

PRODUCT SAFETY & TECHNICAL TRANSPARENCY SHEET

1. Product Overview

The *Power Saver* is a compact, plug-in device designed to operate safely in any household outlet (90–250V). It uses certified electrical components to help stabilize small fluctuations in reactive power within a home circuit. While results vary depending on wiring conditions and load types, the device is fully tested and safe for continuous use.

2. Safety Certifications

Your Power Saver has passed internationally recognized safety and compliance testing:

- **UL 60335-1 Safety Certification**
- **CE EMC Certification (EN 55032 / EN 55035)**
- **CE Low Voltage Directive (EN 60335-1)**
- **FCC Part 15B (U.S. Emissions Compliance)**
- **RoHS Material Safety Certification**

Quoted from UL Report:

“Rated voltage: 90–250V~, Rated Power: 6W... test object meets the requirement.”

This ensures the device is safe, non-hazardous, and compliant with global electrical standards.

3. What the Device Does

The Power Saver contains a certified capacitor network and EMI filtering components. These are commonly used in electrical engineering to:

- Reduce small reactive-power fluctuations
- Improve voltage stability in certain circuits
- Reduce minor harmonic noise
- Provide smoother current flow to sensitive electronics

Quoted from engineering literature:

“Capacitors to correct power factor... minimize power and energy loss, besides avoiding penalties on account of tariff regulatory norms.”

This describes the general principle behind capacitor-based power conditioning.

4. What Customers Should Expect

Because every home’s wiring, load type, and circuit layout is different, results vary. The device is not a replacement for professional electrical upgrades, but it is:

- **Safe**
- **Certified**
- **Low-power (6W)**
- **Non-intrusive**
- **Designed for long-term plug-in use**

Many customers report smoother operation of appliances, reduced flicker, and improved stability in older homes.

5. Safety Features

- Double-insulated Class II construction
- Internal fuse protection
- EMI filtering
- Over-voltage and surge immunity (IEC 61000 tested)
- RoHS-certified non-hazardous materials

Quoted from RoHS Report:

“The products have been tested... and found in conformity with RoHS Directive... PASS.”

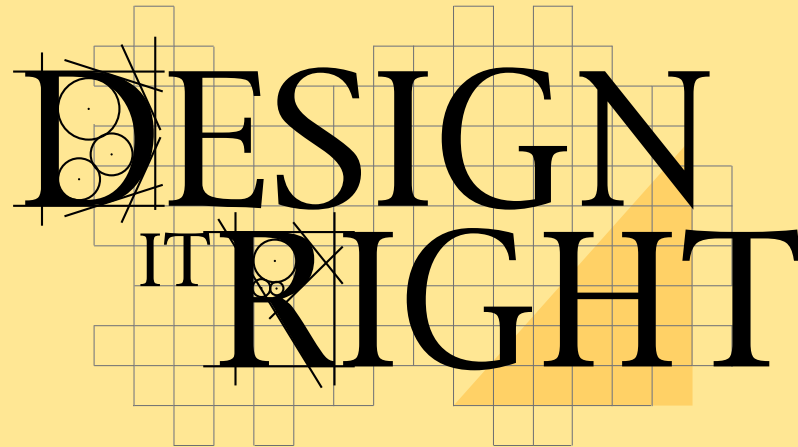
6. Technical Specifications

Feature	Specification
Voltage	90–250V~
Frequency	50/60Hz
Power Consumption	6W
Useful Load Rating	30KW
Construction	Class II (double insulated)
Certifications	UL, CE, FCC, RoHS

7. Customer Assurance

The Power Saver is fully certified, safe, and tested under international standards. It contains no hazardous materials, does not interfere with other electronics, and is approved for sale in the U.S., EU, and worldwide.

Power factor correction: a guide for the plant engineer



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Powering Business Worldwide

Part One: power factor

What is power factor?

Special electrical requirement of inductive loads

Most loads in modern electrical distribution systems are inductive. Examples include motors, transformers, gaseous tube lighting ballasts, and induction furnaces. Inductive loads need a magnetic field to operate.

Inductive loads require two kinds of current:

- Working power (kW) to perform the actual work of creating heat, light, motion, machine output, and so on.
- Reactive power (kVAR) to sustain the magnetic field

Working power consumes watts and can be read on a wattmeter. It is measured in kilowatts (kW). Reactive power doesn't perform useful "work," but circulates between the generator and the load. It places a heavier drain on the power source, as well as on the power source's distribution system. Reactive power is measured in kilovolt-amperes-reactive (kVAR).

Working power and reactive power together make up apparent power. Apparent power is measured in kilovolt-amperes (kVA).

Note: For a discussion on power factor in nonlinear, nonsinusoidal systems, turn to **Page 17**.

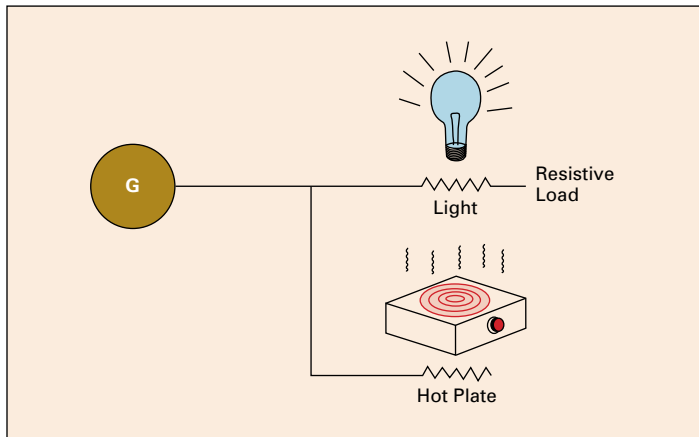


Figure 1. kW Power

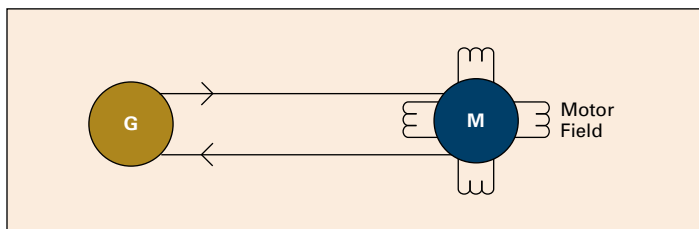


Figure 2. kVAR Power

Fundamentals of power factor

Power factor is the ratio of working power to apparent power. It measures how effectively electrical power is being used. A high power factor signals efficient utilization of electrical power, while a low power factor indicates poor utilization of electrical power.

