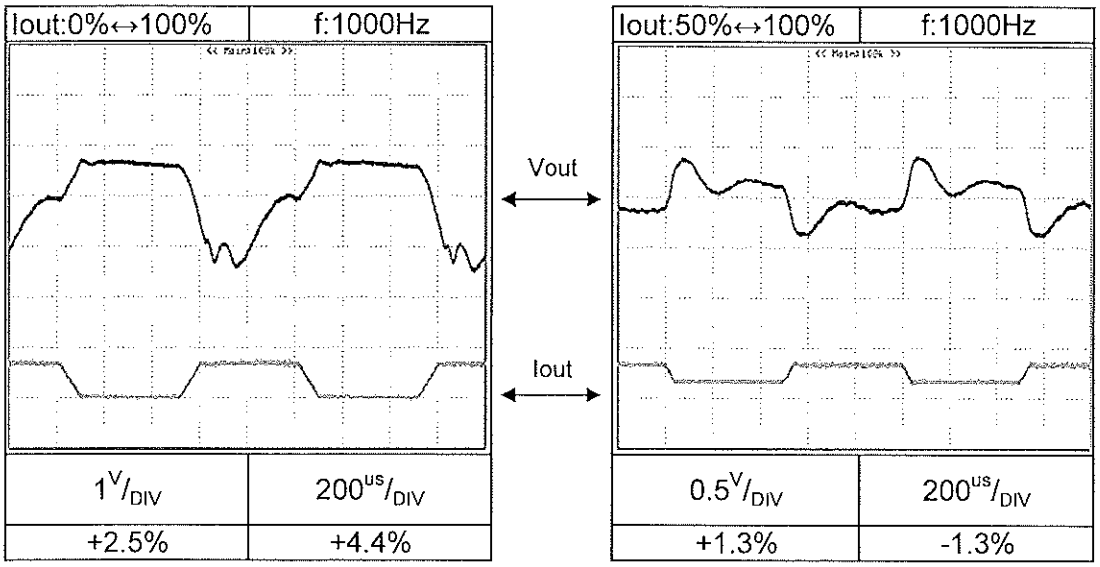
CONDITIONS: Vin: 230VAC
Vout: 100%
Ta: 25°C
Load current: tr=tf=100uS

