# CUS500M1

# EVALUATION DATA

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Terminology used

| | Definition | |
|---|---|---|
| Vin | ..... | Input voltage |
| Vout | ..... | Output voltage |
| Iin | ..... | Input current |
| Iout | ..... | Output current |
| Ta | ..... | Ambient temperature |

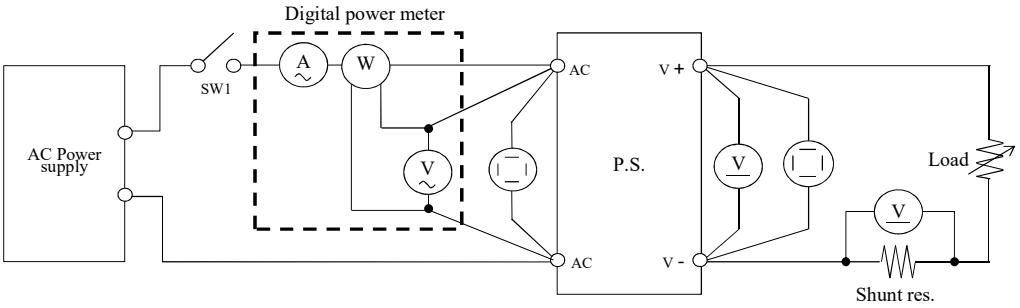
※ Test results are reference data based on our measurement condition.

## 1. Evaluation Method

1-1. Circuit used for determination

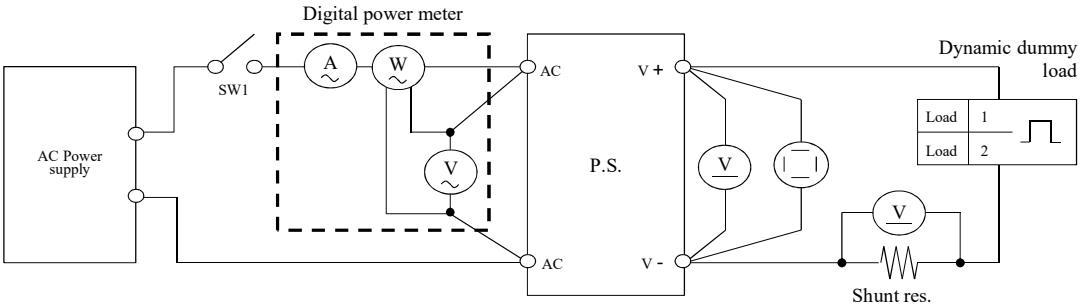
Circuit 1 used for determination

- Steady state data
- Warm up voltage drift characteristics
- Hold up time characteristics
- Output rise characteristics
- Output fall characteristics
- Over current protection (OCP) characteristics
- Over voltage protection (OVP) characteristics
- Response to brown out characteristics

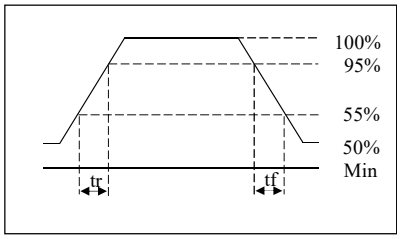



Circuit 2 used for determination

- Dynamic load response characteristics

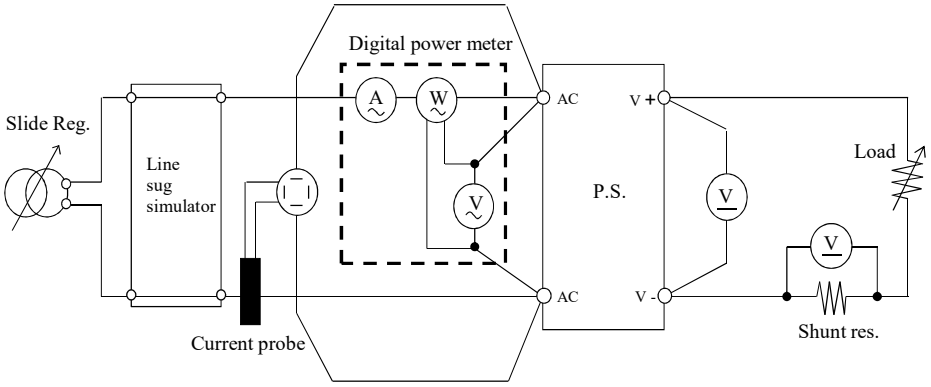



Output current waveform
Iout 50% <==> 100%



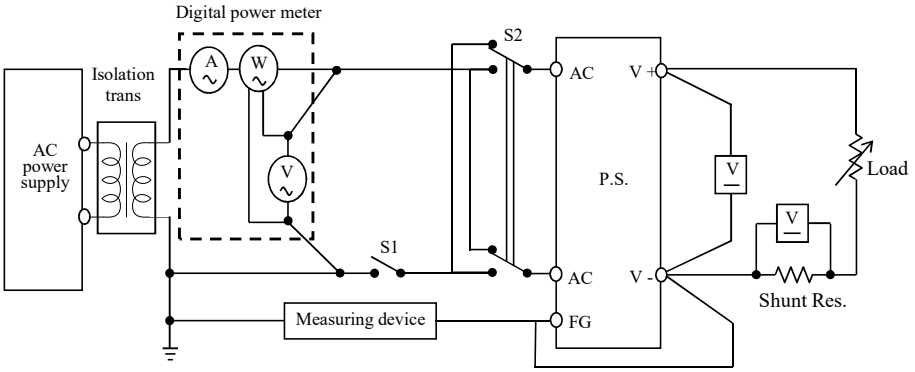
Circuit 3 used for determination

・Inrush current waveform



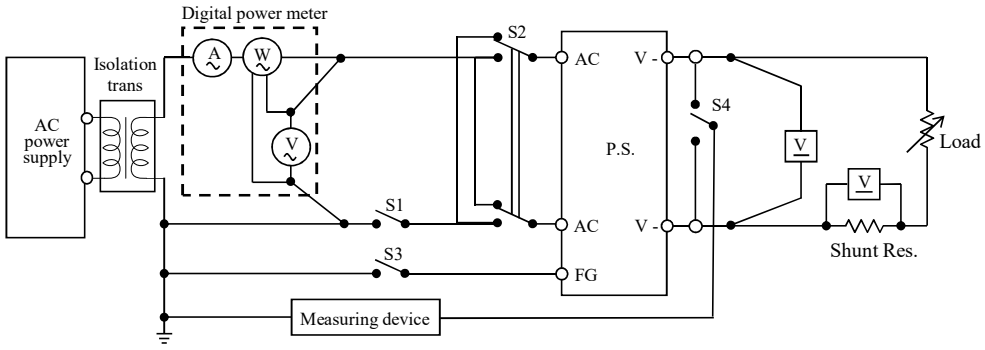

Circuit 4 used for determination

・Earth leakage current characteristics




Measure in all possible combination of position of S2 with :
S1 closed (normal condition), and S1 open (single fault condition)

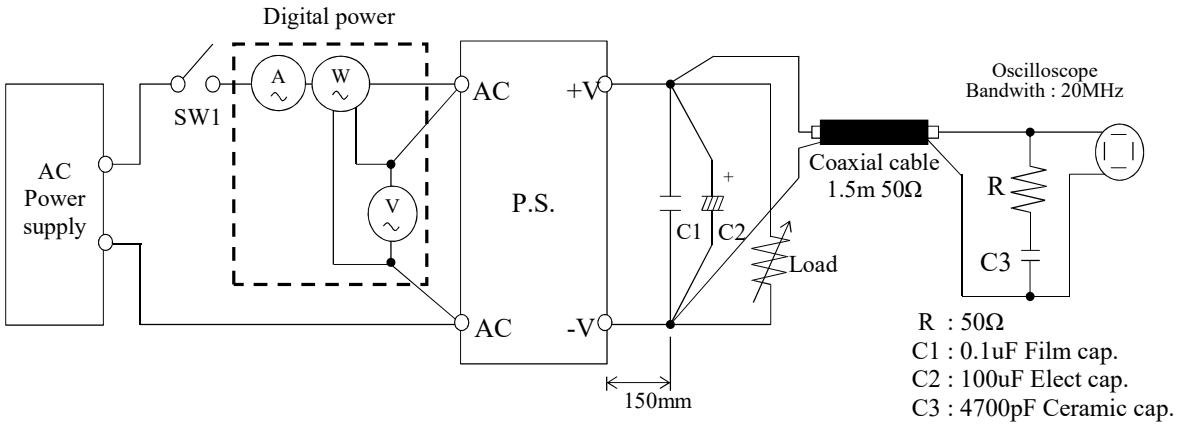
・Patient leakage current




CLASS I equipment:
S1, S3 closed, measure under all possible position of S2 & S4.
Single fault condition: S1 open with S3 close or S1 close with S3 open.

Circuit 5 used for determination

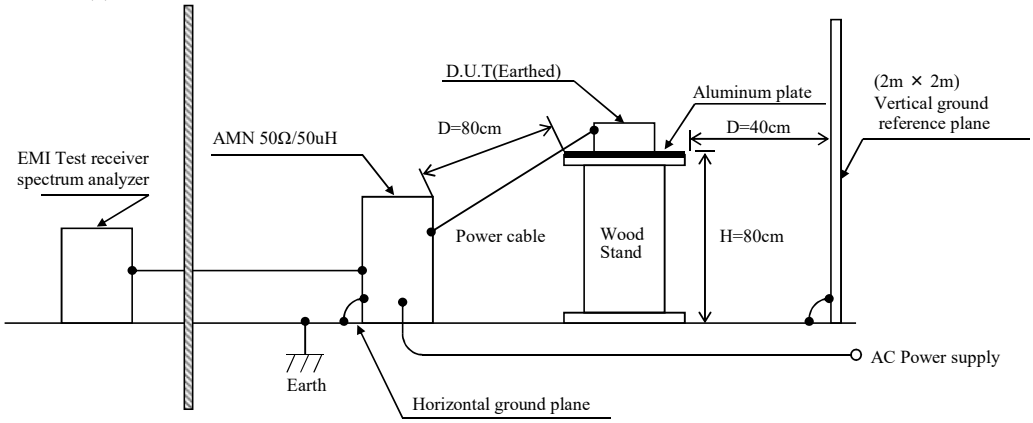
・Output ripple and noise waveform



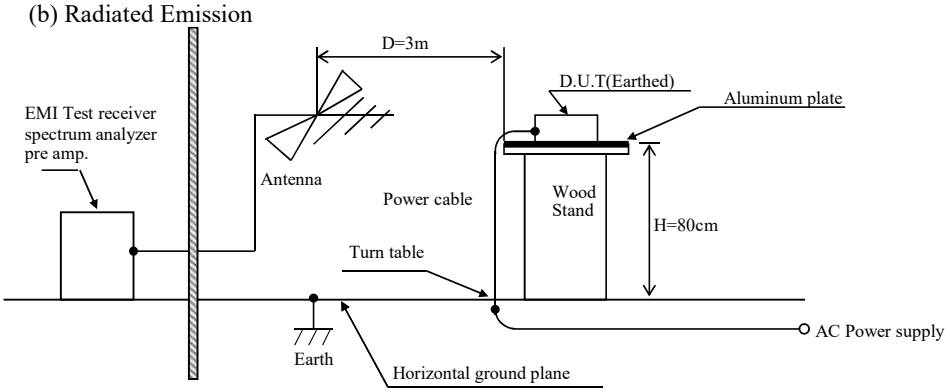

Configuration used for determination

・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 |
| 2 | DIGITAL MULTIMETER | AGILENT | 34970A |
| 3 | DIGITAL POWER METER | YOKOGAWA ELECT. | WT310E |
| 4 | CURRENT PROBE | YOKOGAWA ELECT. | 701930 |
| 5 | DC AMPERE METER | TEKTRONIX | P5100 |
| 6 | DYNAMIC DUMMY LOAD | CHROMA | 63030/63610/63640 |
| 7 | AC SOURCE | KIKUSUI | PCR2000LE |
| 8 | EARTH LEAKAGE CURRENT METER | SIMPSON | 228 |
| 9 | PATIENT LEAKAGE CURRENT METER | SIQ | SIQ16042 |
| 10 | CONTROLLED TEMP. CHAMBER | TABAI-ESPEC | SU-661 |
| 11 | EMI TEST RECEIVER | ROHDE & SCHWARZ | ESCI-03 |
| 12 | LISN | ROHDE & SCHWARZ | ENV216 |
| 13 | BROADBAND ANTENNA | SCHWARZBECK | VULB9168 |
| 14 | LINE SUG SIMULATOR | TAKAMISAWA | PSA-210 |

## 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 °C
Iout : 100 % (41.7A )
Cooling : Forced Air

| Iout \ Vin | 85VAC | 115VAC | 230VAC | 265VAC | Line regulation | |
|---|---|---|---|---|---|---|
| 0% | 11.967V | 11.965V | 11.972V | 11.969V | 7mV | 0.058% |
| 50% | 11.973V | 11.973V | 11.973V | 11.973V | 0mV | 0.000% |
| 100% | - | 11.987V | 11.987V | 11.987V | 0mV | 0.000% |
| Load | 6mV | 22mV | 15mV | 18mV | | |
| regulation | 0.050% | 0.183% | 0.125% | 0.150% | | |

2. Temperature drift

Condition Vin : 115 VAC
Iout : 100 % ( 41.7A )
Cooling : Forced Air

| Ta | -20°C | +25°C | +60°C | Temperature stability | |
|---|---|---|---|---|---|
| Vout | 11.987V | 12.012V | 12.010V | 25mV | 0.208% |

3. Start up voltage and Drop out voltage

Condition Ta : 25 °C
Iout : 80 % ( 33.4A )
Cooling : Forced Air

| | |
|---|---|
| Start up voltage (Vin) | 78.3VAC |
| Drop out voltage (Vin) | 77.2VAC |

24V

1. Regulation - line and load

Condition Ta : 25 °C
Iout : 100 % ( 20.9A )
Cooling : Forced Air

| Iout \ Vin | 85VAC | 115VAC | 230VAC | 265VAC | Line regulation | |
|---|---|---|---|---|---|---|
| 0% | 23.906V | 23.905V | 23.905V | 23.904V | 2mV | 0.008% |
| 50% | 23.910V | 23.909V | 23.909V | 23.909V | 1mV | 0.004% |
| 100% | - | 23.922V | 23.922V | 23.922V | 0mV | 0.000% |
| Load | 4mV | 17mV | 17mV | 18mV | | |
| regulation | 0.017% | 0.071% | 0.071% | 0.075% | | |