To determine power factor (PF), divide working power (kW) by apparent power (kVA). In a linear or sinusoidal system, the result is also referred to as the cosine θ .

$$PF = \frac{kW}{kVA} = \cosine \theta$$

For example, if you had a boring mill that was operating at 100 kW and the apparent power consumed was 125 kVA, you would divide 100 by 125 and come up with a power factor of 0.80.

$$\frac{(kW) 100}{(kVA) 125} = (PF) 0.80$$

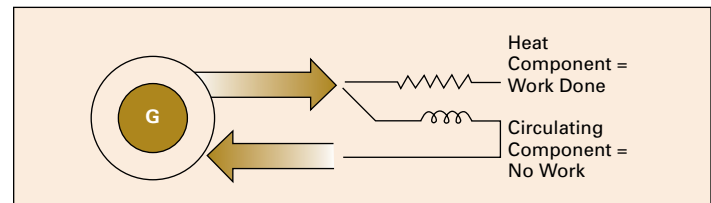


Figure 3. kVA Power

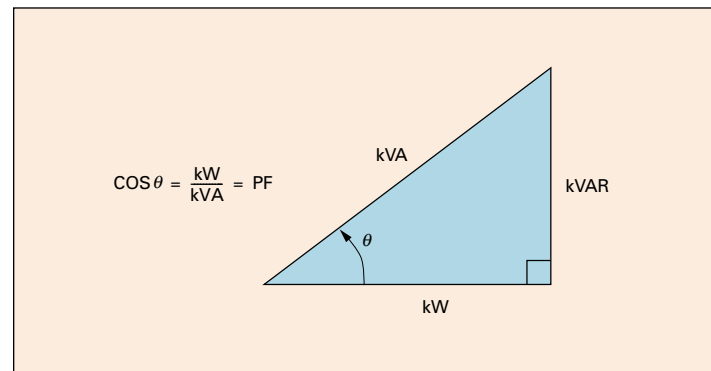


Figure 4. Power Triangle

Note: A right power triangle is often used to illustrate the relationship between kW, kVAR, and kVA.

Should I be concerned about low power factor?

Low power factor means you're not fully utilizing the electrical power you're paying for.

As the triangle relationships in **Figure 5** demonstrate, kVA decreases as power factor increases. At 70% power factor, it requires 142 kVA to produce 100 kW. At 95% power factor, it requires only 105 kVA to produce 100 kW. Another way to look at it is that at 70% power factor, *it takes 35% more current to do the same work.*

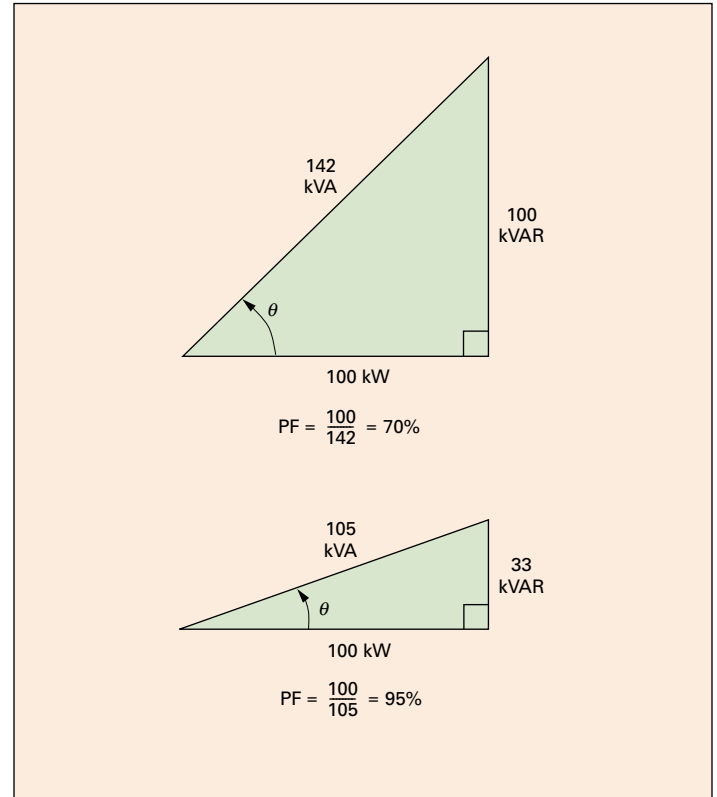


Figure 5. Typical Power Triangles

What can I do to improve power factor?

You can improve power factor by adding power factor correction capacitors to your plant distribution system.

When apparent power (kVA) is greater than working power (kW), the utility must supply the excess reactive current plus the working current. Power capacitors act as reactive current generators. (See **Figure 6.**) By providing the reactive current, they reduce the total amount of current your system must draw from the utility.

95% power factor provides maximum benefit

Theoretically, capacitors could provide 100% of needed reactive power. In practical usage, however, *power factor correction to approximately 95% provides maximum benefit.*

The power triangle in **Figure 7** shows apparent power demands on a system before and after adding capacitors. By installing power capacitors and increasing power factor to 95%, apparent power is reduced from 142 kVA to 105 kVA—a reduction of 35%.