32V

f=100Hz



f=1kHz

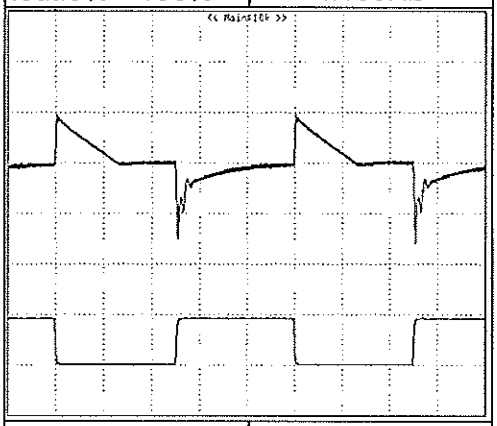


2.11. Dynamic load response characteristics

CONDITIONS: Vin: 230VAC
Vout: 100%
Ta: 25°C
Load current: tr=tf=100uS

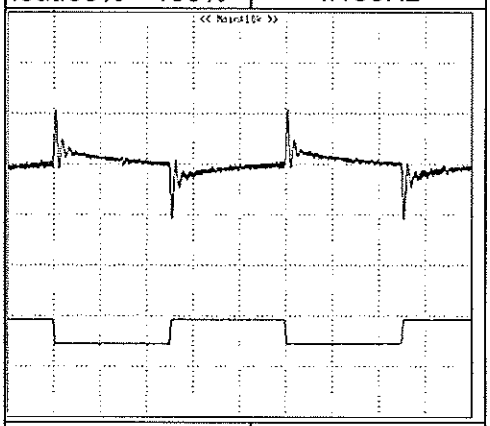
48V

f=100Hz

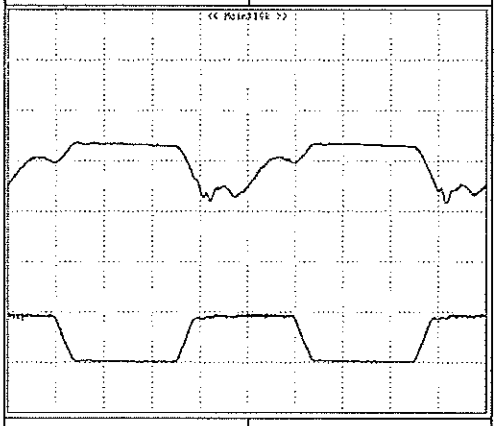
Iout:0%↔100%	f:100Hz
	
$1^{V}/_{DIV}$	$2^{ms}/_{DIV}$
+2%	-3.3%

Vout

Iout

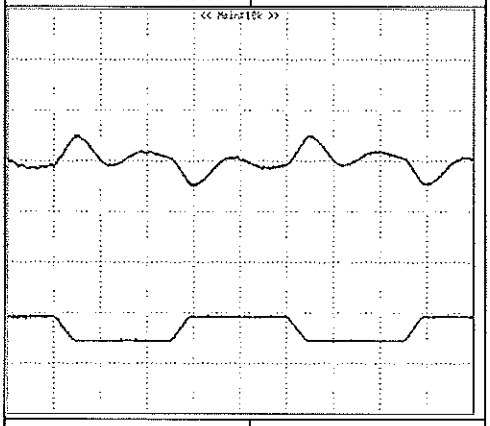
Iout:50%↔100%	f:100Hz
	
$0.5^{V}/_{DIV}$	$2^{ms}/_{DIV}$
+1.1%	-1.1%

f=1kHz

Iout:0%↔100%	f:1000Hz
	
$2^{V}/_{DIV}$	$200^{us}/_{DIV}$