2. Temperature drift

Condition Vin : 115 VAC
Iout : 100 % (20.9A )
Cooling : Forced Air

| Ta | -20°C | +25°C | +60°C | Temperature stability | |
|---|---|---|---|---|---|
| Vout | 23.922V | 23.970V | 23.959V | 48mV | 0.200% |

3. Start up voltage and Drop out voltage

Condition Ta : 25 °C
Iout : 80 % (16.7A )
Cooling : Forced Air

| | |
|---|---|
| Start up voltage (Vin) | 77.9VAC |
| Drop out voltage (Vin) | 76.7VAC |

48V

1. Regulation - line and load

Condition Ta : 25 °C
Iout : 100 % ( 10.5A )
Cooling : Forced Air

| Iout \ Vin | 85VAC | 115VAC | 230VAC | 265VAC | Line regulation | |
|---|---|---|---|---|---|---|
| 0% | 47.911V | 47.910V | 47.910V | 47.910V | 1mV | 0.002% |
| 50% | 47.906V | 47.906V | 47.905V | 47.905V | 1mV | 0.002% |
| 100% | - | 47.918V | 47.917V | 47.917V | 1mV | 0.002% |
| Load | 5mV | 12mV | 12mV | 12mV | | |
| regulation | 0.010% | 0.025% | 0.025% | 0.025% | | |

2. Temperature drift

Condition Vin : 115 VAC
Iout : 100 % ( 10.5A )
Cooling : Forced Air

| Ta | -20°C | +25°C | +60°C | Temperature stability | |
|---|---|---|---|---|---|
| Vout | 47.918V | 48.045V | 48.054V | 136mV | 0.283% |

3. Start up voltage and Drop out voltage

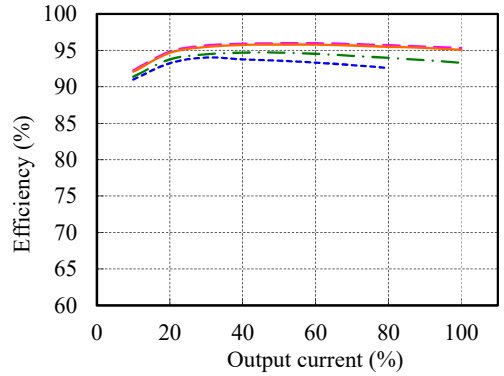
Condition Ta : 25 °C
Iout : 80 % ( 8.4A )
Cooling : Forced Air

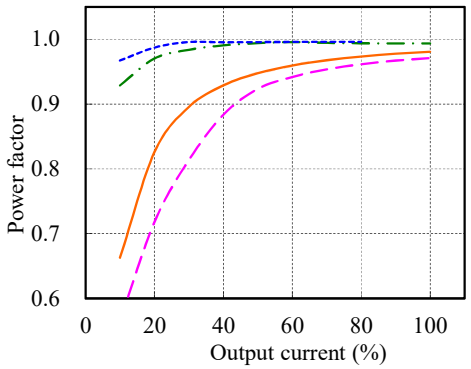
| | |
|---|---|
| Start up voltage (Vin) | 78.3VAC |
| Drop out voltage (Vin) | 77.0VAC |

(2) Efficiency and Power factor vs. Output current

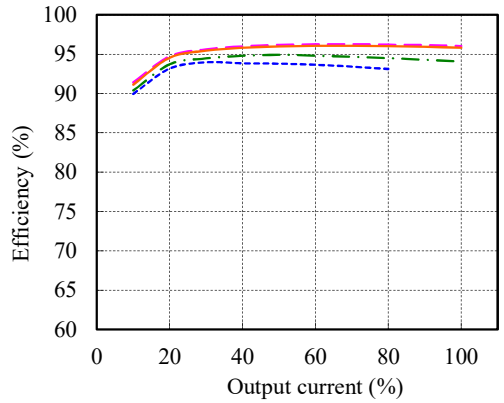
Conditions Vin : 85 VAC
115 VAC
230 VAC
265 VAC
Ta : 25 ℃
Cooling : Forced air

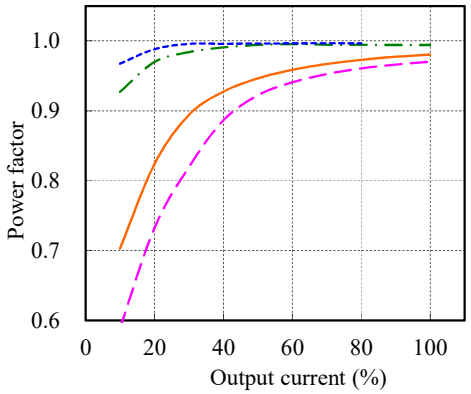
12V



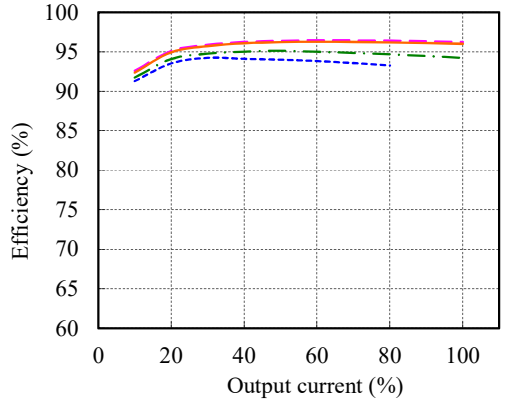



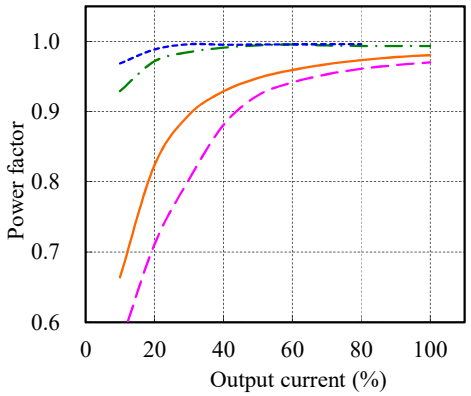

24V




48V



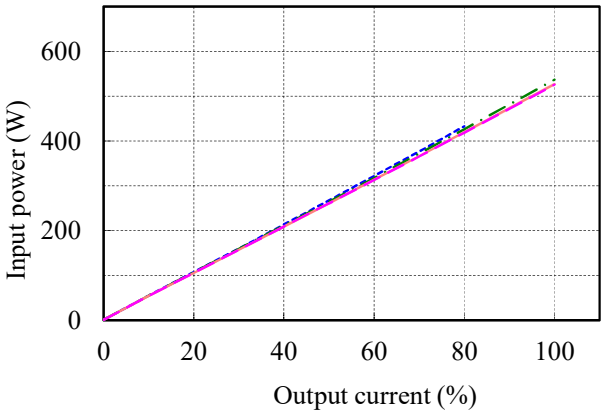



(3) Input power vs. Output current

Conditions Vin : 85 VAC
115 VAC
230 VAC
265 VAC
Ta : 25 ℃
Cooling : Forced air

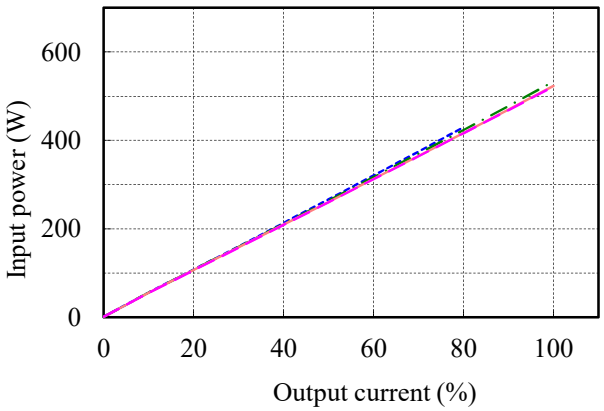
12V

| Vin | Input power |
|---|---|
| | Iout : 0% |
| 85VAC | 1.1W |
| 115VAC | 0.8W |
| 230VAC | 0.8W |
| 265VAC | 0.8W |



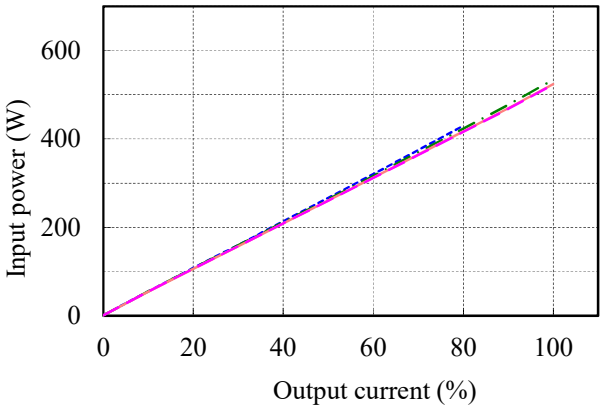

24V

| Vin | Input power |
|---|---|
| | Iout : 0% |
| 85VAC | 1.1W |
| 115VAC | 0.9W |
| 230VAC | 0.9W |
| 265VAC | 0.9W |




48V

| Vin | Input power |
|---|---|
| | Iout : 0% |
| 85VAC | 1.4W |
| 115VAC | 1.1W |
| 230VAC | 1.0W |
| 265VAC | 1.1W |

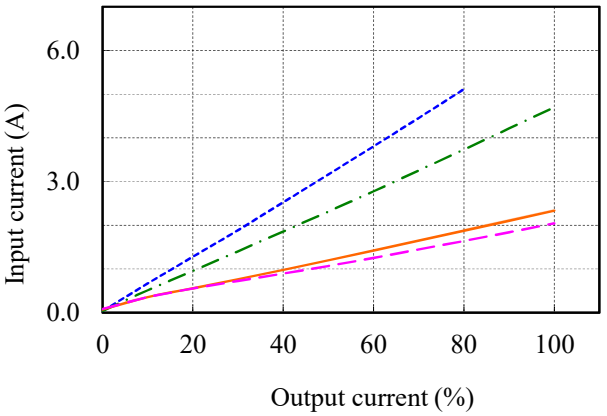


(4) Input current vs. Output current

Conditions Vin : 85 VAC
115 VAC
230 VAC
265 VAC
Ta : 25 °C
Cooling : Forced air

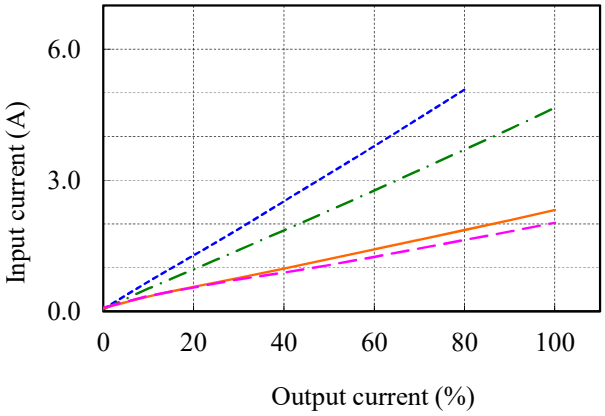
12V

| Vin | Input current |
|---|---|
| | Iout : 0% |
| 85VAC | 0.04A |
| 115VAC | 0.04A |
| 230VAC | 0.07A |
| 265VAC | 0.08A |



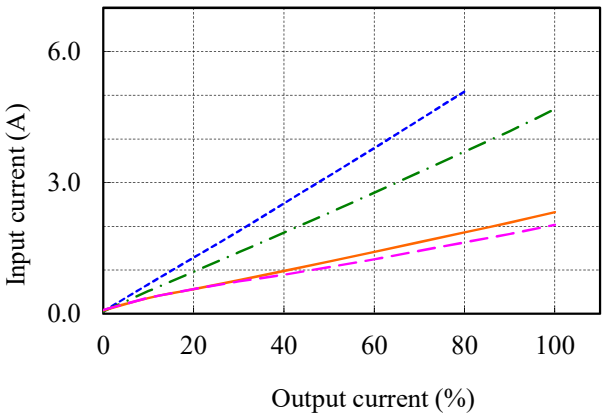

24V

| Vin | Input current |
|---|---|
| | Iout : 0% |
| 85VAC | 0.05A |
| 115VAC | 0.05A |
| 230VAC | 0.07A |
| 265VAC | 0.08A |




48V

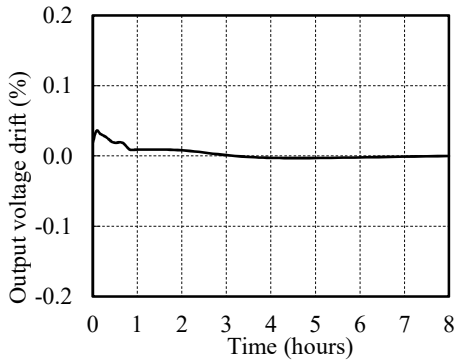
| Vin | Input current |
|---|---|
| | Iout : 0% |
| 85VAC | 0.05A |
| 115VAC | 0.05A |
| 230VAC | 0.08A |
| 265VAC | 0.09A |



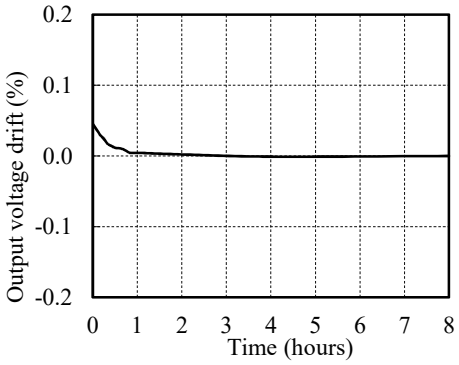
## 2-2. Warm up voltage drift characteristics