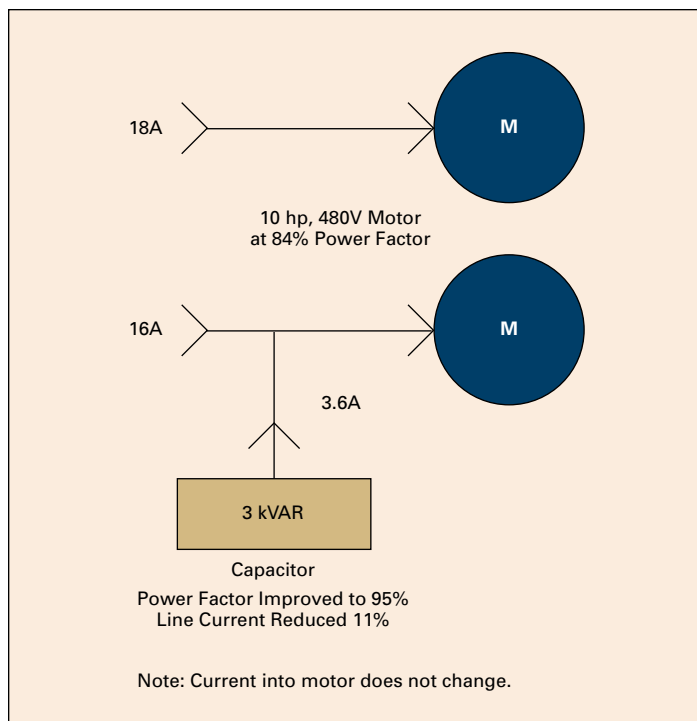


Figure 6. Capacitors as kVAR Generators

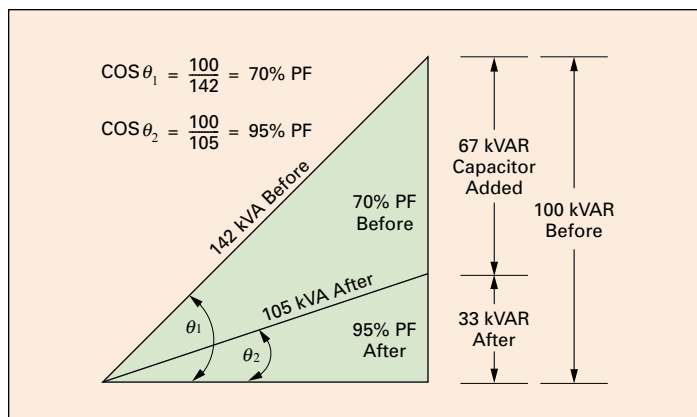


Figure 7. Required Apparent Power Before and After Adding Capacitors

How much can I save by installing power capacitors?

Power capacitors provide many benefits:

- Reduced electric utility bills
- Increased system capacity
- Improved voltage
- Reduced losses

Reduced utility bills

Your electric utility provides working (kW) and reactive power (kVAR) to your plant in the form of apparent power (kVA). While reactive power (kVAR) doesn't register on kW demand or kW hour meters, the utility's transmission and distribution system must be large enough to provide the total power. Utilities have various ways of passing the expense of larger generators, transformers, cables, switches, and the like, along to you.

As shown in the following case histories, capacitors can save you money no matter how your utility bills you for power.

kVA billing

The utility measures and bills every ampere of current, including reactive current.

Case 1

Assume an uncorrected 460 kVA demand, 480V, three-phase at 0.87 power factor (normally good).

Billing:

\$4.75/kVA demand
Correct to 0.97 power factor

Solution:

kVA × power factor = kW
 $460 \times 0.87 = 400$ kW actual demand

$$\frac{\text{kW}}{\text{PF}} = \text{kVA}$$

$$\frac{400}{0.97} = 412 \text{ corrected billing demand}$$

From **Table 6** kW multipliers, to raise the power factor from 0.87 to 0.97 requires capacitor:

Multiplier of 0.316 × kW
 $0.316 \times 400 = 126$ kVAR (use 140 kVAR)

Uncorrected original billing:

$460 \text{ kVA} \times \$4.75 = \$2185 / \text{month}$
 $\underline{-\$1957}$
 $\$ 228 / \text{month savings} \times 12$
 $\$2736 \text{ annual savings}$

Corrected new billing:

$412 \text{ kVA} \times \$4.75 = \$1957 / \text{month}$
140 kVAR, 480V capacitor cost: \$1600 (installation extra).
This capacitor pays for itself in less than eight months.

Case 2

Assume the same conditions except that:

400 kW @ 87% = 460 kVA

400 kW @ 97% = 412 kVA corrected billing

kVA demand charge:

\$1.91 / kVA / month (112,400 kWh / month energy consumed)

Energy charge:

\$0.0286 / kWh (first 200 kWh / kVA of demand)

\$0.0243 / kWh (next 300 kWh / kVA of demand)

\$0.021 / kWh (all over 500 kWh / kVA of demand)

Uncorrected:

$460 \text{ kVA} \times \$1.91 = \878.60

$\underline{-\$786.92}$

\$ 91.68 savings in demand charge

Corrected:

$412 \text{ kVA} \times \$1.91 = \786.92

Uncorrected energy:

kWh = 112,400

$460 \times 200 = 92,000$ kWh

@ 0.0286 = \$2631.20

$460 \times 300 = 138,000$

but balance only = 20,400

@ \$0.0243 = \$495.72

\$2631.20

+ \$ 495.72

\$3126.92 uncorrected energy charge

Corrected energy:

kWh = 112,400

$460 \times 200 = 82,400$ kWh

@ 0.0286 = \$2356.64

$460 \times 300 = 123,600$

but balance only = 30,000

@ \$0.0243 = \$729.00

\$2356.64

+ \$ 729.00

\$3085.64 corrected energy charge

\$3126.92

$\underline{-\$3085.64}$

\$ 41.28 savings in energy charge due to rate charge

(9600 kWh in first step reduced by \$0.0043)

This is not a reduction in energy consumed, but in billing only.