+1.6%	+3.5%

Vout

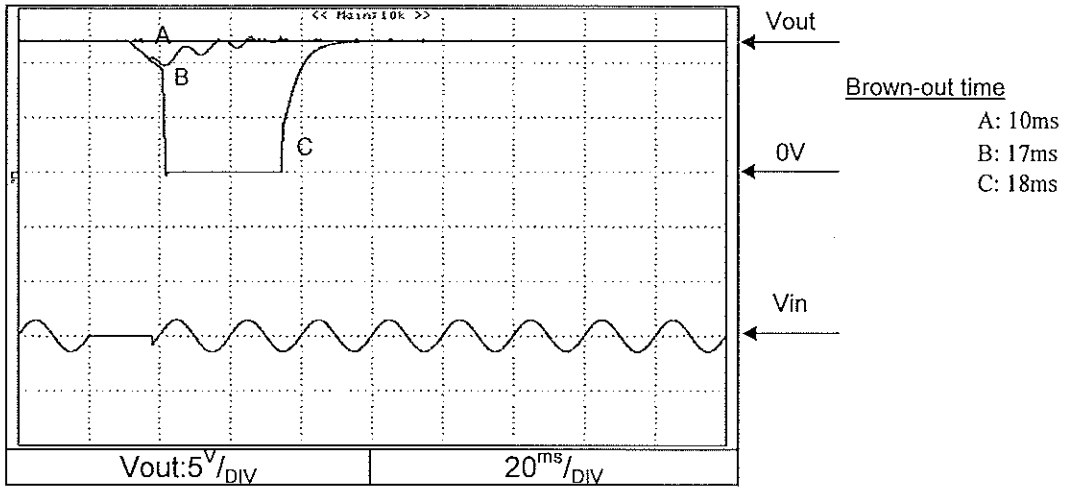
Iout

Iout:50%↔100%	f:1000Hz
	
$1^{V}/_{DIV}$	$200^{us}/_{DIV}$
+1.1%	-1%

2.12. Response to brown out characteristics

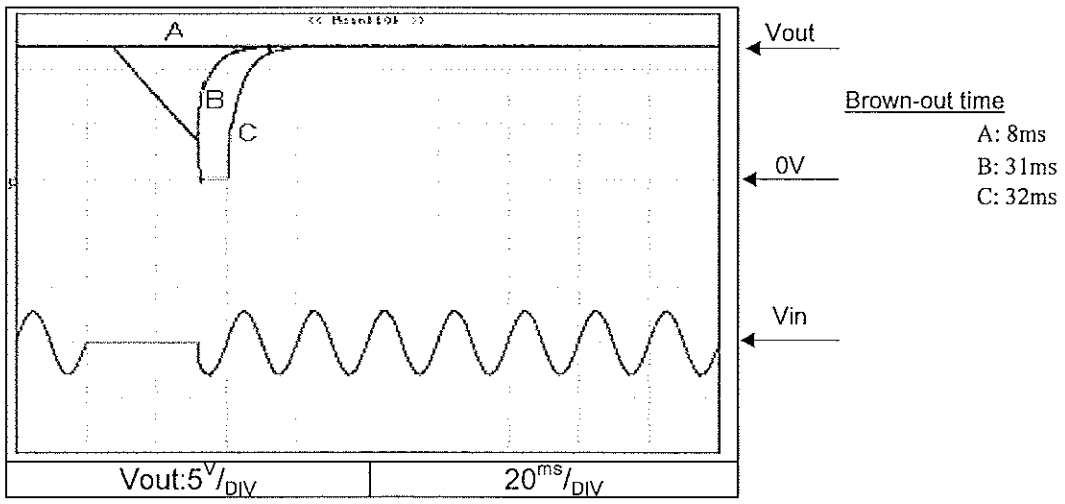
CONDITIONS: Vin: 115 VAC
Ta: 25°C

12V



Brown-out time
A: 10ms
B: 17ms
C: 18ms

CONDITIONS: Vin: 230 VAC
Ta: 25°C

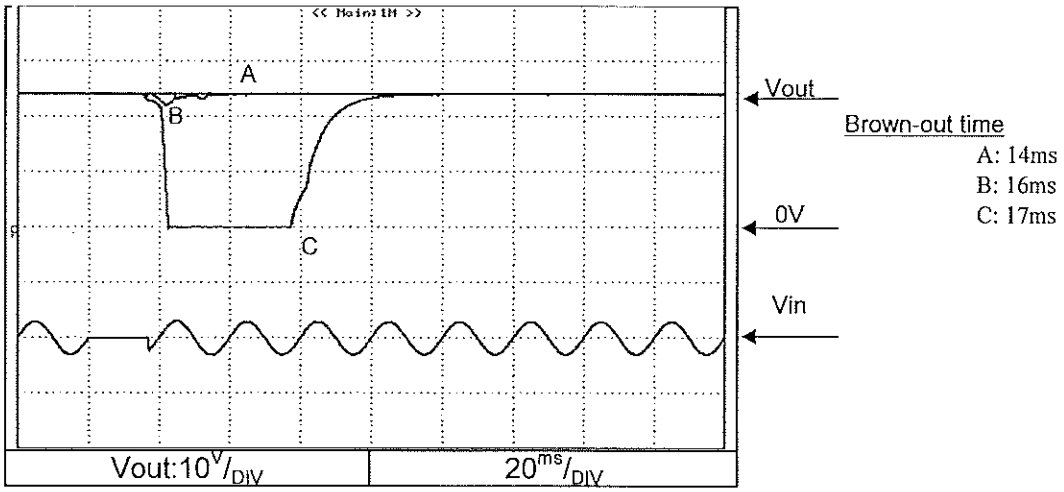


Brown-out time
A: 8ms
B: 31ms
C: 32ms

2.12. Response to brown out characteristics

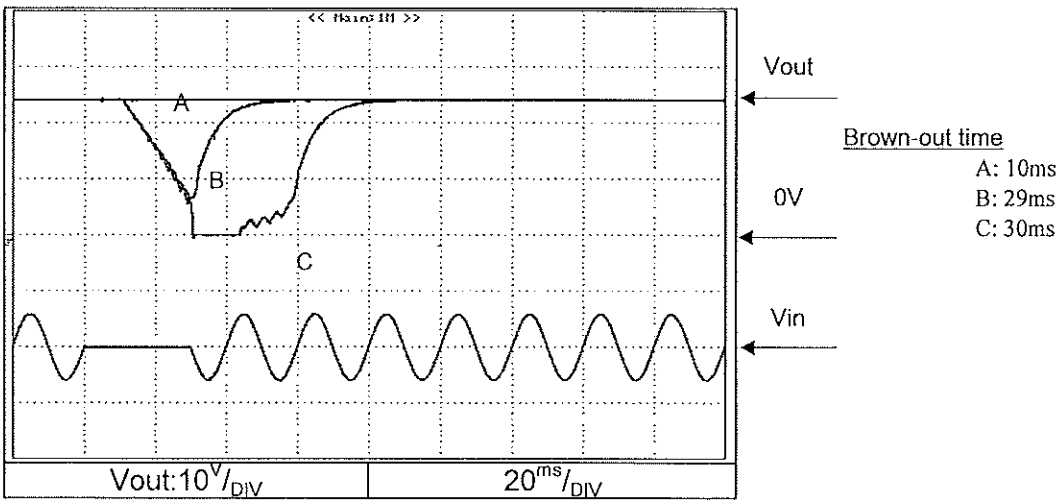
CONDITIONS: Vin: 115 VAC