Conditions Vin : 115 VAC
Iout : 100 %
Ta : 25 °C
Cooling : Forced Air

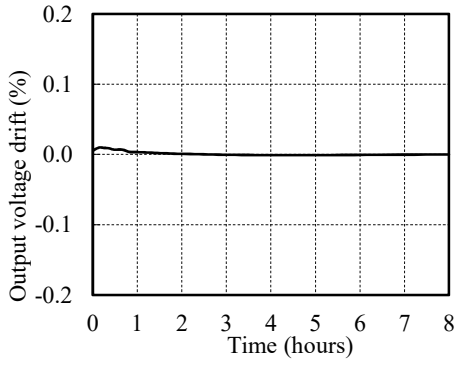
12V




24V

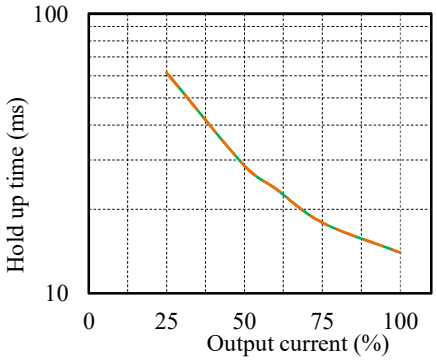


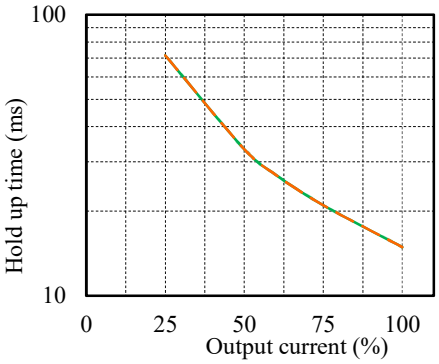

48V

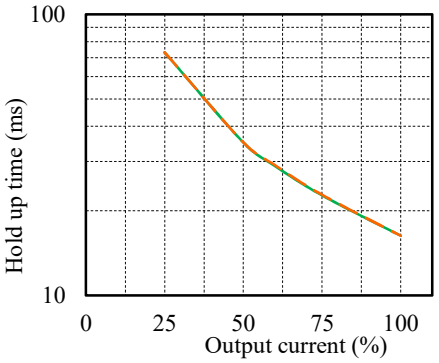



## 2-3. Hold up time characteristics

Conditions Vin : 115 VAC
230 VAC
Ta : 25 °C
Cooling : Forced Air



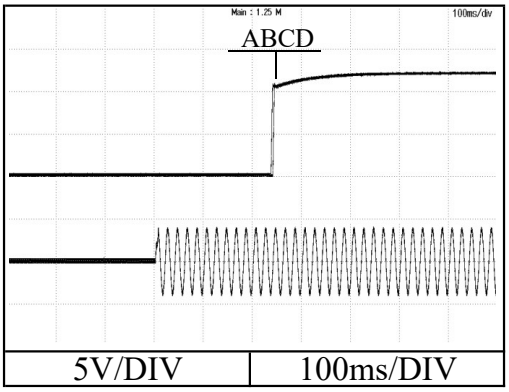



2-4. Output rise characteristics

Conditions Vin : 85 VAC (A)
115 VAC (B)
230 VAC (C)
265 VAC (D)
Ta : 25 °C
Cooling : Forced Air

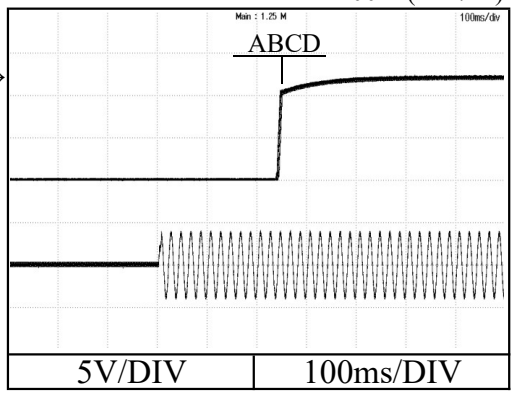
12V

Iout : 0%



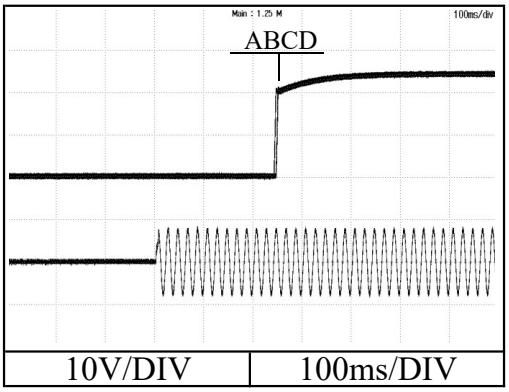

← Vout →
← 0V →
← Vin →

Iout : 100% ( 41.7A )



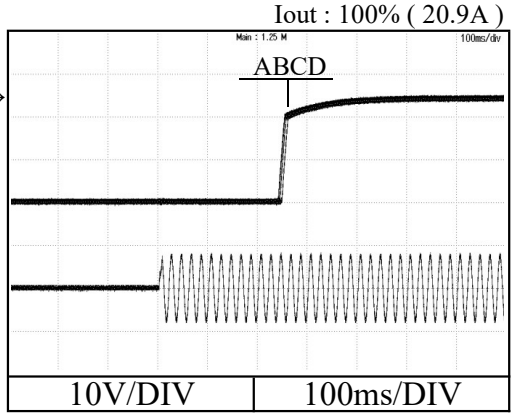

24V

Iout : 0%



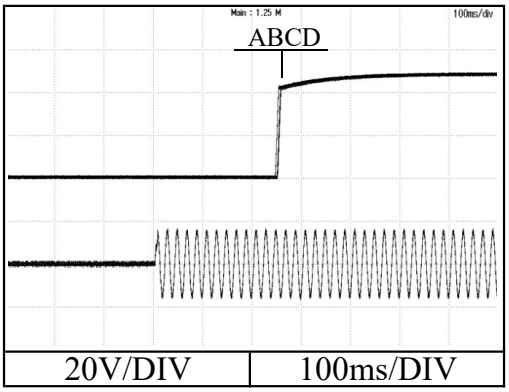

← Vout →
← 0V →
← Vin →

Iout : 100% ( 20.9A )



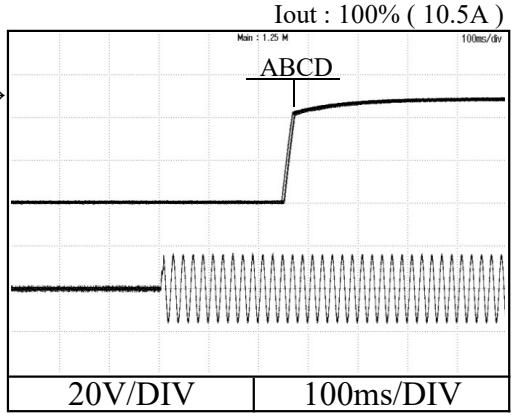

48V

Iout : 0%




← Vout →
← 0V →
← Vin →

Iout : 100% ( 10.5A )

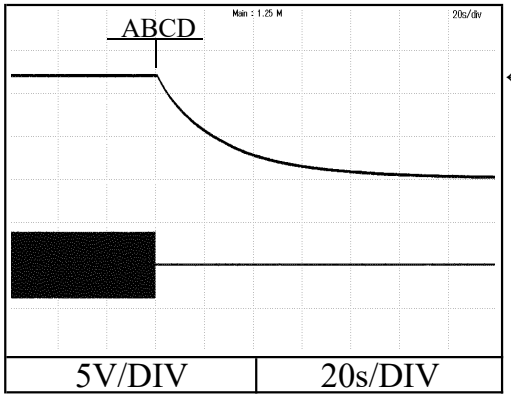


2-5. Output fall characteristics

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

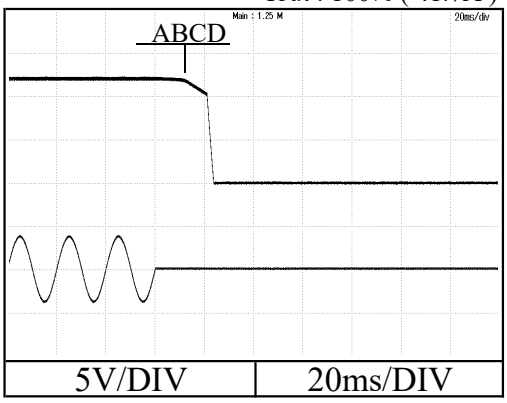
12V

Iout : 0%



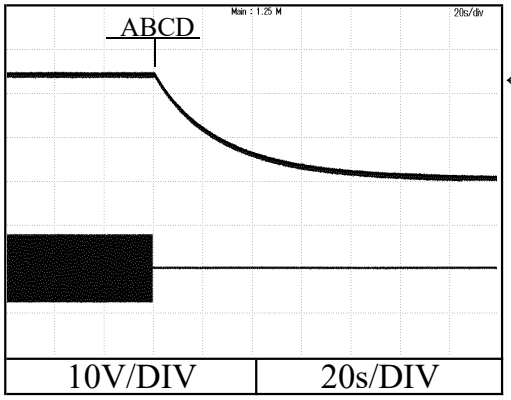

← Vout →
← 0V →
← Vin →

Iout : 100% ( 41.7A )



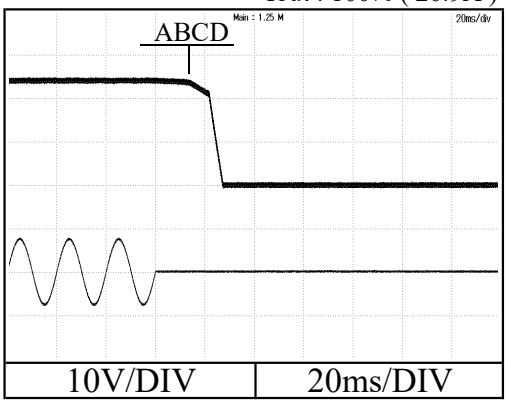

24V

Iout : 0%



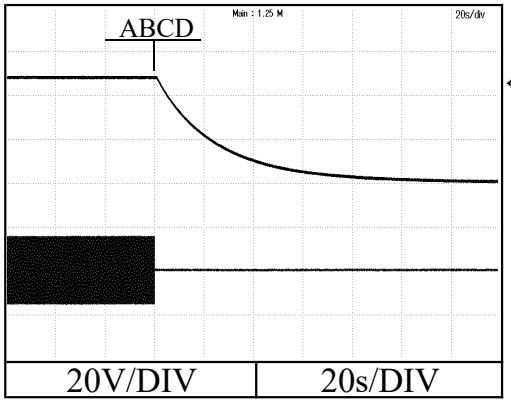

← Vout →
← 0V →
← Vin →

Iout : 100% ( 20.9A )



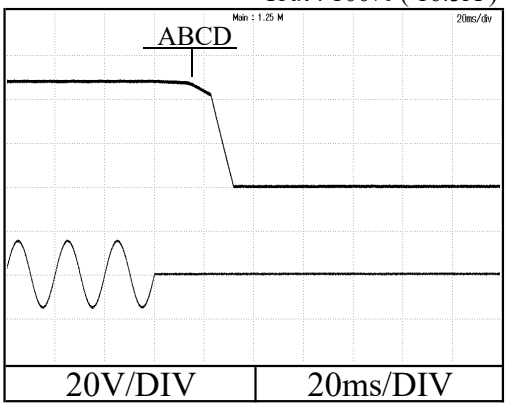

48V

Iout : 0%




← Vout →
← 0V →
← Vin →

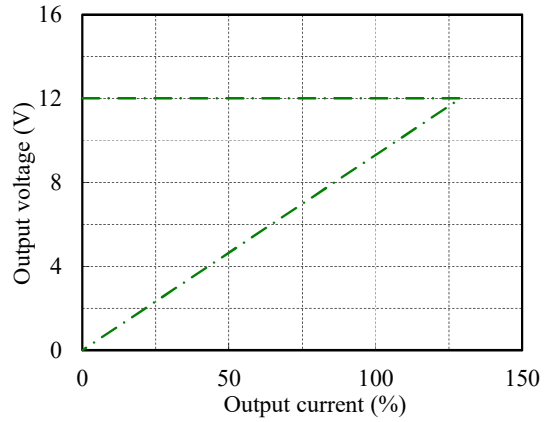
Iout : 100% ( 10.5A )



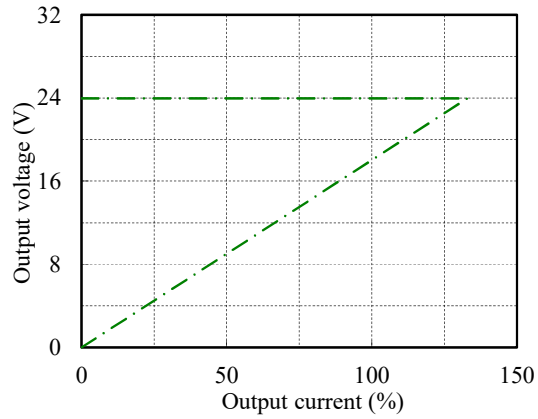
## 2-6. Over current protection (OCP) characteristics

Conditions Vin : 115 VAC
Ta : 25 ℃
Cooling : Forced Air

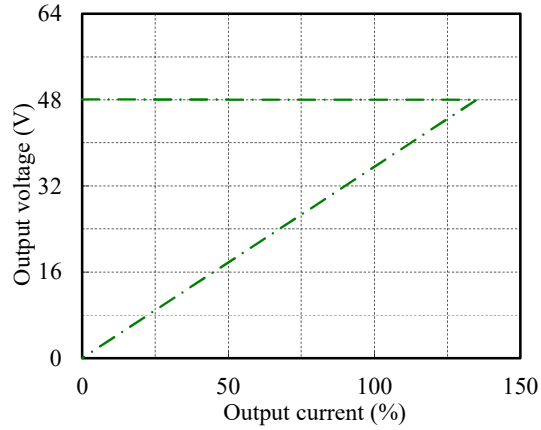
12V




24V



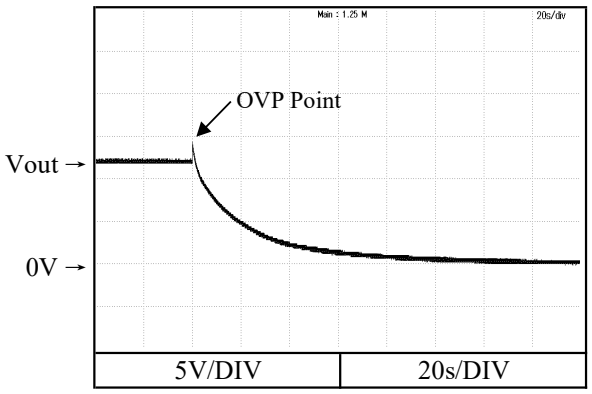

48V



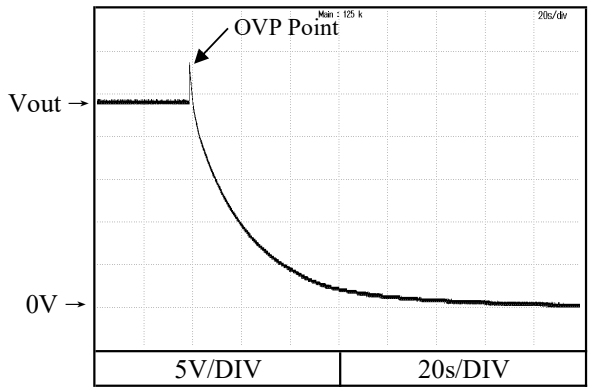

## 2-7. Over voltage protection (OVP) characteristics

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

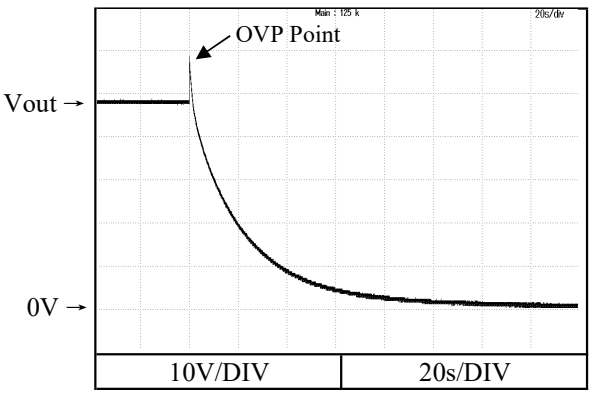
12V




24V




48V

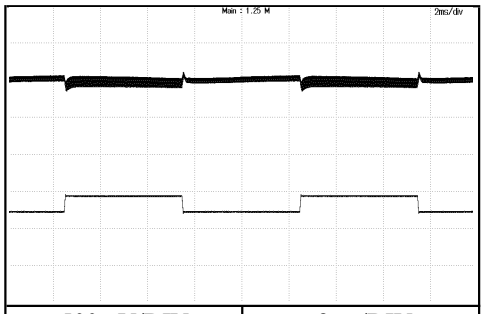


2-8. Dynamic load response characteristics

Conditions Vin : 115 VAC
Iout : 50 %↔ 100 %
(tr = tf = 50us)
Ta : 25 ℃
Cooling : Forced Air