\$ 41.28 energy

$\underline{-\$ 91.68 \text{ demand}}$

\$ 132.96 monthly total savings

$\times \frac{12}{1}$

\$1595.52

A 130 kVAR capacitor can be paid for in less than 14 months.

kW demand billing with power factor adjustment

The utility charges according to the kW demand and adds a surcharge or adjustment for power factor. The adjustment may be a multiplier applied to kW demand. The following formula shows a billing based on 90% power factor:

$$\frac{\text{kW demand} \times 0.90}{\text{actual power factor}}$$

If power factor was 0.84, the utility would require 7% increase in billing, as shown in this formula:

$$\frac{\text{kW} \times 0.90}{0.84} = 107 \text{ (multiplier)}$$

Some utilities charge for low power factor but give a credit or bonus for power above a certain level.

Case 2

With the same 400 kW load, the power factor is only 81%. In this example, the customer will pay an adjustment on:

$$\frac{400 \times 0.90}{0.81} = 444 \text{ billing kW demand}$$

(From Case 1: When the power factor = 96%, the billing demand is 375 kW = \$3495.00 per month.)

First	40 kW	@ \$10.00	= \$ 400.00
Next	160 kW	@ \$ 9.50	= \$1520.00
Next	244 kW	@ \$ 9.00	= \$2196.00
Total	444 kW		\$4116.00 – \$3495.00 = \$621.00 x 12 = \$7452.00

Yearly savings if corrected to 96%.

\$4116.00	Charge at 81 %
–\$3720.00	Normal kW demand charge
\$ 395.00	Power factor adjustment for 81% power factor ❶

To raise 81% power factor to 96%, select the multiplier from **Table 6**. $0.432 \times 400 \text{ kW} = 173 \text{ kVAR}$. Use 180 kVAR to ensure a 96% power factor. The cost of a 180 kVAR capacitor is \$1900.00, and the payoff is less than four months.

❶ 55 kVAR would eliminate the penalty by correcting power factor to 85%.

Case 1

Assume a 400 kW load, 87% power factor with the following utility tariff.

Demand charges:

First 40 kW @ \$10.00 / kW monthly billing demand
Next 160 kW @ \$ 9.50 / kW
Next 800 kW @ \$ 9.00 / kW
All over 1000 kW @ \$ 8.50 / kW

Power factor clause:

Rates based on power factor of 90% or higher. When power factor is less than 85%, the demand will be increased 1% for each 1% that the power factor is below 90%. If the power factor is higher than 95%, the demand will be decreased 1% for each 1% that the power factor is above 90%.

There would be no penalty for 87% power factor. However, a bonus could be credited if the power factor were raised to 96%.

To raise an 87% power factor to 96%, refer to **Table 6**. Find $0.275 \times 400 \text{ kW} = 110 \text{ kVAR}$. (Select 120 kVAR to ensure the maintenance of the 96% level.)

To calculate savings:

Normal	400 kW	billing demand
First	40 kW	@ \$10.00 = \$ 400.00
Next	160 kW	@ \$ 9.50 = \$1520.00
Bal.	200 kW	@ \$ 9.00 = \$1800.00
Total	400 kW	\$3720.00 normal monthly billing

New billing:

$$\frac{\text{kW} \times 0.90}{\text{New power factor}} = \frac{400 \times 0.90}{0.96} = 375 \text{ kW demand}$$

First	40 kW	@ \$10.00	= \$ 400.00
Next	160 kW	@ \$ 9.50	= \$1520.00
Bal.	175 kW	@ \$ 9.00	= \$1575.00
			\$3495.00 power factor adjusted billing

kVAR reactive demand charge

The utility imposes a direct charge for the use of magnetizing power, usually a waiver of some percentage of kW demand. For example, if this charge were 60 cents per kVAR for everything over 50% of kW, and a 400 kW load existed at the time, the utility would provide 200 kVAR free.

Case 1

Assume a 400 kW load demand at 81% power factor.

Tariff structure:

Demand charge is:

\$635.00 for the first 200 kW demand
\$ 2.80 per kW for all addition

Reactive demand charge is:

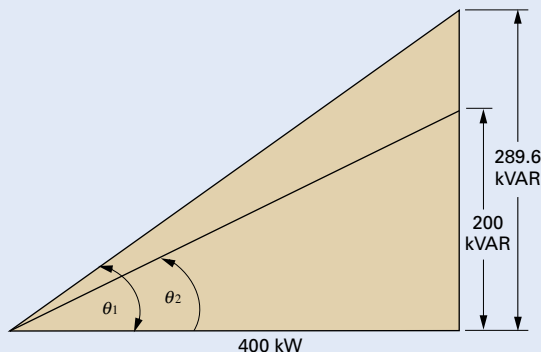
\$ 0.60 per kVAR in excess of 50% of kW demand

In this example, kW demand = 400 kW,
therefore 50% = 200 kVAR which will be furnished at no cost.

$$\cos \theta = \text{PF} = \frac{\text{kW}}{\text{kVA}} \text{ or } \frac{\text{Adj}}{\text{Hyp}}$$

$$\tan \theta = \frac{\text{kvar}}{\text{kW}} \text{ or } \frac{\text{Opp}}{\text{Adj}}$$

This ratio is the basis for the table of Multipliers (See **Table 5**).



With 200 kVAR allowed at no cost, then

$$\theta_2 = \frac{200}{400} \text{ 0.5 or 50\% of kW}$$

From 1.0 or unity power factor column, **Table 6**, note that 0.500 falls between 89% and 90% power factor. The billing excess kVAR is above that level 81% power factor.

$$\tan \theta_1 = 0.724 \text{ kVAR} = \text{kW} \times \tan \theta_1 = 400 \times 0.724 = 289.6 \text{ kVAR}$$

Because 200 kVAR is allowed, the excess kVAR is 89.6 (round to 90) $\times$ \$0.60 = \$54.00 per month billing for reactive demand.