Ta: 25°C

24V



Brown-out time
A: 14ms
B: 16ms
C: 17ms

CONDITIONS: Vin: 230 VAC
Ta: 25°C

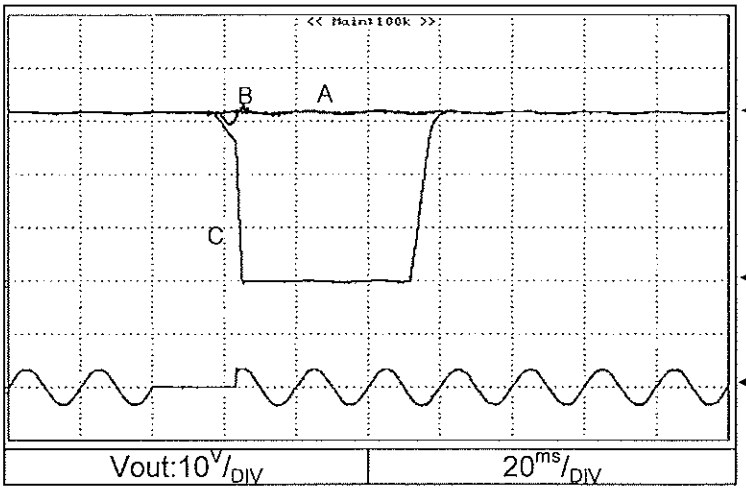


Brown-out time
A: 10ms
B: 29ms
C: 30ms

2.12. Response to brown out characteristics

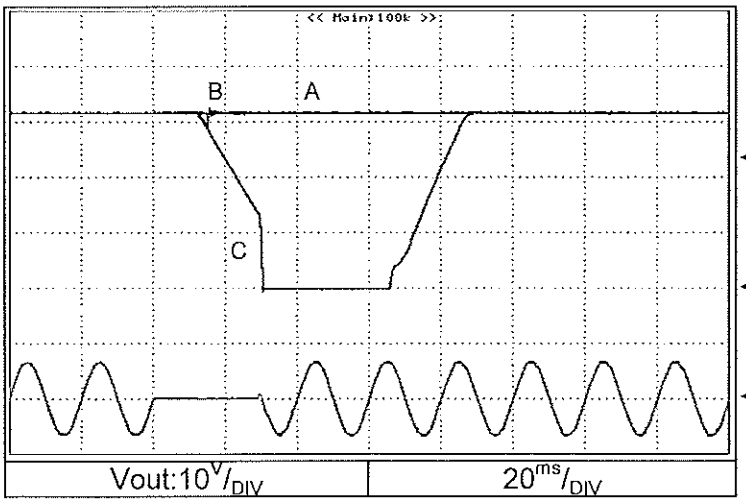
CONDITIONS: Vin: 115 VAC
Ta: 25°C

32V



Brown-out time
A: 16ms
B: 17ms
C: 23ms

CONDITIONS: Vin: 230 VAC
Ta: 25°C

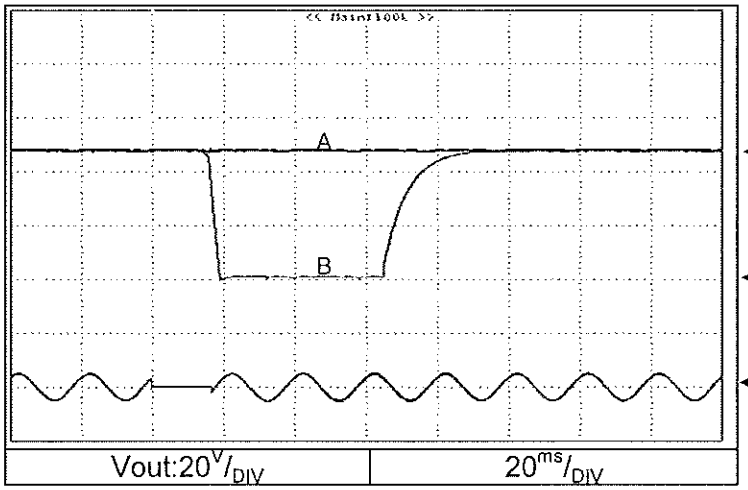


Brown-out time
A: 14ms
B: 15ms
C: 29ms

2.12. Response to brown out characteristics