12V

f = 100Hz

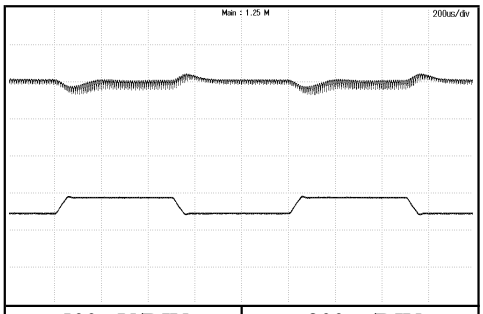


| 500mV/DIV | 2ms/DIV |
|---|---|
| +0.92% | -1.26% |

←Vout→

←Iout→
←Iout:0%→

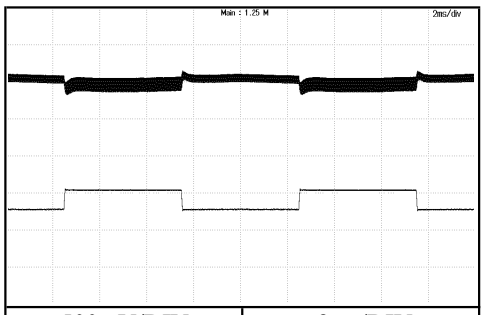
f = 1kHz



| 500mV/DIV | 200µs/DIV |
|---|---|
| +0.94% | -1.47% |

24V

f = 100Hz

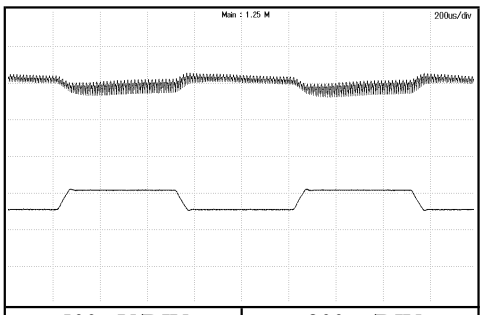


| 500mV/DIV | 2ms/DIV |
|---|---|
| +0.63% | -0.72% |

←Vout→

←Iout→
←Iout:0%→

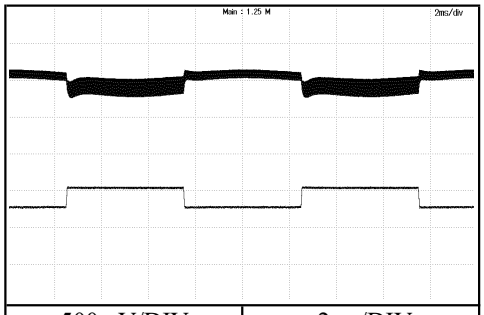
f = 1kHz



| 500mV/DIV | 200µs/DIV |
|---|---|
| +0.58% | -0.79% |

48V

f = 100Hz

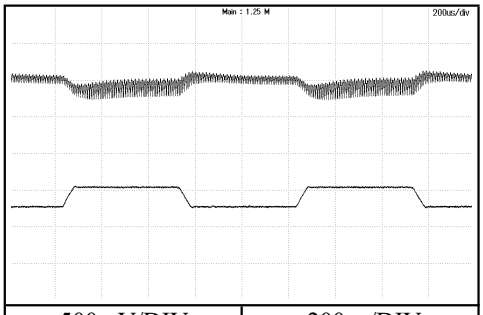


| 500mV/DIV | 2ms/DIV |
|---|---|
| +0.31% | -0.50% |

←Vout→

←Iout→
←Iout:0%→

f = 1kHz



| 500mV/DIV | 200µs/DIV |
|---|---|
| +0.28% | -0.56% |

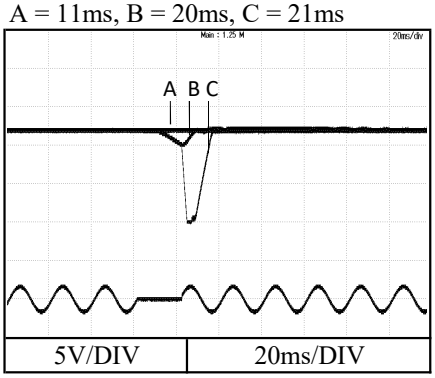
2-9. Response to brown out characteristics

Conditions Iout : 100 %
Ta : 25 ℃
Cooling : Forced Air

Interruption time
A : Output voltage does not drop.
B : Output voltage drop down to 20~40% of the nominal output voltage.
C : Output voltage drops until 0V.

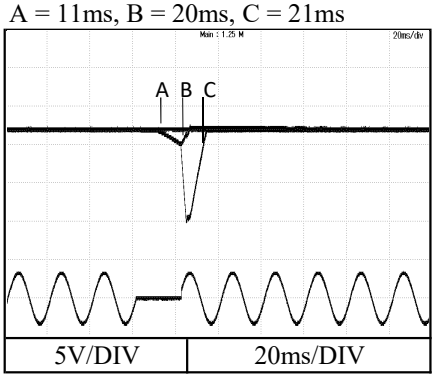
12V

Vin : 115VAC
A = 11ms, B = 20ms, C = 21ms



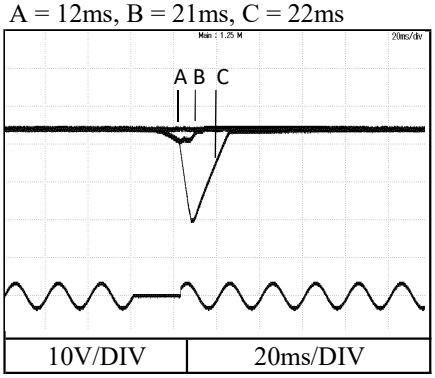

←Vout→
←0V→
←Vin→

Vin : 230VAC
A = 11ms, B = 20ms, C = 21ms



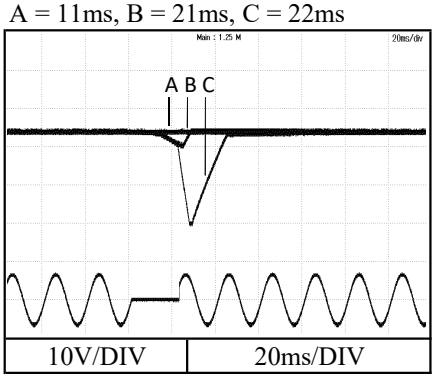

24V

Vin : 115VAC
A = 12ms, B = 21ms, C = 22ms



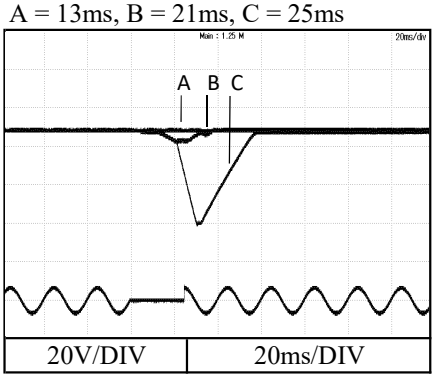

←Vout→
←0V→
←Vin→

Vin : 230VAC
A = 11ms, B = 21ms, C = 22ms



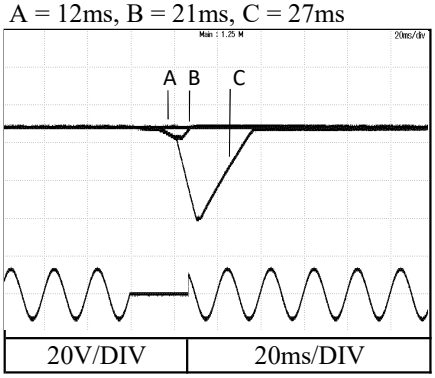

48V

Vin : 115VAC
A = 13ms, B = 21ms, C = 25ms




←Vout→
←0V→
←Vin→

Vin : 230VAC
A = 12ms, B = 21ms, C = 27ms

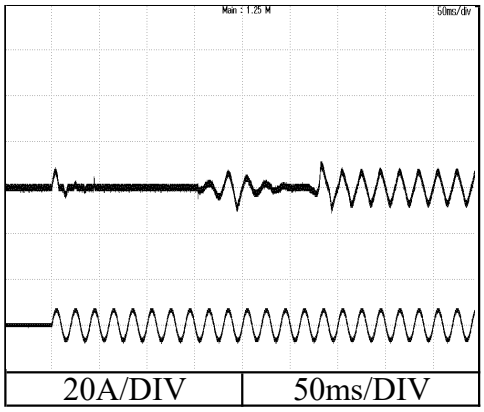


2-10. Inrush current waveform

Conditions Vin : 115 VAC
Iout : 10.5A (100%)
Ta : 25 ℃
Cooling : Forced Air

48V

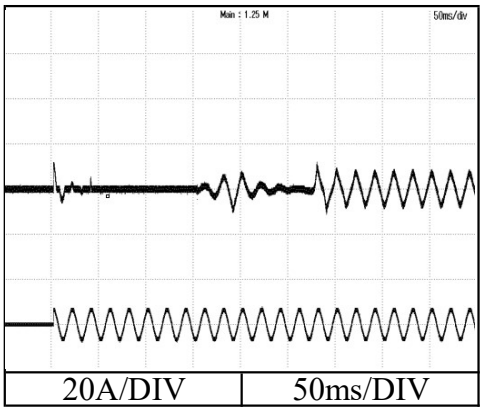
Switch on phase angle of input AC voltage
ϕ = 0°




← Iin →

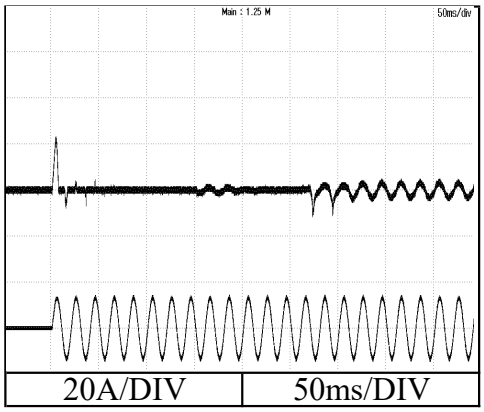
← Vin →

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




Conditions Vin : 230 VAC
Iout : 10.5A (100%)
Ta : 25 ℃
Cooling : Forced Air

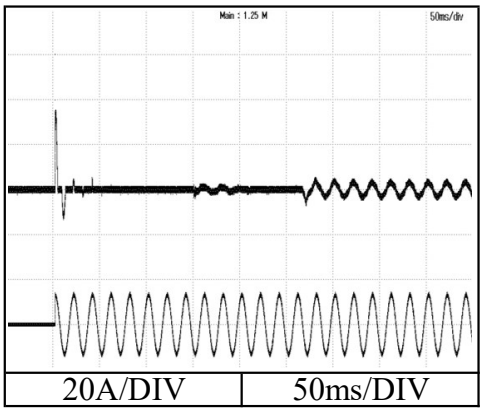
Switch on phase angle of input AC voltage
ϕ = 0°




← Iin →

← Vin →

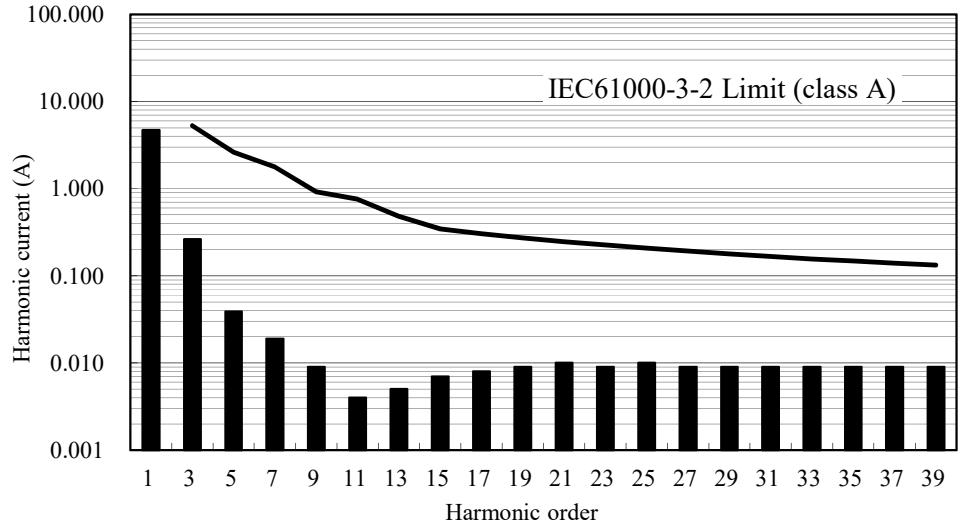
Switch on phase angle of input AC voltage
ϕ = 90°