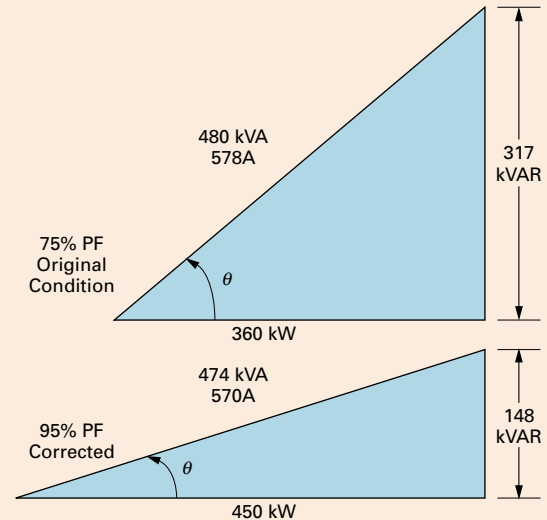
Solution:

To correct 400 kW from 81% to 90% requires 400×0.240 (from **Table 6**) = 96 kVAR. (Use 100 kVAR.) The approximate cost for this capacitor is \$1250.00. The payoff is about 23 months.

Charges for kVAR vary from about 15 cents to a dollar, and free kVAR ranges from 25% (97% power factor) to 75% (80% power factor) of kW demand.

Increased system capacity

Power factor correction capacitors increase system current-carrying capacity. Raising the power factor on a kW load reduces kVA. Therefore, by adding capacitors, you can add additional kW load to your system without altering the kVA.



A plant has a 500 kVA transformer operating near capacity. It draws 480 kVA or 578A at 480V. The present power factor is 75%, so the actual working power available is 360 kW.

It is desired to increase production by 25%, which means that about 450 kW output must be obtained. How is this accomplished? A new transformer would certainly be one solution. For 450 kW output, the transformer would be rated at 600 kVA to handle 75% power factor load. More likely, the next size standard rating would be needed (750 kVA).

Perhaps a better solution would be to improve the power factor and release enough capacity to accommodate the increased load.

To correct 450 kW from 75% to 95%, power factor requires 450×0.553 (from **Table 6**) = 248.8 kVAR use 250 kVAR at about \$2800.00.

Figure 8. Correcting Power Factor Increases Transformer Output

The same principle holds true for reducing current on overloaded facilities. Increasing power factor from 75% to 95% on the same kW load results in 21% lower current flow. Put another way, it takes 26.7% more current for a load to operate at 75%, and 46.2% more current to operate at 65%.

Industries with low power factor benefit most from capacitors

Low power factor results when inactive motors are operated at less than full load. This often occurs in cycle processes—such as those using circular saws, ball mills, conveyors, compressors, grinders, punch presses, and the like—where motors are sized for the heaviest load. Examples of situations where low power factor (from 30% to 50%) occur include a surface grinder performing a light cut, an unloaded air compressor, and a circular saw spinning without cutting.

The following industries typically exhibit low power factors:

Table 1. Typical Low Power Factor Industries

Industry	Uncorrected Power Factor
Saw mills	45%–60%
Plastic (especially extruders)	55%–70%
Machine tools, stamping	60%–70%
Plating, textiles, chemicals, breweries	65%–75%
Hospitals, granaries, foundries	70%–80%

Include power capacitors in new construction and expansion plans

Including power capacitors in your new construction and expansion plans can reduce the size of transformers, bus, switches, and the like, and bring your project in at lower cost.

Figure 9 shows how much system kVA can be released by improving power factor. Raising the power factor from 70% to 90% releases 0.32 kVA per kW. On a 400 kW load, 128 kVA is released.

Improved voltage conditions

Low voltage, resulting from excessive current draw, causes motors to be sluggish and overheated. As power factor decreases, total line current increases, causing further voltage drop. By adding capacitors to your system and improving voltage, you get more efficient motor performance and longer motor life.

Reduced losses

Losses caused by poor power factor are due to reactive current flowing in the system. These are watt-related charges and can be eliminated through power factor correction. Power loss (watts) in a distribution system is calculated by squaring the current and multiplying it by the circuit resistance (12R). To calculate loss reduction:

$$\% \text{ reduction losses} = 100 - 100 \times \left(\frac{\text{original power factor}}{\text{new power factor}} \right)^2$$