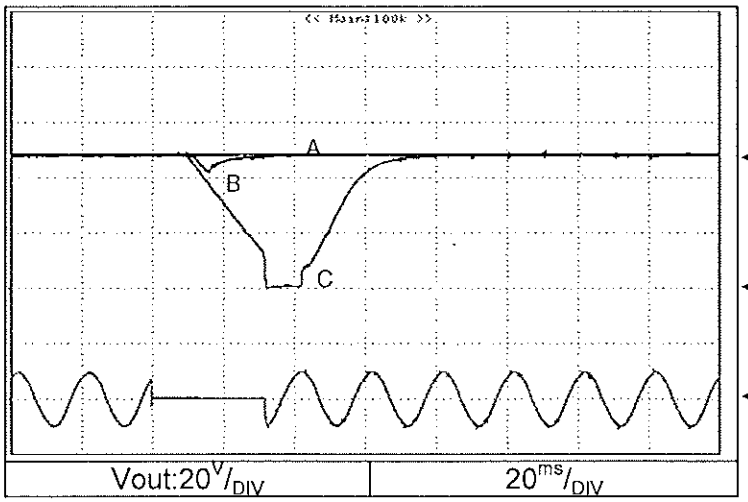
CONDITIONS: Vin: 115 VAC
Ta: 25°C

48V



Brown-out time
A: 14ms
B: 17ms

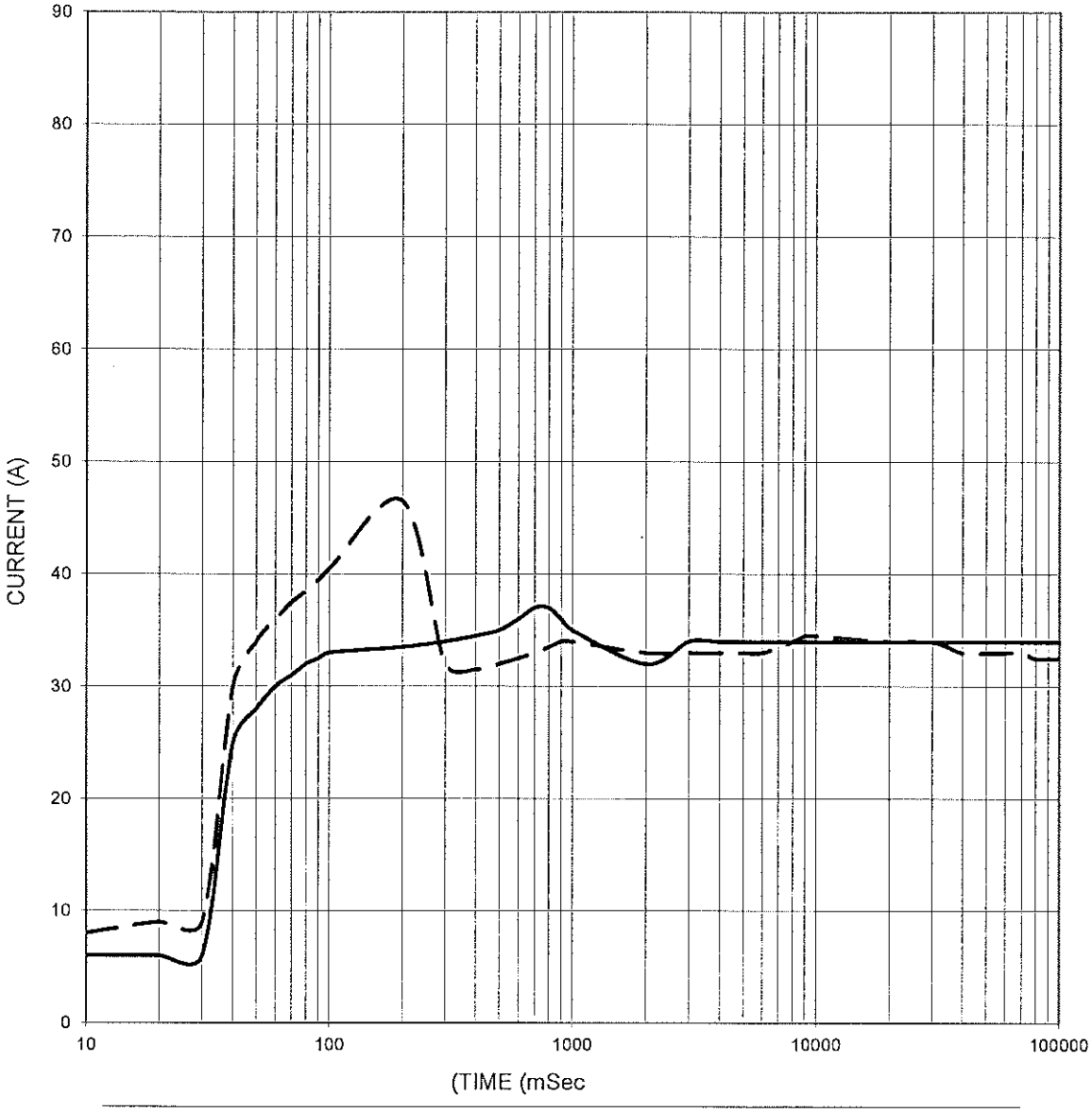
CONDITIONS: Vin: 230 VAC
Ta: 25°C



Brown-out time
A: 10ms
B: 13ms
C: 32ms

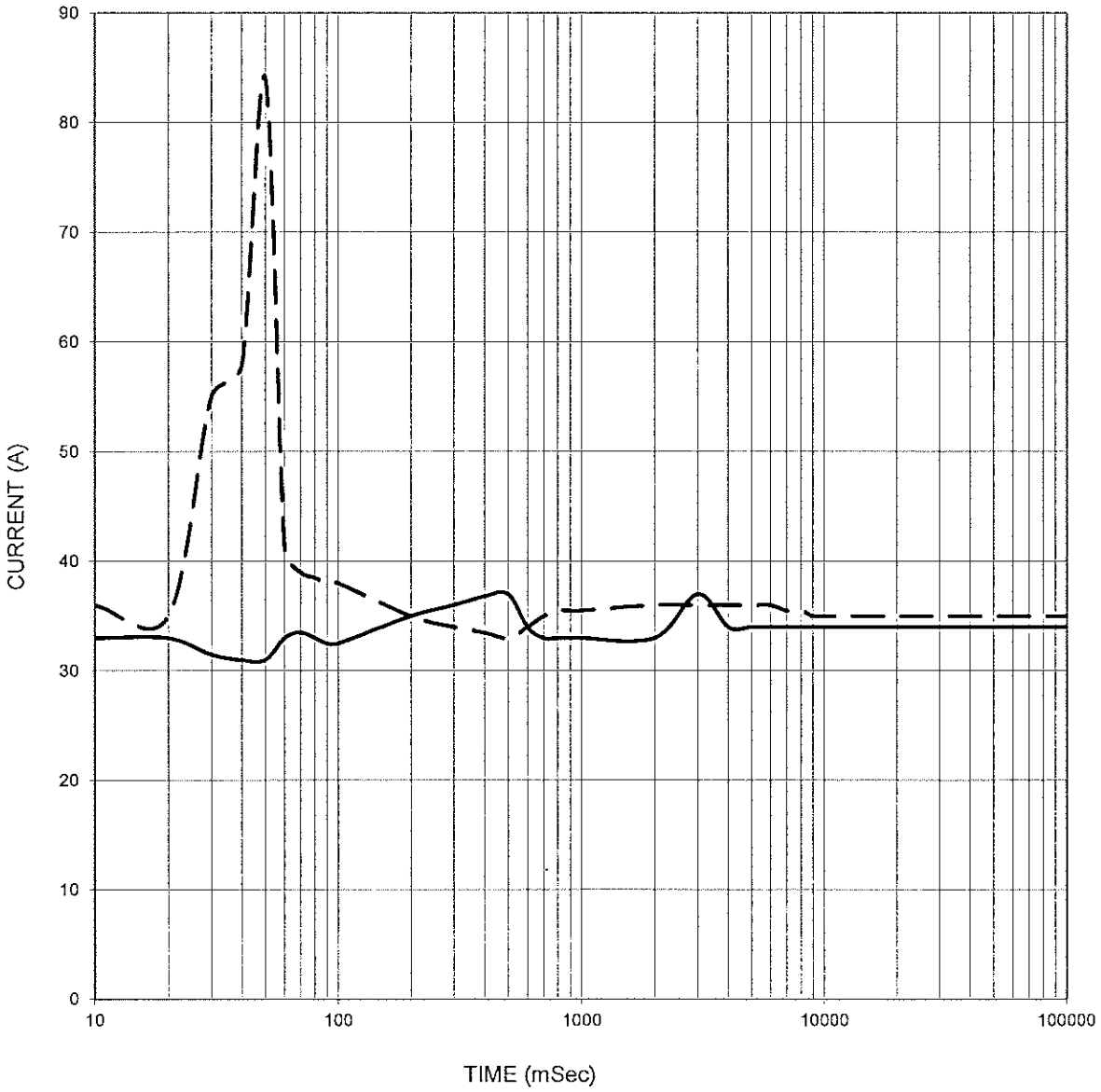
2.13. Inrush current characteristics

CONDITIONS: Vin: 115 VAC———
230 VAC- - - - -
Vout: 100%
Iout: 0%
Ta: 25°C



2.13. Inrush current characteristics

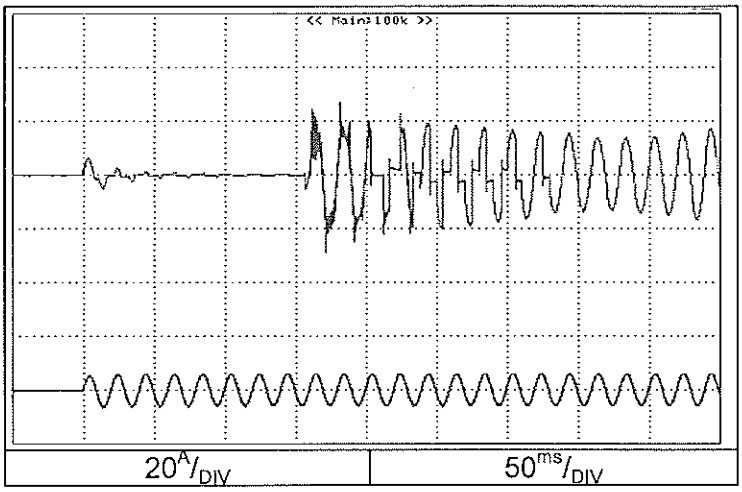
CONDITIONS: Vin: 115 VAC———
230 VAC- - - - -
Vout: 100%
Iout: 100%
Ta: 25°C