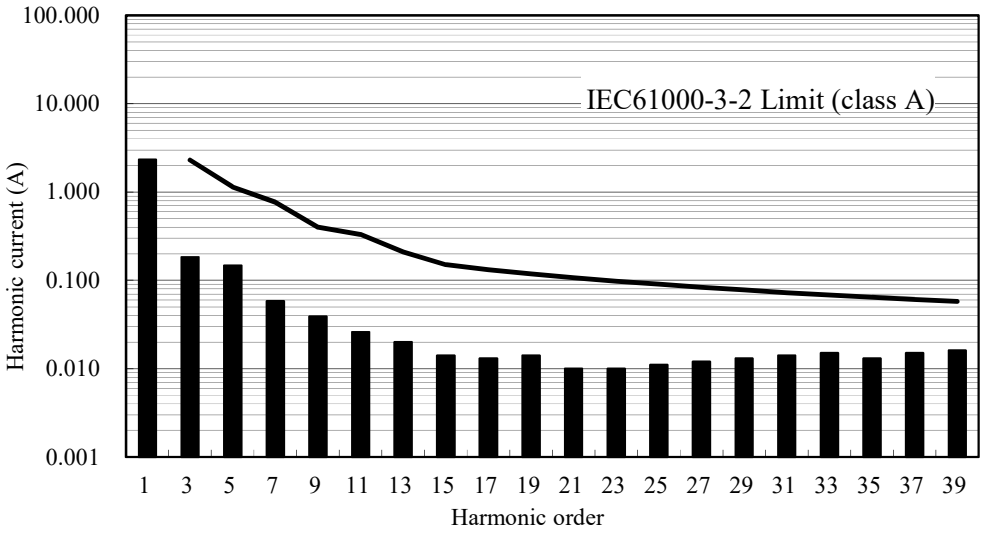
2-11. Input current harmonics

Conditions
Vin : 115 VAC
Iout : 10.5A (100%)
Ta : 25 ℃
Cooling : Forced Air

48V




Conditions
Vin : 230 VAC
Iout : 10.5A (100%)
Ta : 25 ℃
Cooling : Forced Air

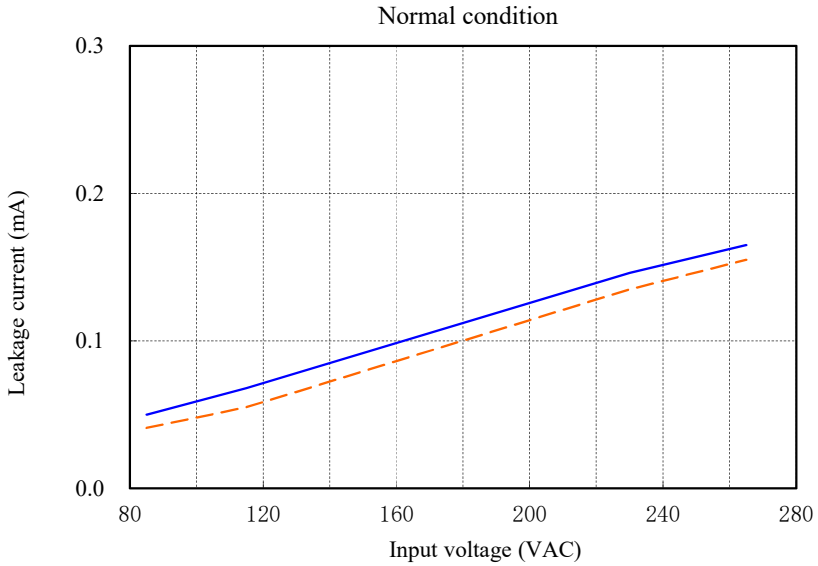


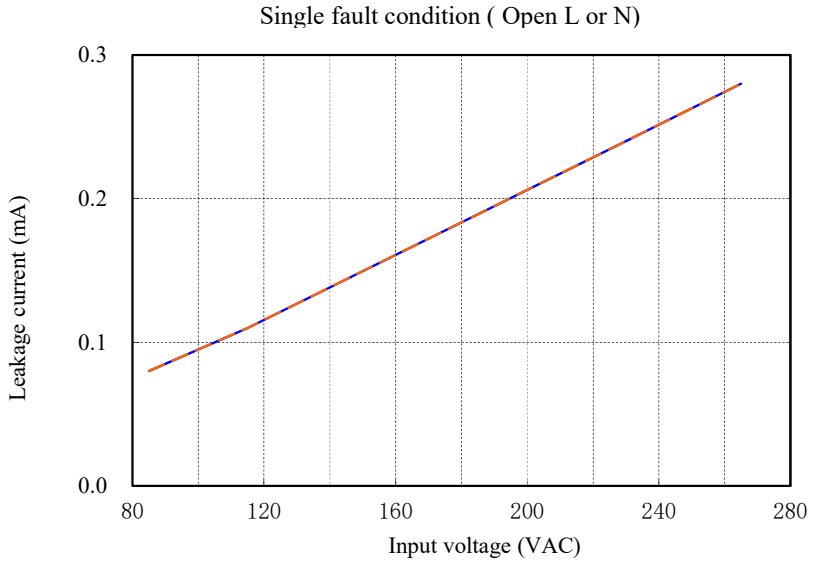
2-12. Leakage current characteristics

Earth leakage current of CLASS I equipment

Conditions Iout : 0 %
100 %
Ta : 25 °C
f : 60 Hz
Cooling : Forced Air

48V



2-12. Leakage current characteristics

Patient leakage current of CLASS I equipment

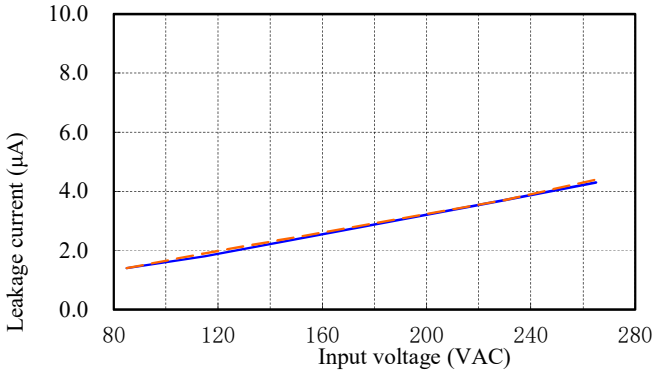
Conditions Iout : 0 %
100 %
Ta : 25 °C
f : 60 Hz
Cooling : Forced Air

48V

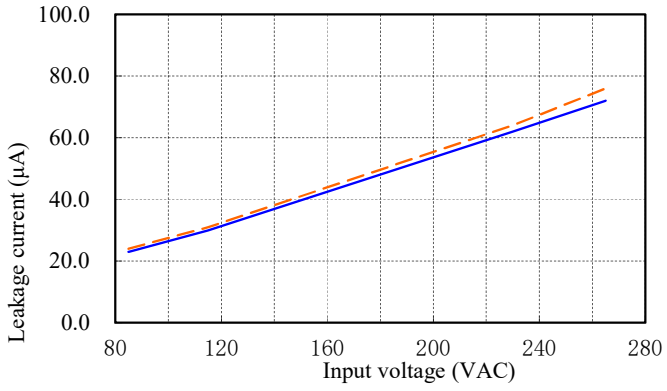
Normal condition




Single fault condition (Open L or N)




Single fault condition (Open FG)

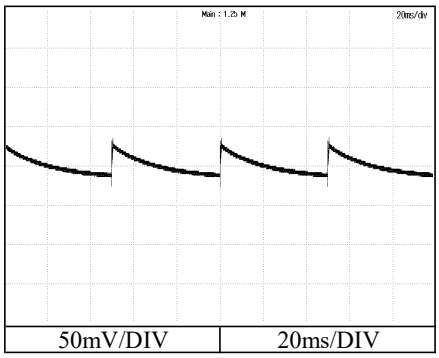


2-13. Output ripple and noise waveform

Conditions Vin : 115 VAC
Ta : 25 ℃
Cooling : Forced Air

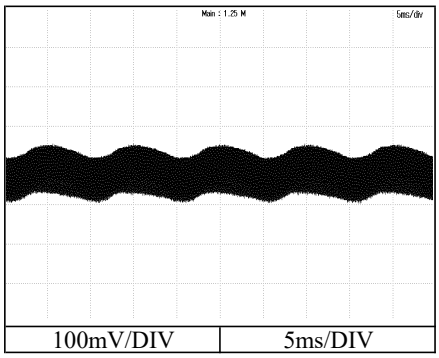
12V

Iout : 0 %




50mV/DIV | 20ms/DIV

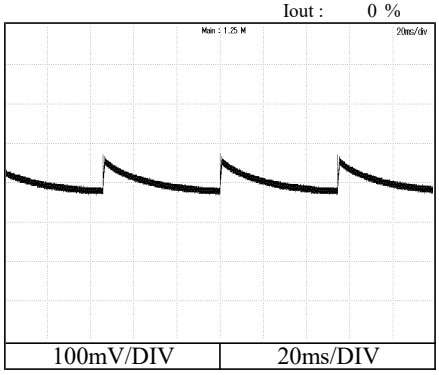
Iout : 100 %




100mV/DIV | 5ms/DIV

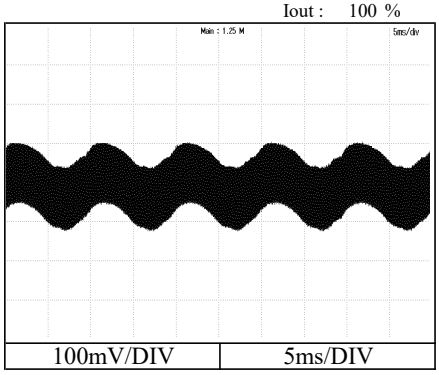
24V

Iout : 0 %




100mV/DIV | 20ms/DIV

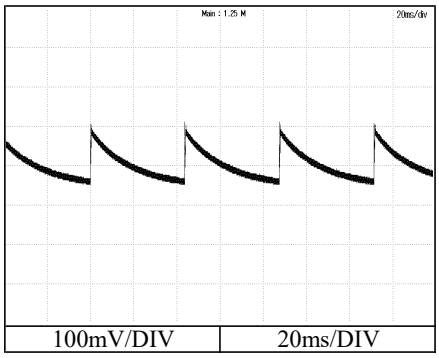
Iout : 100 %




100mV/DIV | 5ms/DIV

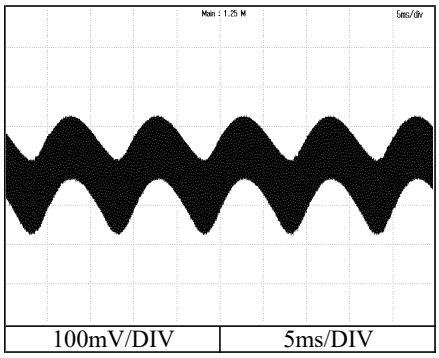
48V

Iout : 0 %




100mV/DIV | 20ms/DIV

Iout : 100 %




100mV/DIV | 5ms/DIV

2-14. Electro-Magnetic Interference characteristics

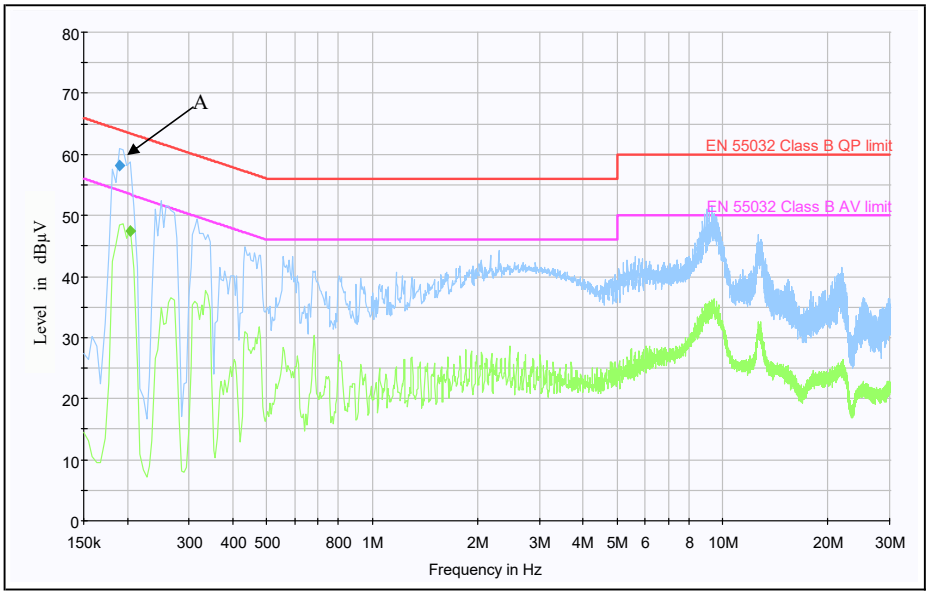
Conditions Vin : 115 VAC
Iout : 41.7 A (100%)
Ta : 25 ℃
Cooling : Forced Air

Conducted Emission

12V

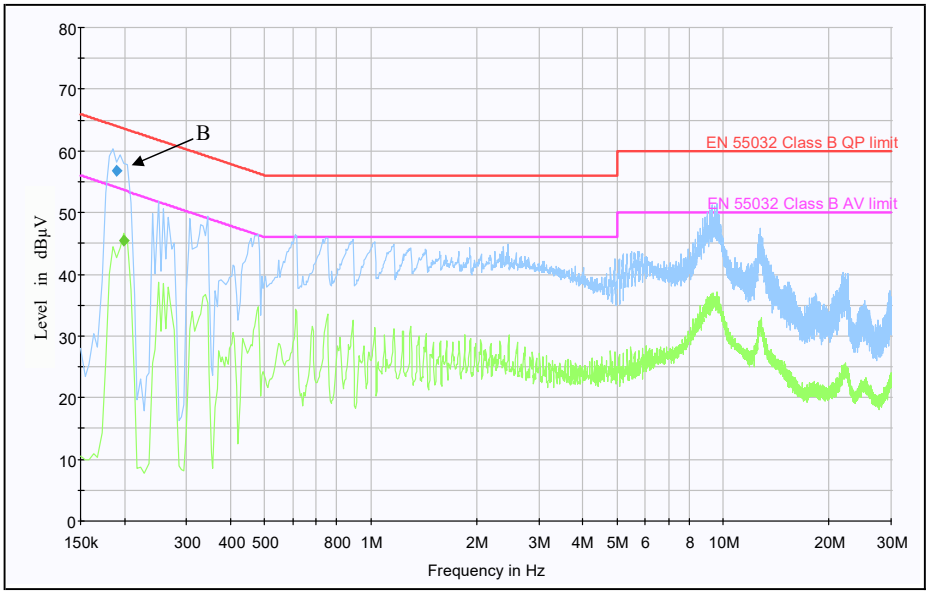
Phase : L

| Ref. Data | Point A (190kHz) Limit (dB) | Measure (dB) |
|---|---|---|
| QP | 64.0 | 58.1 |
| AV | 53.4 | 47.5 |