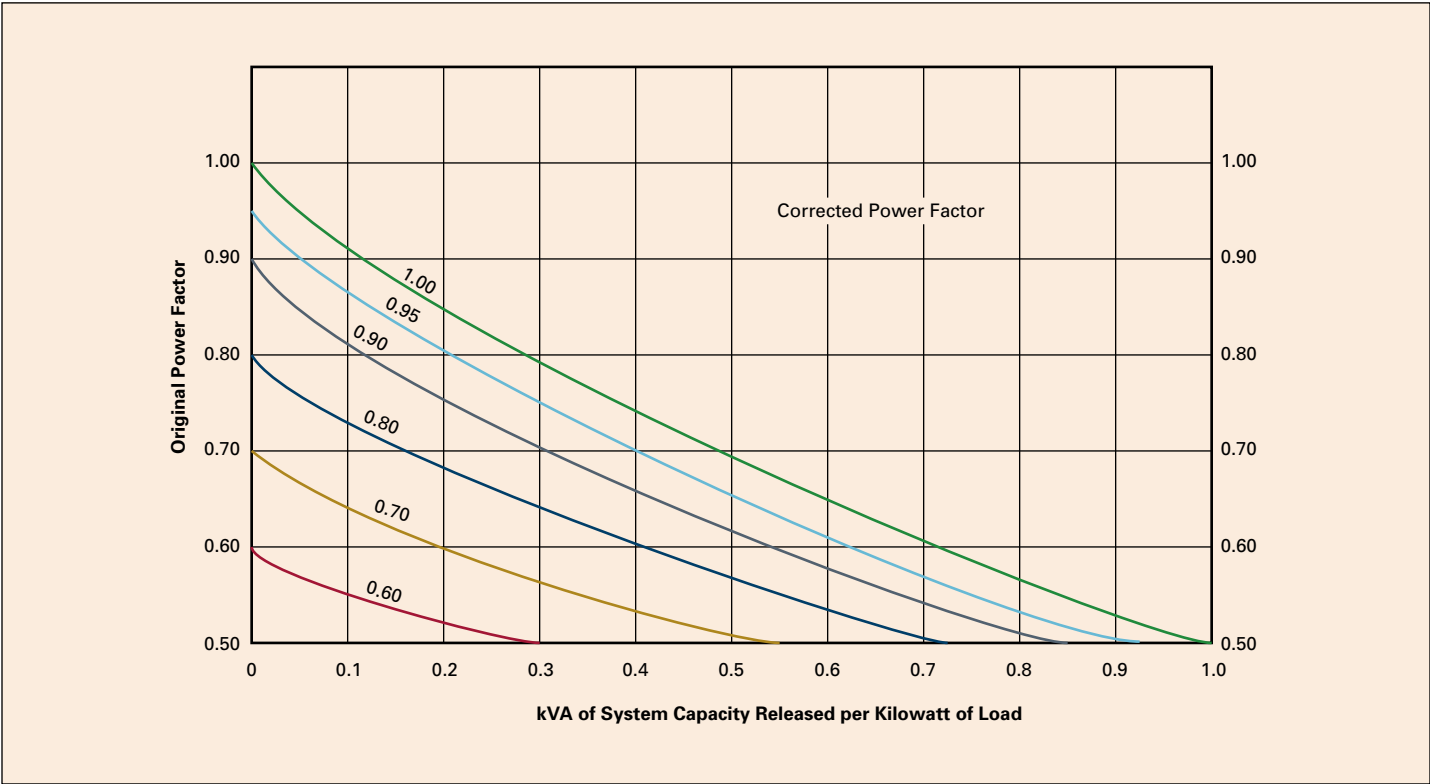


Figure 9. Corrected Power Factor Releases System kVA

How can I select the right capacitors for my specific application needs?

Once you've decided that your facility can benefit from power factor correction, you'll need to choose the optimum type, size, and number of capacitors for your plant.

There are two basic types of capacitor installations: individual capacitors on linear or sinusoidal loads, and banks of fixed or automatically switched capacitors at the feeder or substation.

Individual vs. banked installations

Advantages of individual capacitors at the load:

- Complete control; capacitors cannot cause problems on the line during light load conditions
- No need for separate switching; motor always operates with capacitor
- Improved motor performance due to more efficient power use and reduced voltage drops
- Motors and capacitors can be easily relocated together
- Easier to select the right capacitor for the load
- Reduced line losses
- Increased system capacity

Advantages of bank installations at the feeder or substation:

- Lower cost per kVAR
- Total plant power factor improved—reduces or eliminates all forms of kVAR charges
- Automatic switching ensures exact amount of power factor correction, eliminates over-capacitance and resulting overvoltages

Table 2. Summary of Advantages/Disadvantages of Individual, Fixed Banks, Automatic Banks, Combination

Method	Advantages	Disadvantages
Individual capacitors	Most technically efficient, most flexible	Higher installation and maintenance cost
Fixed bank	Most economical, fewer installations	Less flexible, requires switches and/or circuit breakers
Automatic bank	Best for variable loads, prevents overvoltages, low installation cost	Higher equipment cost
Combination	Most practical for larger numbers of motors	Least flexible

Consider the particular needs of your plant

When deciding which type of capacitor installation best meets your needs, you'll have to weigh the advantages and disadvantages of each and consider several plant variables, including load type, load size, load constancy, load capacity, motor starting methods, and manner of utility billing.

Load type

If your plant has many large motors, 50 hp and above, it is usually economical to install one capacitor per motor and switch the capacitor and motor together. If your plant consists of many small motors, 1/2 to 25 hp, you can group the motors and install one capacitor at a central point in the distribution system. Often, the best solution for plants with large and small motors is to use both types of capacitor installations.

Load size

Facilities with large loads benefit from a combination of individual load, group load, and banks of fixed and automatically-switched capacitor units. A small facility, on the other hand, may require only one capacitor at the control board.

Sometimes, only an isolated trouble spot requires power factor correction. This may be the case if your plant has welding machines, induction heaters, or DC drives. If a particular feeder serving a low power factor load is corrected, it may raise overall plant power factor enough that additional capacitors are unnecessary.

Load constancy

If your facility operates around the clock and has a constant load demand, fixed capacitors offer the greatest economy. If load is determined by eight-hour shifts five days a week, you'll want more switched units to decrease capacitance during times of reduced load.

Load capacity

If your feeders or transformers are overloaded, or if you wish to add additional load to already loaded lines, correction must be applied at the load. If your facility has surplus amperage, you can install capacitor banks at main feeders. If load varies a great deal, automatic switching is probably the answer.

Utility billing

The severity of the local electric utility tariff for power factor will affect your payback and ROI. In many areas, an optimally designed power factor correction system will pay for itself in less than two years.

How much kVAR do I need?

The unit for rating power factor capacitors is a kVAR, equal to 1000 volt-amperes of reactive power. The kVAR rating signifies how much reactive power the capacitor will provide.

Sizing capacitors for individual motor loads

To size capacitors for individual motor loads, use **Table 3** on the following page. Simply look up the type of motor frame, RPM, and horsepower. The charts indicate the kVAR rating you need to bring power factor to 95%. The charts also indicate how much current is reduced when capacitors are installed.