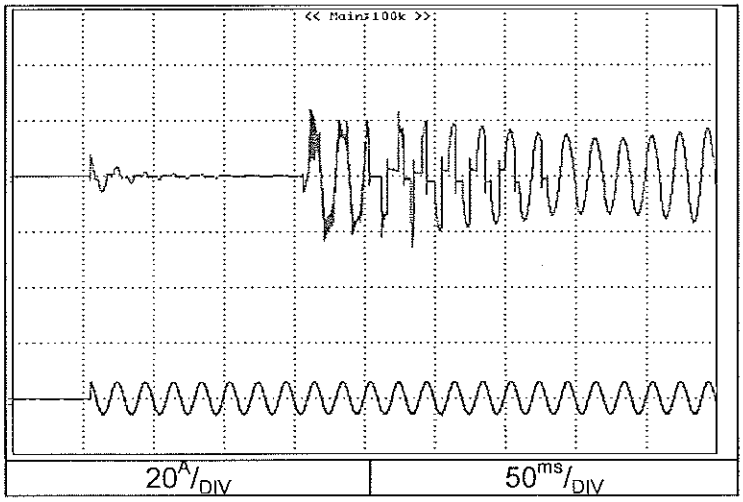
2.14. Inrush current waveform

CONDITIONS: Vin: 115 VAC
Vout: 100%
Ta: 25˚C

Switch on phase angle of input AC
Φ=0˚



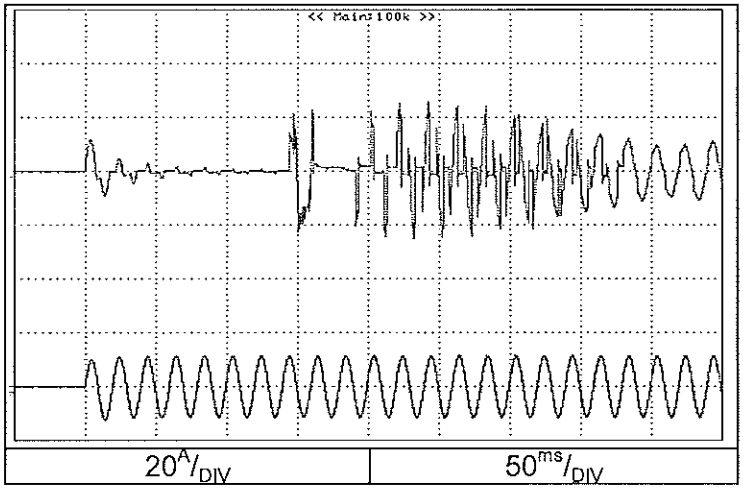
Switch on phase angle of input AC
Φ=90˚



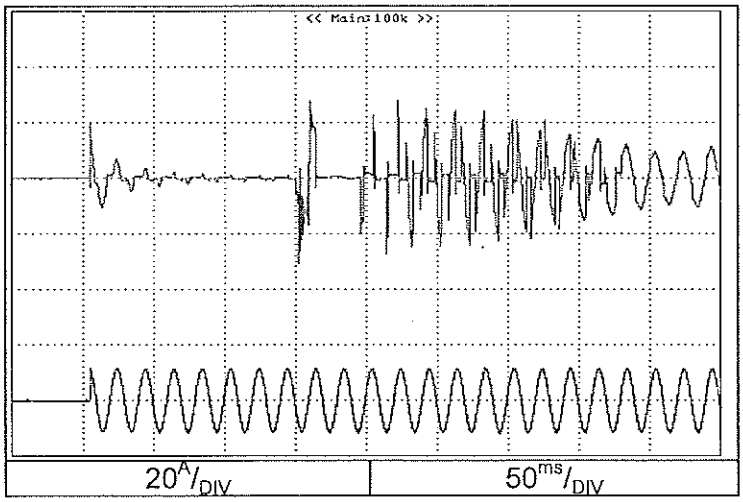
2.14. Inrush current waveform

CONDITIONS: Vin: 230 VAC
Vout: 100%
Ta: 25°C

Switch on phase angle of input AC
Φ=0°



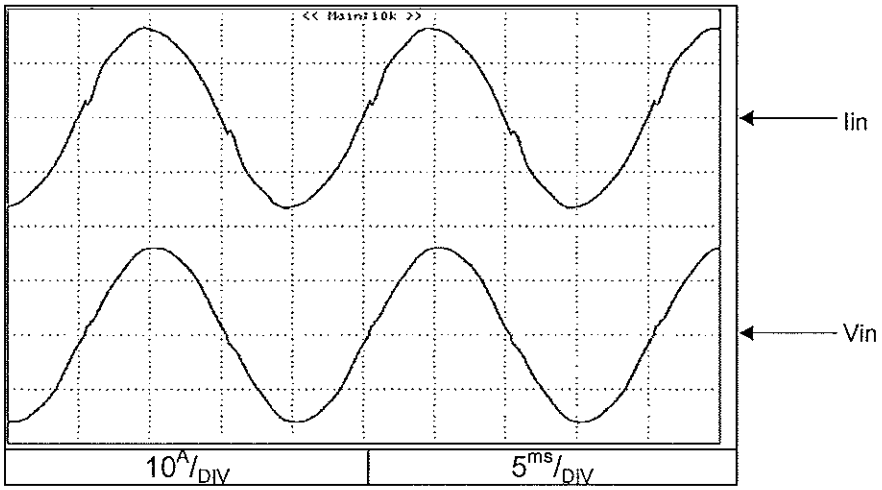
Switch on phase angle of input AC