Phase : N

| Ref. Data | Point B (190kHz) Limit (dB) | Measure (dB) |
|---|---|---|
| QP | 64.0 | 56.8 |
| AV | 53.6 | 45.4 |



2-14. Electro-Magnetic Interference characteristics

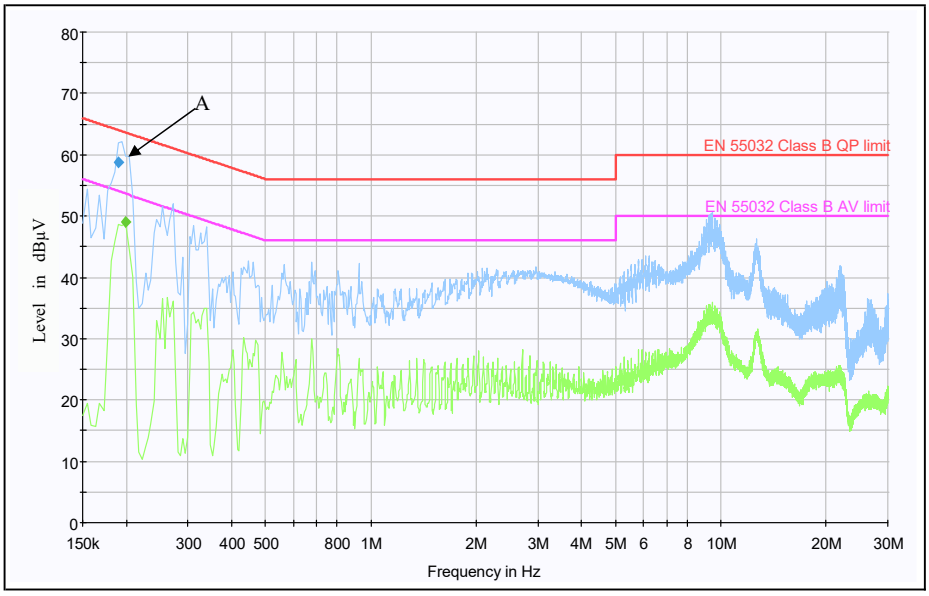
Conditions Vin : 230 VAC
Iout : 41.7 A (100%)
Ta : 25 ℃
Cooling : Forced Air

Conducted Emission

12V

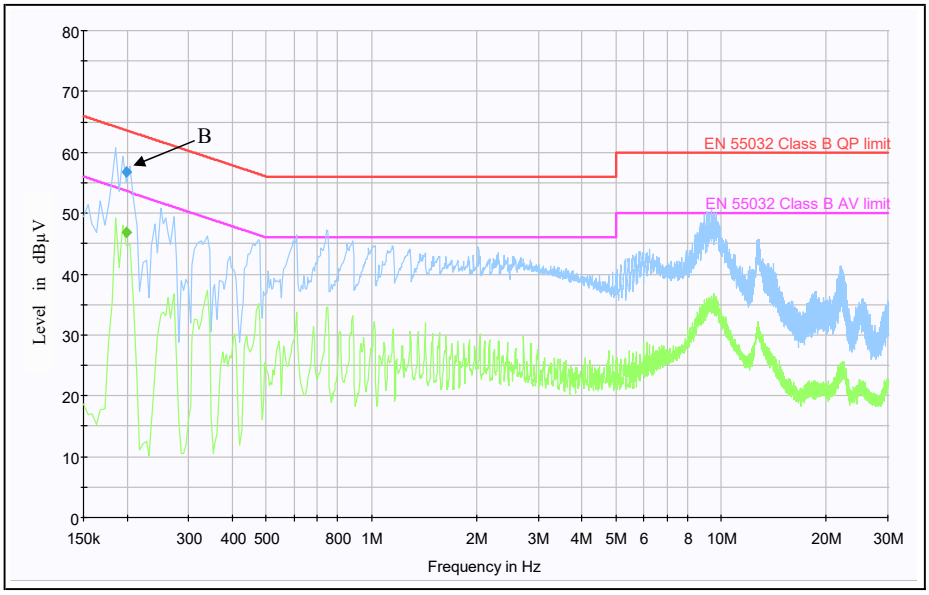
Phase : L

| Ref. Data | Point A (199kHz) Limit (dB) | Measure (dB) |
|---|---|---|
| QP | 64.0 | 58.8 |
| AV | 53.6 | 49.0 |




Phase : N

| Ref. Data | Point B (199kHz) Limit (dB) | Measure (dB) |
|---|---|---|
| QP | 63.6 | 56.7 |
| AV | 53.6 | 46.8 |



2-14. Electro-Magnetic Interference characteristics

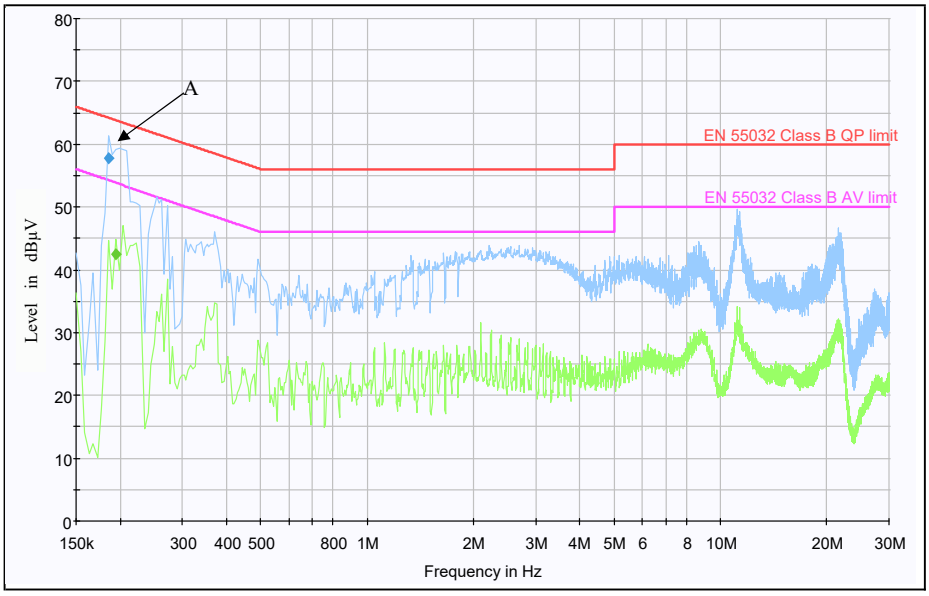
Conditions Vin : 115 VAC
Iout : 20.9 A (100%)
Ta : 25 ℃
Cooling : Forced Air

Conducted Emission

24V

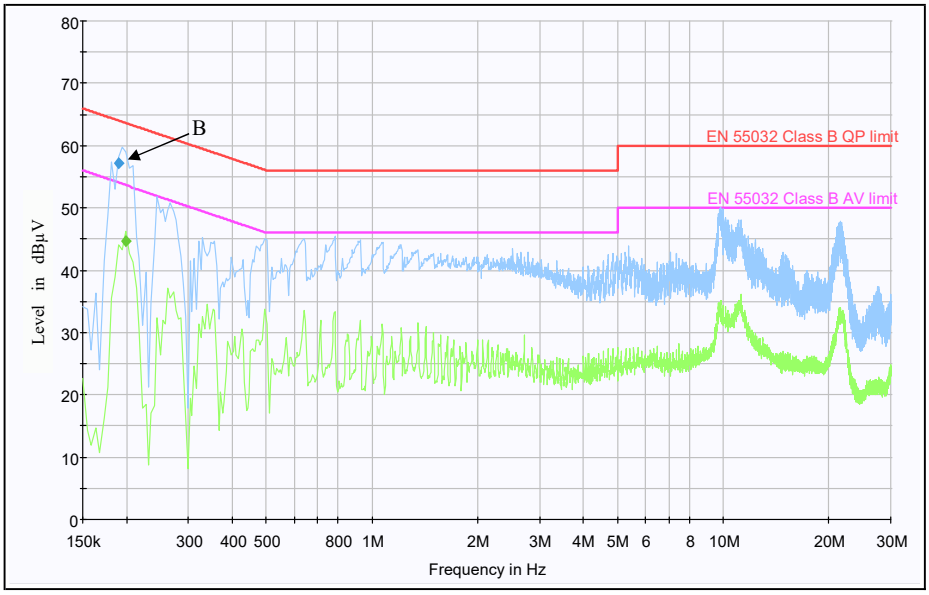
Phase : L

| Ref. Data | Point A (190kHz) Limit (dB) | Measure (dB) |
|---|---|---|
| QP | 64.2 | 58.2 |
| AV | 53.8 | 46.1 |




Phase : N

| Ref. Data | Point B (185kHz) Limit (dB) | Measure (dB) |
|---|---|---|
| QP | 64.0 | 57.2 |
| AV | 53.6 | 44.7 |



2-14. Electro-Magnetic Interference characteristics

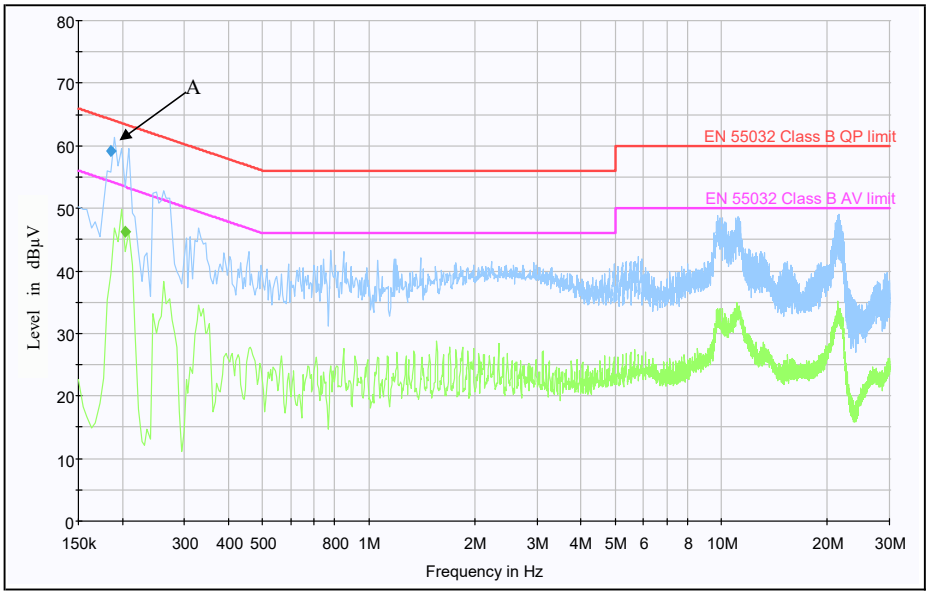
Conditions Vin : 230 VAC
Iout : 20.9 A (100%)
Ta : 25 ℃
Cooling : Forced Air

Conducted Emission

24V

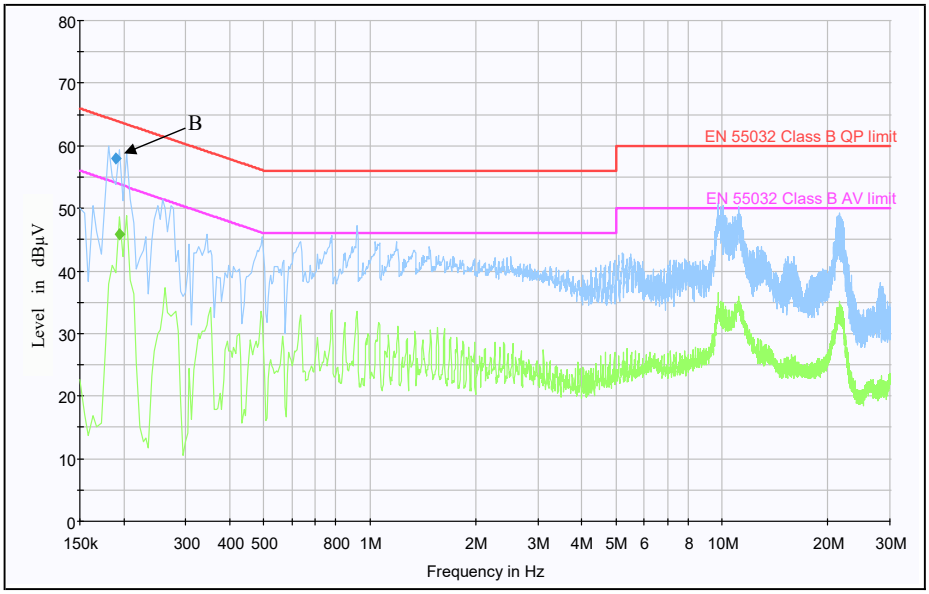
Phase : L

| Ref. Data | Point A (185kHz) Limit (dB) | Measure (dB) |
|---|---|---|
| QP | 64.2 | 59.1 |
| AV | 53.3 | 46.3 |




Phase : N

| Ref. Data | Point B (195kHz) Limit (dB) | Measure (dB) |
|---|---|---|
| QP | 64.0 | 57.9 |
| AV | 53.8 | 45.9 |



2-14. Electro-Magnetic Interference characteristics

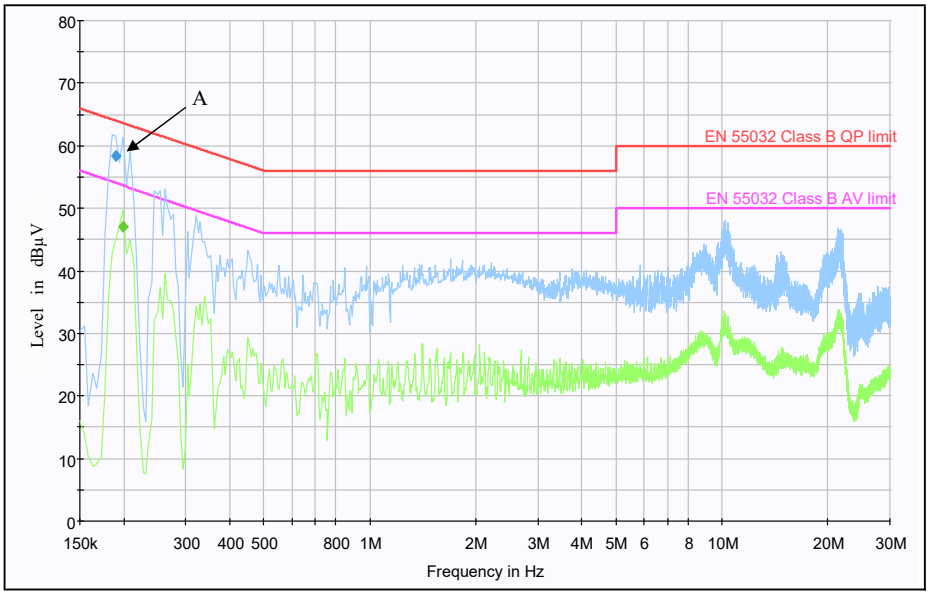
Conditions Vin : 115 VAC
Iout : 10.5 A (100%)
Ta : 25 ℃
Cooling : Forced Air