Sizing capacitors for entire plant loads

If you know the total kW consumption of your plant, its present power factor, and the power factor you're aiming for, you can use **Table 6**, on **Page 13** to select capacitors.

Table 3. Suggested Maximum Capacitor Ratings

Induction Motor hp Rating	Number of Poles and Nominal Motor Speed in RPM											
	2–3600 RPM			4–1800 RPM			6–1200 RPM			8–900 RPM		
	Capacitor kVAR	Current Reduction %	Capacitor kVAR	Current Reduction %	Capacitor kVAR	Current Reduction %	Capacitor kVAR	Current Reduction %	Capacitor kVAR	Current Reduction %	Capacitor kVAR	Current Reduction %
Used for High-Efficiency Motors and Older Design (Pre “T-Frame”) Motors ①												
3	1.5	14	1.5	15	1.5	20	2	27	2.5	35	3	41
5	2	12	2	13	2	17	3	25	4	32	4	37
7.5	2.5	11	2.5	12	3	15	4	22	5	30	6	34
10	3	10	3	11	3	14	5	21	6	27	7.5	31
15	4	9	4	10	5	13	6	18	8	23	9	27
20	5	9	5	10	6	12	7.5	16	9	21	12.5	25
25	6	9	6	10	7.5	11	9	15	10	20	15	23
30	7	8	7	9	9	11	10	14	12.5	18	17.5	22
40	9	8	9	9	10	10	12.5	13	15	16	20	20
50	12.5	8	10	9	12.5	10	15	12	20	15	25	19
60	15	8	15	8	15	10	17.5	11	22.5	15	27.5	19
75	17.5	8	17.5	8	17.5	10	20	10	25	14	35	18
100	22.5	8	20	8	25	9	27.5	10	35	13	40	17
125	27.5	8	25	8	30	9	30	10	40	13	50	16
150	30	8	30	8	35	9	37.5	10	50	12	50	15
200	40	8	37.5	8	40	9	50	10	60	12	60	14
250	50	8	45	7	50	8	60	9	70	11	75	13
300	60	8	50	7	60	8	60	9	80	11	90	12
350	60	8	60	7	75	8	75	9	90	10	95	11
400	75	8	60	6	75	8	85	9	95	10	100	11
450	75	8	75	6	80	8	90	9	100	9	110	11
500	75	8	75	6	85	8	100	9	100	9	120	10
“T-Frame” NEMA® “Design B” Motors ①												
2	1	14	1	24	1.5	30	2	42	2	40	3	50
3	1.5	14	1.5	23	2	28	3	38	3	40	4	49
5	2	14	2.5	22	3	26	4	31	4	40	5	49
7.5	2.5	14	3	20	4	21	5	28	5	38	6	45
10	4	14	4	18	5	21	6	27	7.5	36	8	38
15	5	12	5	18	6	20	7.5	24	8	32	10	34
20	6	12	6	17	7.5	19	9	23	10	29	12.5	30
25	7.5	12	7.5	17	8	19	10	23	12.5	25	17.5	30
30	8	11	8	16	10	19	15	22	15	24	20	30
40	12.5	12	15	16	15	19	17.5	21	20	24	25	30
50	15	12	17.5	15	20	19	22.5	21	22.5	24	30	30
60	17.5	12	20	15	22.5	17	25	20	30	22	35	28
75	20	12	25	14	25	15	30	17	35	21	40	19
100	22.5	11	30	14	30	12	35	16	40	15	45	17
125	25	10	35	12	35	12	40	14	45	15	50	17
150	30	10	40	12	40	12	50	14	50	13	60	17
200	35	10	50	11	50	11	70	14	70	13	90	17
250	40	11	60	10	60	10	80	13	90	13	100	17
300	45	11	70	10	75	12	100	14	100	13	120	17
350	50	12	75	8	90	12	120	13	120	13	135	15
400	75	10	80	8	100	12	130	13	140	13	150	15
450	80	8	90	8	120	10	140	12	160	14	160	15
500	100	8	120	9	150	12	160	12	180	13	180	15

① For use with three-phase, 60 Hz NEMA Classification B Motors to raise full load power factor to approximately 95%.

Table 4. Suggested Capacitor Ratings, in kVARs, for NEMA Design C and D, and Wound-Rotor Motors

Induction Motor Rating (hp)	Design C Motor		Design D Motor	
	1800 and 1200 r/Minimum	900 r/Minimum	1200 r/Minimum	Wound-Rotor Motor
15	5	5	5	5.5
20	5	6	6	7
25	6	6	6	7
30	7.5	9	10	11
40	10	12	12	13
50	12	15	15	17.5
60	17.5	18	18	20
75	19	22.5	22.5	25
100	27	27	30	33
125	35	37.5	37.5	40
150	37.5	45	45	50
200	45	60	60	65
250	54	70	70	75
300	65	90	75	85

Note: Applies to three-phase, 60 Hz motors when switched with capacitors as single unit.

Note: Use motor manufacturer's recommended kVAR as published in the performance data sheets for specific motor types: drip-proof, TEFC, severe duty, high-efficiency, and NEMA design.