Φ=90°



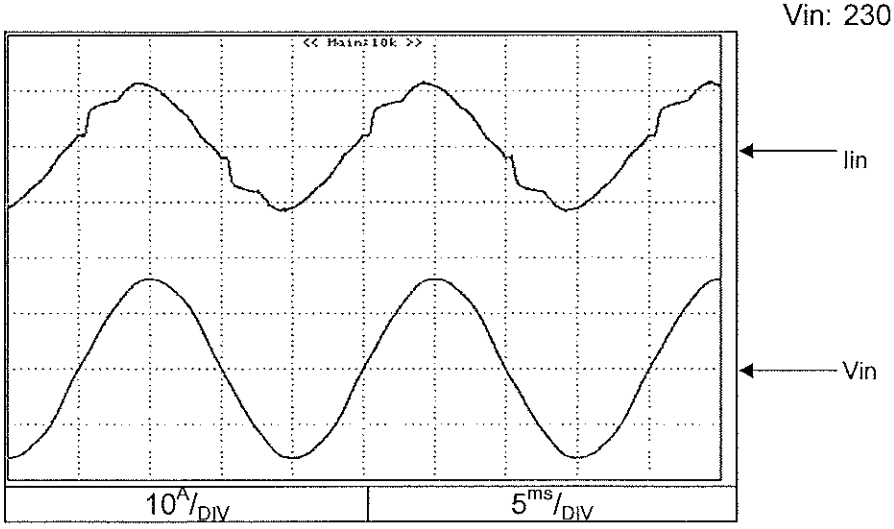
2.15. Input current waveform

CONDITIONS: Vout: 100%
Ta: 25˚C

Vin: 115 VAC



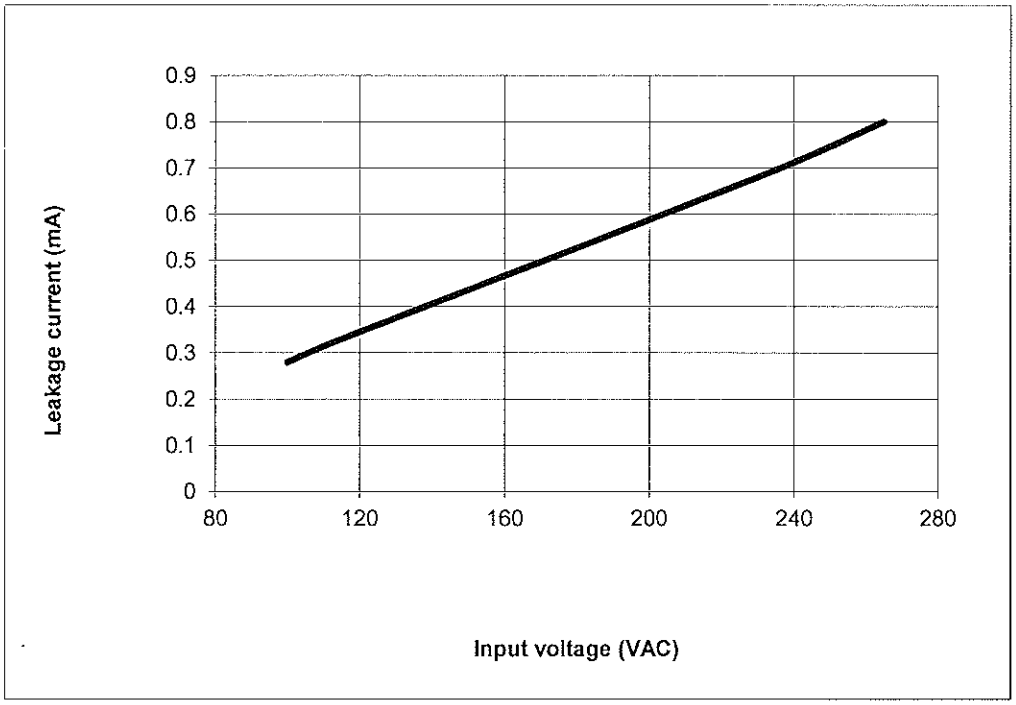
Vin: 230 VAC



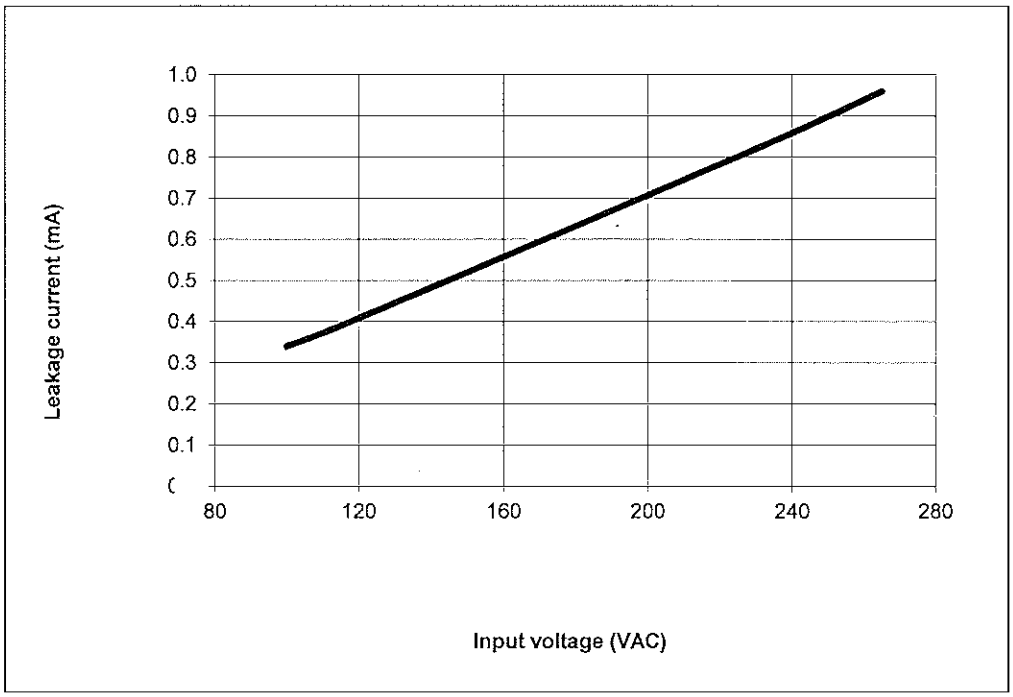
2.16. Leakage current characteristics

CONDITIONS: Iout: 100%
Ta: 25°C
f: 50Hz

L-G



N-G

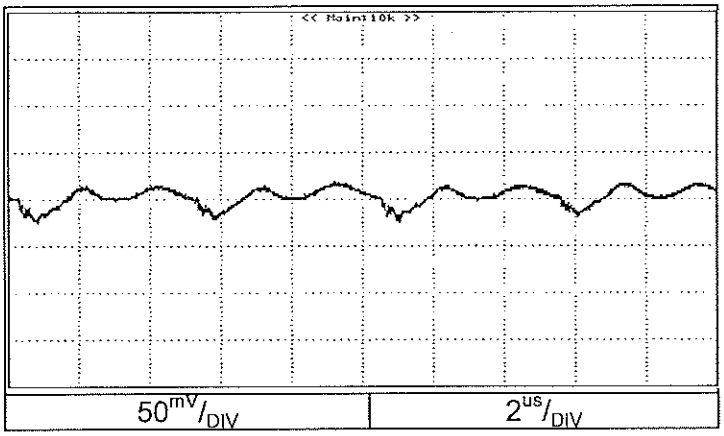


2.17. Output ripple and noise waveform

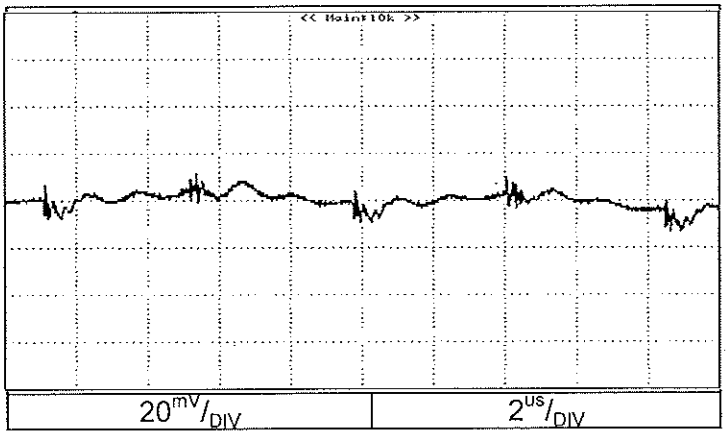
CONDITIONS: Vin: 115VAC
Iout: 100%
Ta: 25°C