Conducted Emission

48V

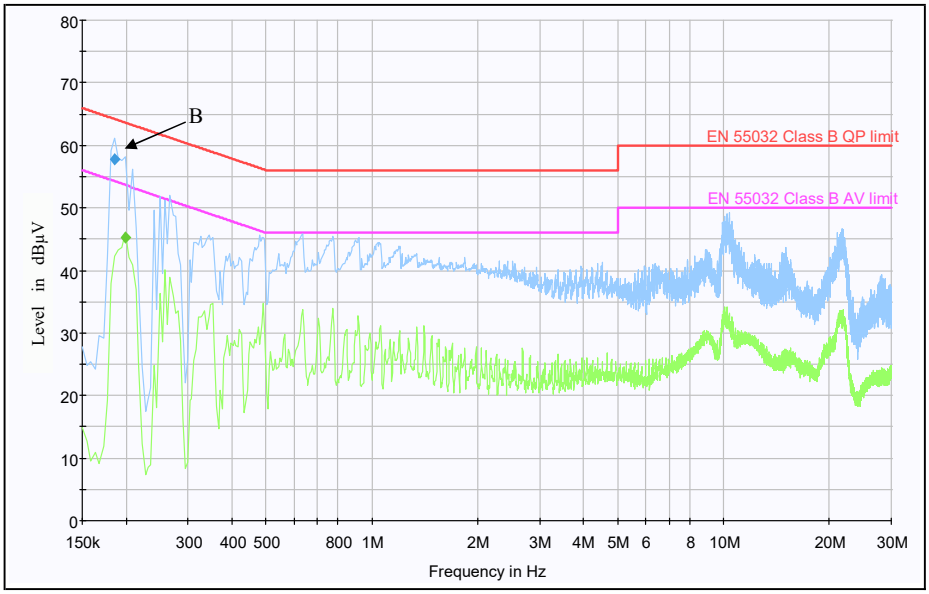
Phase : L

| Ref. Data | Point A (195kHz) Limit (dB) | Measure (dB) |
|---|---|---|
| QP | 64.0 | 58.3 |
| AV | 53.6 | 47.0 |




Phase : N

| Ref. Data | Point B (185kHz) Limit (dB) | Measure (dB) |
|---|---|---|
| QP | 64.2 | 57.8 |
| AV | 53.6 | 45.2 |



2-14. Electro-Magnetic Interference characteristics

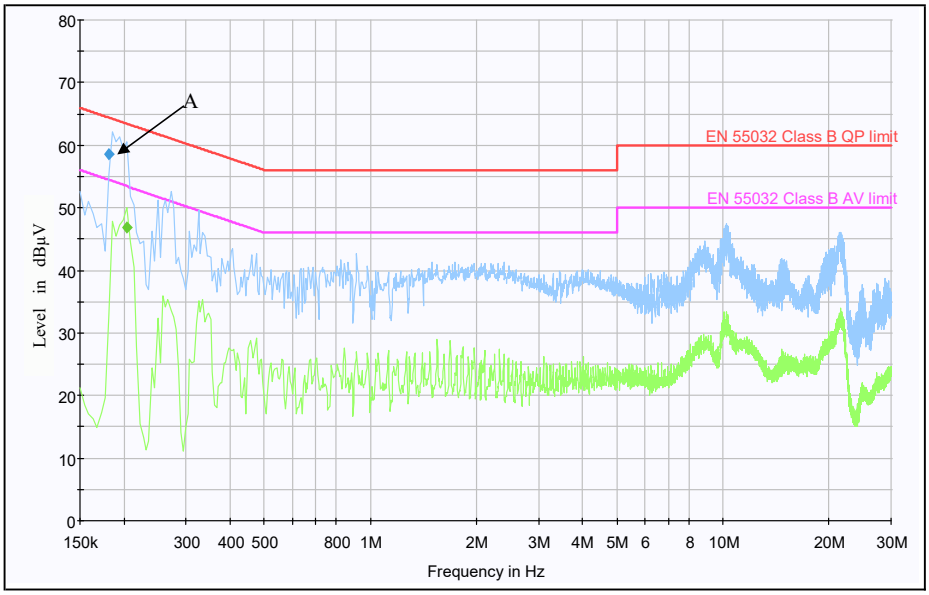
Conditions Vin : 230 VAC
Iout : 10.5 A (100%)
Ta : 25 ℃
Cooling : Forced Air

Conducted Emission

48V

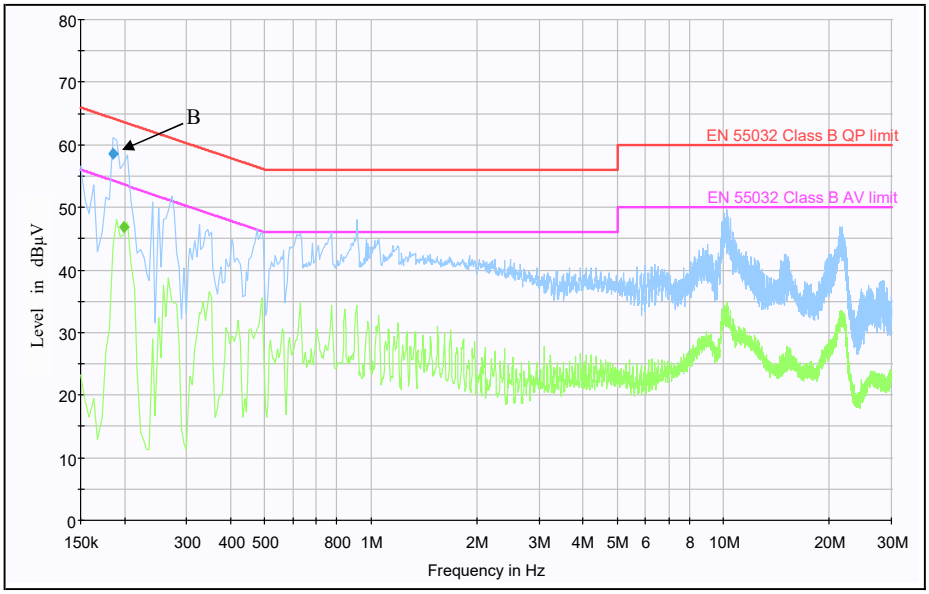
Phase : L

| Ref. Data | Point A (195kHz) Limit (dB) | Measure (dB) |
|---|---|---|
| QP | 64.4 | 58.6 |
| AV | 53.4 | 46.9 |




Phase : N

| Ref. Data | Point B (195kHz) Limit (dB) | Measure (dB) |
|---|---|---|
| QP | 64.2 | 58.6 |
| AV | 53.6 | 46.9 |



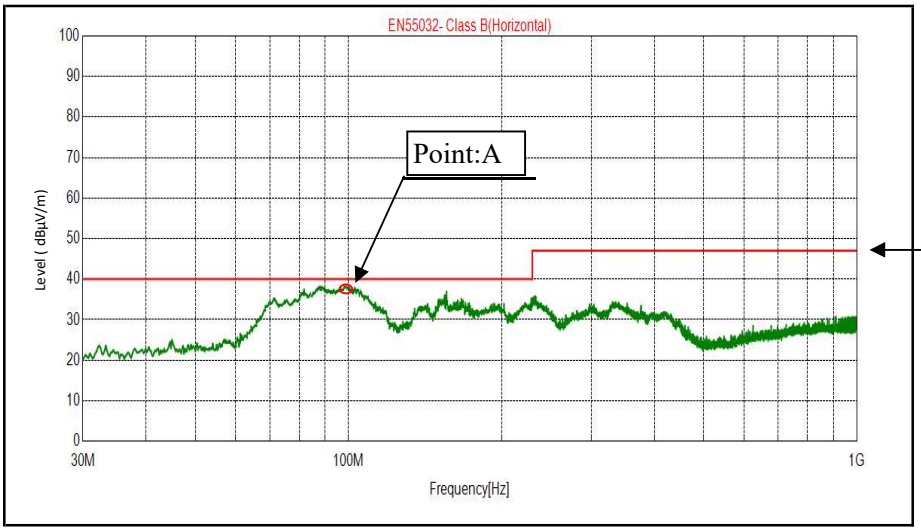
2-14. Electro-Magnetic Interference characteristics

Conditions Vin : 115 VAC
Iout : 41.7A (100%)
Ta : 25 ℃
Cooling : Forced Air

Radiated Emission

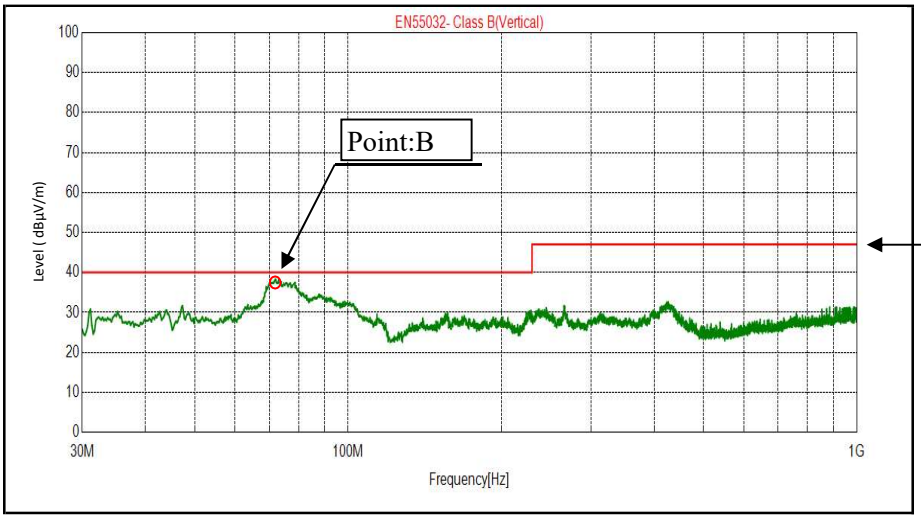
12V

HORIZONTAL




| Ref. Data | Point A (99MHz) Limit (dBuV) | Measure (dBuV) |
|---|---|---|
| QP | 40.0 | 36.5 |

VERTICAL




| Ref. Data | Point B (72MHz) Limit (dBuV) | Measure (dBuV) |
|---|---|---|
| QP | 40.0 | 36.2 |

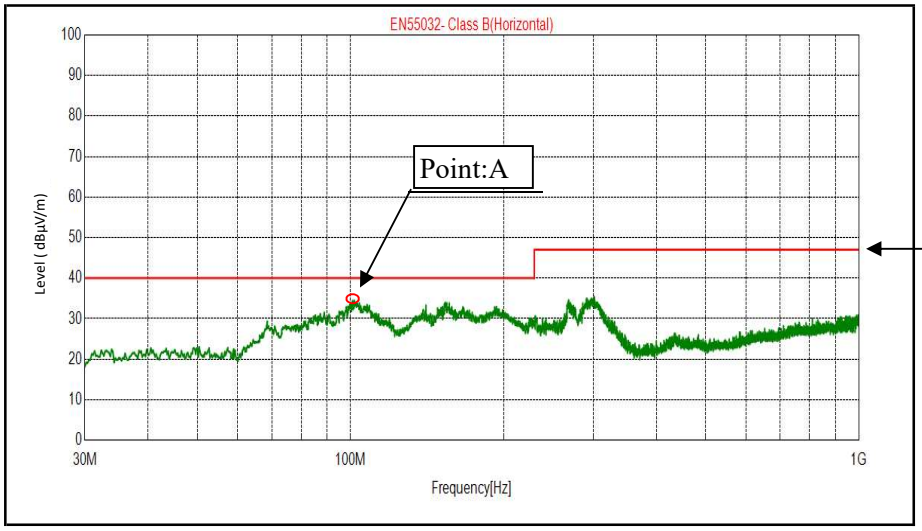
2-14. Electro-Magnetic Interference characteristics

Conditions Vin : 230 VAC
Iout : 41.7A (100%)
Ta : 25 ℃
Cooling : Forced Air

Radiated Emission

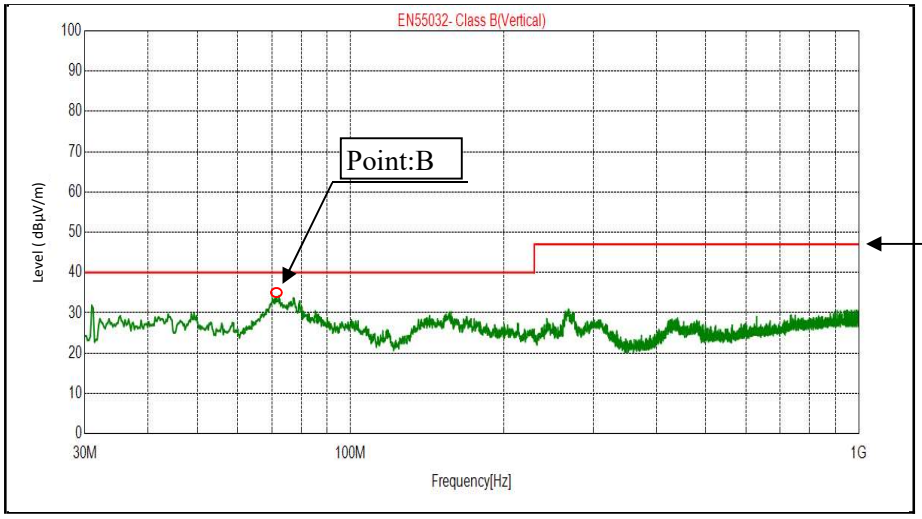
12V

HORIZONTAL




| Ref. Data | Point A (103MHz) Limit (dBuV) | Measure (dBuV) |
|---|---|---|
| QP | 40.0 | 34.7 |

VERTICAL




| Ref. Data | Point B (72MHz) Limit (dBuV) | Measure (dBuV) |
|---|---|---|
| QP | 40.0 | 34.2 |

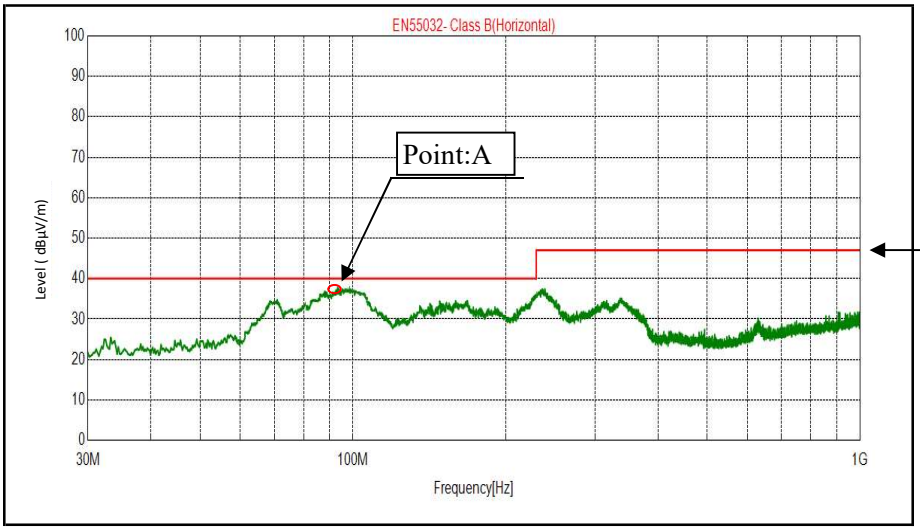
2-14. Electro-Magnetic Interference characteristics

Conditions Vin : 115 VAC
Iout : 20.9A (100%)
Ta : 25 ℃
Cooling : Forced Air

Radiated Emission

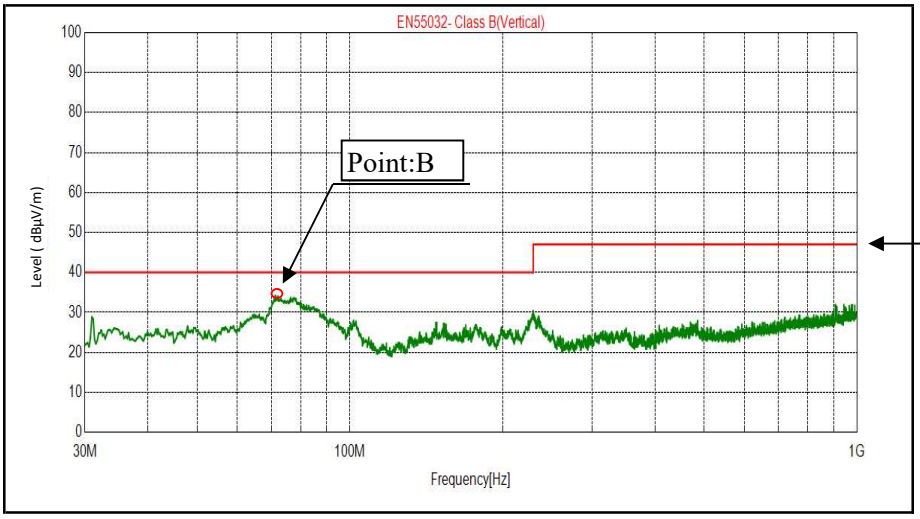
24V

HORIZONTAL




| Ref. Data | Point A (94MHz) Limit (dBuV) | Measure (dBuV) |
|---|---|---|
| QP | 40.0 | 35.9 |

VERTICAL




| Ref. Data | Point B (72MHz) Limit (dBuV) | Measure (dBuV) |
|---|---|---|
| QP | 40.0 | 33.9 |

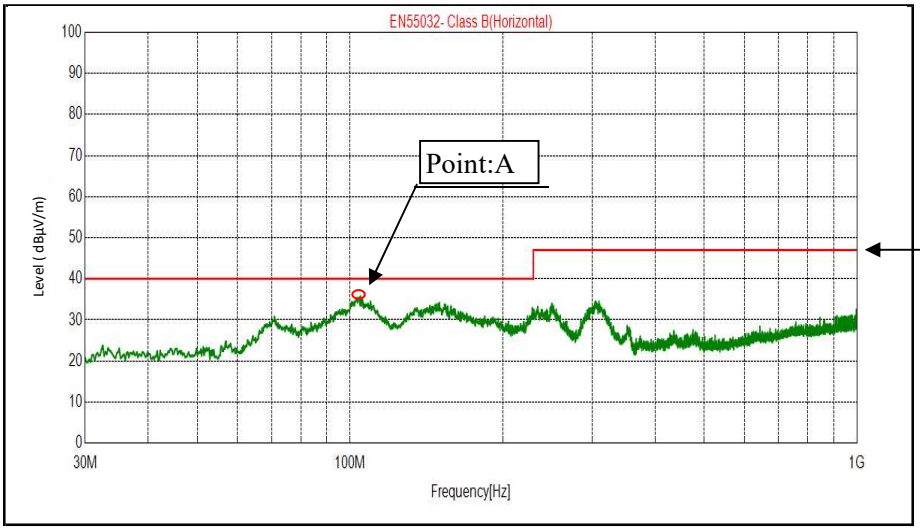
2-14. Electro-Magnetic Interference characteristics

Conditions Vin : 230 VAC
Iout : 20.9A (100%)
Ta : 25 ℃
Cooling : Forced Air

Radiated Emission

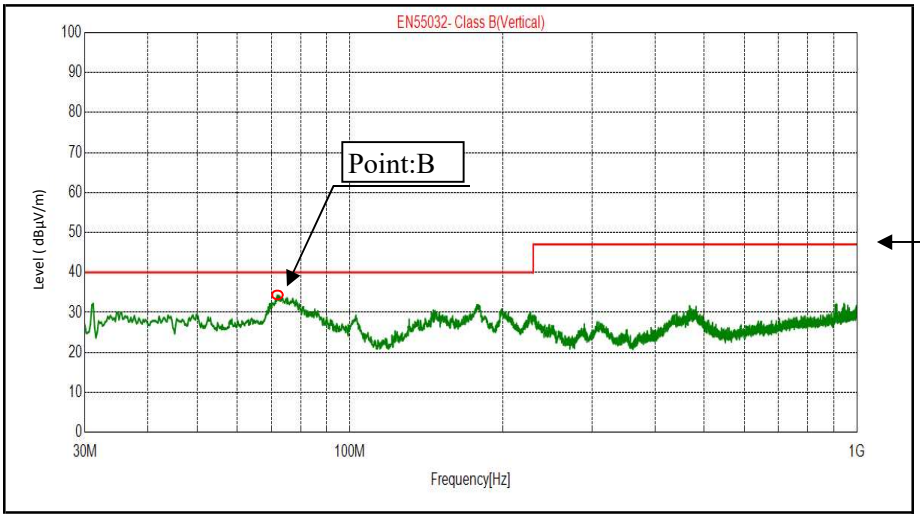
24V

HORIZONTAL




| Ref. Data | Point A (104MHz) Limit (dBuV) | Measure (dBuV) |
|---|---|---|
| QP | 40.0 | 36.3 |

VERTICAL




| Ref. Data | Point B (73MHz) Limit (dBuV) | Measure (dBuV) |
|---|---|---|
| QP | 40.0 | 33.8 |

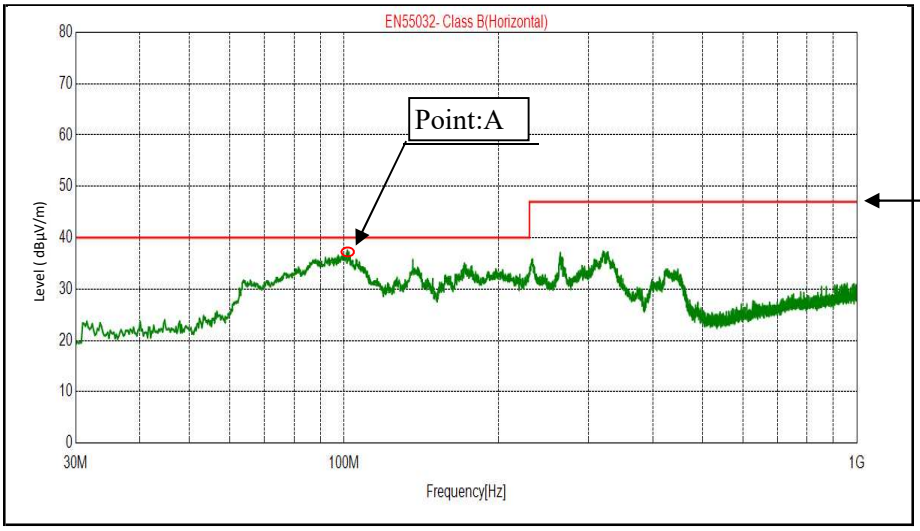
2-14. Electro-Magnetic Interference characteristics

Conditions Vin : 115 VAC
Iout : 10.5A (100%)
Ta : 25 ℃
Cooling : Forced Air

Radiated Emission

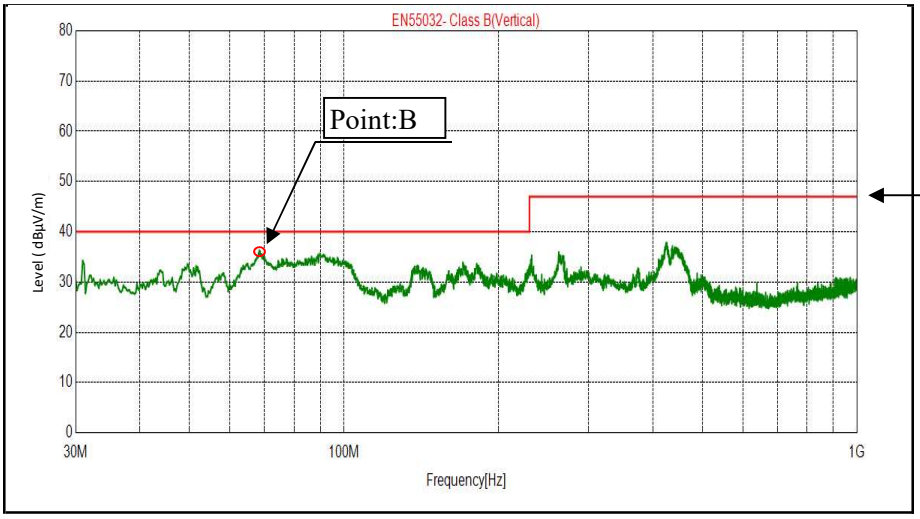
48V

HORIZONTAL




| Ref. Data | Point A (102MHz) Limit (dBuV) | Measure (dBuV) |
|---|---|---|
| QP | 40.0 | 34.1 |

VERTICAL




| Ref. Data | Point B (69MHz) Limit (dBuV) | Measure (dBuV) |
|---|---|---|
| QP | 40.0 | 35.4 |

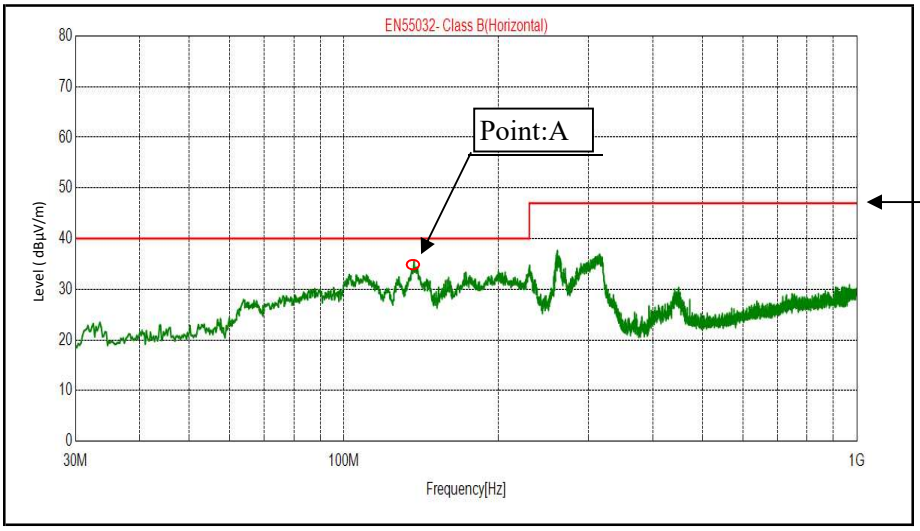
2-14. Electro-Magnetic Interference characteristics

Conditions Vin : 230 VAC
Iout : 10.5A (100%)
Ta : 25 ℃
Cooling : Forced Air

Radiated Emission

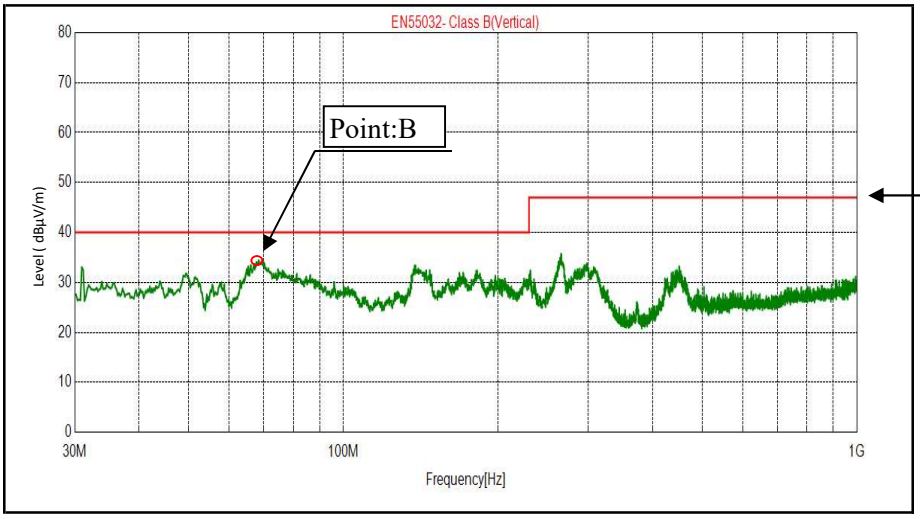
48V

HORIZONTAL




| Ref. Data | Point A (137MHz) Limit (dBuV) | Measure (dBuV) |
|---|---|---|
| QP | 40.0 | 36.1 |

VERTICAL




| Ref. Data | Point B (69MHz) Limit (dBuV) | Measure (dBuV) |
|---|---|---|
| QP | 40.0 | 34.8 |