Normal Mode

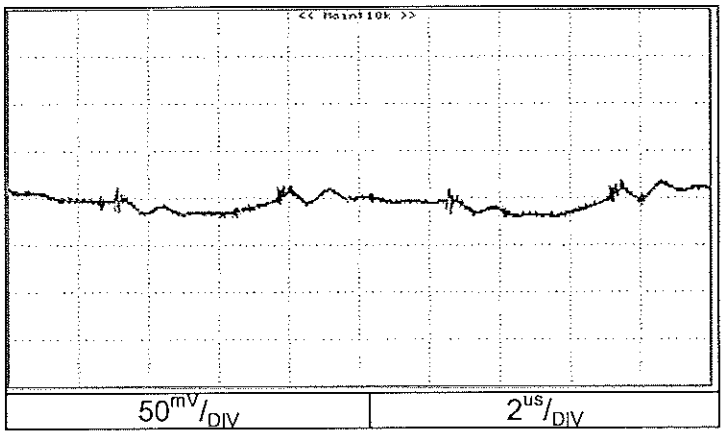
12V



24V



32V

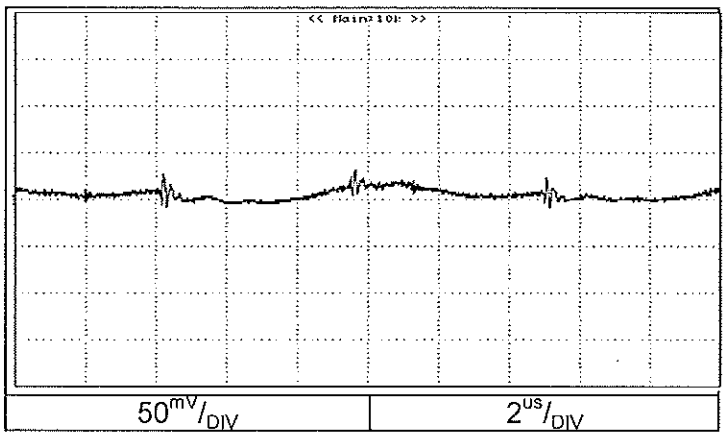


2.17. Output ripple and noise waveform

CONDITIONS: Vin: 115VAC
Iout: 100%
Ta: 25°C

Normal Mode

48V

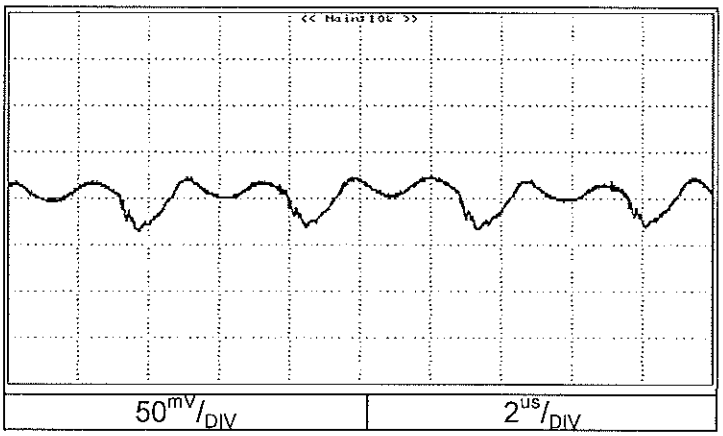


2.17. Output ripple and noise waveform

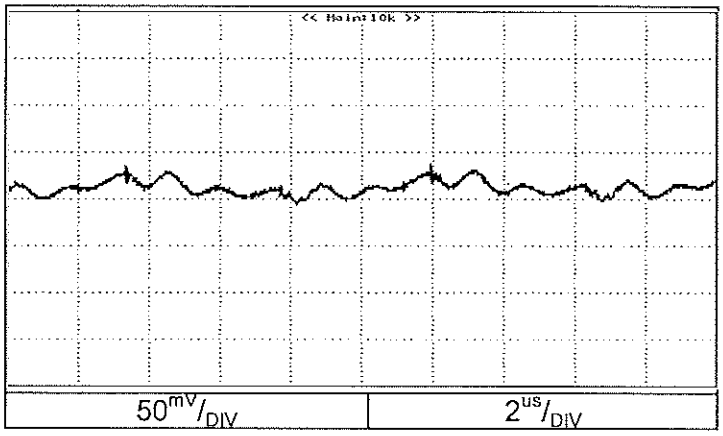
CONDITIONS: Vin: 230VAC
Iout: 100%
Ta: 25°C

Normal Mode

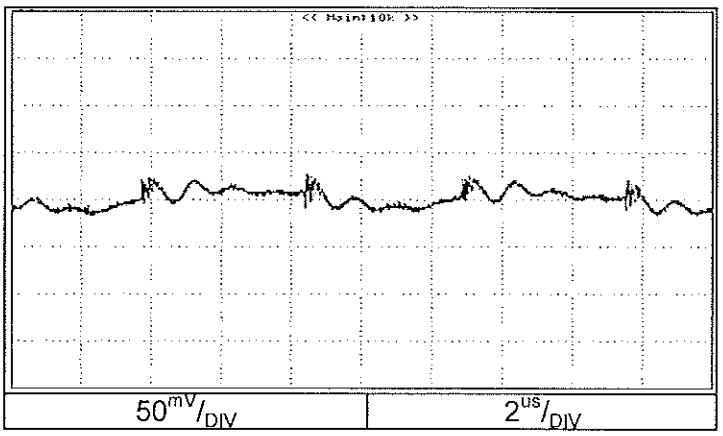
12V



24V



32V

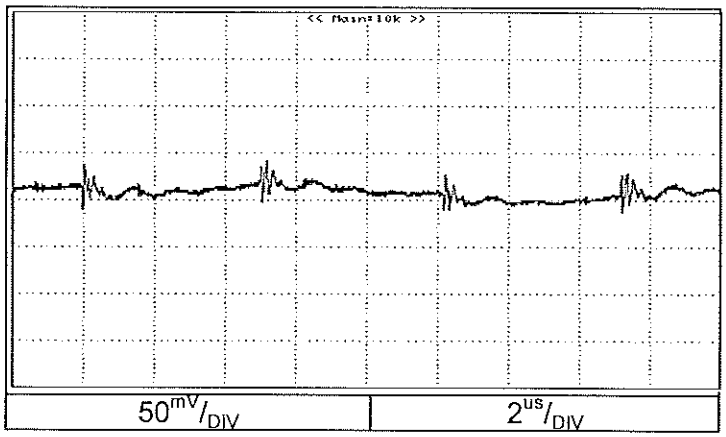


2.17. Output ripple and noise waveform

CONDITIONS: Vin: 230VAC
Iout: 100%
Ta: 25°C

Normal Mode

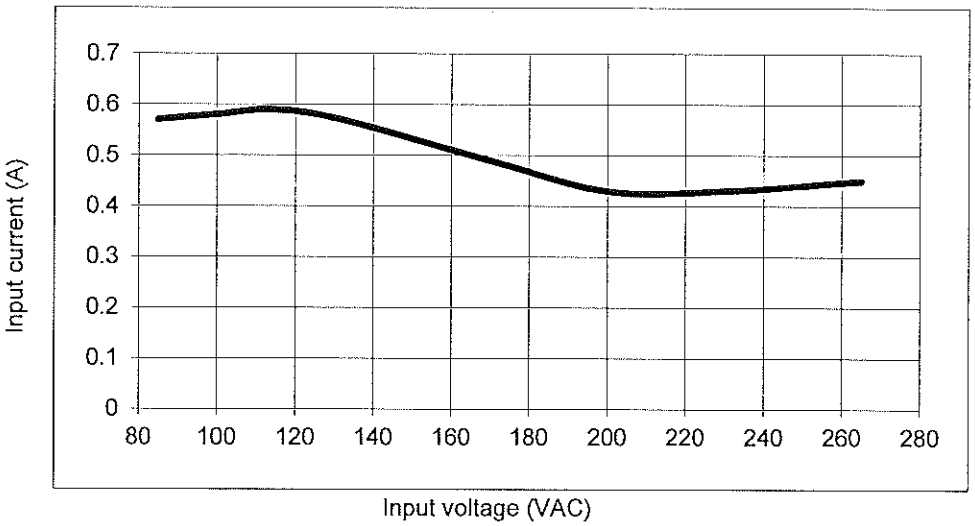
48V



2.18. Standby current

CONDITIONS: Ta: 25°C

Io=0%



Remote control OFF