Table 5. Suggested Capacitor Ratings for Medium Voltage Motors

Induction Motor hp Rating	Number of Poles and Nominal Motor Speed in RPM											
	2–3600 RPM		4–1800 RPM		6–1200 RPM		8–900 RPM		10–720 RPM		12–600 RPM	
	Capacitor kVAR	Current Reduction %	Capacitor kVAR	Current Reduction %	Capacitor kVAR	Current Reduction %	Capacitor kVAR	Current Reduction %	Capacitor kVAR	Current Reduction %	Capacitor kVAR	Current Reduction %
2400 and 4160V—Open												
100	25	8	25	10	25	11	25	11	25	12	25	15
125	25	7	25	9	25	10	25	10	25	11	50	15
150	25	7	25	8	25	9	25	9	25	11	50	14
200	50	7	50	8	50	9	50	9	50	10	75	14
250	50	7	50	7	50	8	75	9	75	10	75	14
300	50	7	50	7	75	8	75	9	75	9	100	13
350	50	6	50	6	75	8	75	9	75	9	100	12
400	75	6	75	6	75	7	100	9	100	9	100	11
450	75	6	75	6	75	6	100	9	100	9	125	10
500	75	5	75	6	100	6	125	9	125	9	125	9
600	75	5	100	6	100	6	125	8	150	9	150	9
700	100	5	100	6	125	6	150	8	150	8	150	8
800	100	5	150	6	150	6	150	7	200	8	200	8
900	125	5	150	6	200	6	200	7	250	8	250	8
1000	150	5	200	6	250	5	250	6	250	7	250	7
1250	200	5	200	5	250	5	300	6	300	6	300	6
2400 and 4160V—Totally Enclosed Fan Cooled												
100	25	7	25	8	25	9	25	11	25	11	25	13
125	25	7	25	7	25	8	25	11	25	11	50	13
150	25	6	25	7	25	8	50	11	50	11	50	13
200	50	6	50	7	50	8	50	11	50	11	75	13
250	50	6	50	7	50	8	75	11	75	11	75	13
300	50	6	50	7	75	8	75	10	100	11	100	13
350	75	6	75	7	100	8	100	10	100	11	125	13
400	75	6	75	7	100	8	100	10	100	11	150	13
450	75	6	100	7	100	8	125	10	125	11	150	13
500	100	5	125	7	125	7	150	10	150	11	150	13

Above sizes are intended to provide a corrected power factor of approximately 95% at full load. Because of the limited number of capacitor ratings available, it is not possible to raise every motor PF to 95%.

To calculate kVAR required to correct power factor to a specific target value, use the following formula:

$$\text{kVAR}_{\text{(required)}} = \frac{\text{hp} \times 0.746}{\% \text{ EFF}} \left(\frac{\sqrt{1 - \text{PFa}^2}}{\text{PFa}} - \frac{\sqrt{1 - \text{PFt}^2}}{\text{PFt}} \right)$$

Where

hp: motor nameplate horsepower
 %EFF: motor nameplate efficiency (enter the value in decimal)
 PFa: motor nameplate actual power factor
 PFt: target power factor

Note: Consult the motor manufacturer's data sheet to verify the maximum kVAR of capacitors that can be directly connected at motor terminals. To avoid self-excitation, do not exceed the maximum kVAR rating that is specified by the motor manufacturer.

Instructions for Table 6 on Page 13:

1. Find the present power factor in column one.
2. Read across to optimum power factor column.
3. Multiply that number by kW demand.

Example:

If your plant consumes 410 kW, is currently operating at 73% power factor, and you want to correct power factor to 95%, you would:

1. Find 0.73 in column one.
2. Read across to 0.95 column.
3. Multiply 0.607 by 410 = 249 (round to 250).
4. You need 250 kVAR to bring your plant to 95% power factor.

If you don't know the existing power factor level of your plant, you will have to calculate it before using **Table 6** on the following page. To calculate existing power factor: kW divided by kVA = power factor.

Table 6. Multipliers to Determine Capacitor Kilovars Required for Power Factor Correction

Original Power Factor	Corrected Power Factor																				
	0.8	0.81	0.82	0.83	0.84	0.85	0.86	0.87	0.88	0.89	0.9	0.91	0.92	0.93	0.94	0.95	0.96	0.97	0.98	0.99	1.0
0.50	0.982	1.008	1.034	1.060	1.086	1.112	1.139	1.165	1.192	1.220	1.248	1.276	1.306	1.337	1.369	1.403	1.440	1.481	1.529	1.589	1.732
0.51	0.937	0.962	0.989	1.015	1.041	1.067	1.094	1.120	1.147	1.175	1.203	1.231	1.261	1.292	1.324	1.358	1.395	1.436	1.484	1.544	1.687
0.52	0.893	0.919	0.945	0.971	0.997	1.023	1.050	1.076	1.103	1.131	1.159	1.187	1.217	1.248	1.280	1.314	1.351	1.392	1.440	1.500	1.643
0.53	0.850	0.876	0.902	0.928	0.954	0.980	1.007	1.033	1.060	1.088	1.116	1.144	1.174	1.205	1.237	1.271	1.308	1.349	1.397	1.457	1.600
0.54	0.809	0.835	0.861	0.887	0.913	0.939	0.966	0.992	1.019	1.047	1.075	1.103	1.133	1.164	1.196	1.230	1.267	1.308	1.356	1.416	1.559
0.55	0.769	0.795	0.821	0.847	0.873	0.899	0.926	0.952	0.979	1.007	1.035	1.063	1.093	1.124	1.156	1.190	1.227	1.268	1.316	1.376	1.519
0.56	0.730	0.756	0.782	0.808	0.834	0.860	0.887	0.913	0.940	0.968	0.996	1.024	1.054	1.085	1.117	1.151	1.188	1.229	1.277	1.337	1.480
0.57	0.692	0.718	0.744	0.770	0.796	0.822	0.849	0.875	0.902	0.930	0.958	0.986	1.016	1.047	1.079	1.113	1.150	1.191	1.239	1.299	1.442
0.58	0.655	0.681	0.707	0.733	0.759	0.785	0.812	0.838	0.865	0.893	0.921	0.949	0.979	1.010	1.042	1.076	1.113	1.154	1.202	1.262	1.405
0.59	0.619	0.645	0.671	0.697	0.723	0.749	0.776	0.802	0.829	0.857	0.885	0.913	0.943	0.974	1.006	1.040	1.077	1.118	1.166	1.226	1.369
0.60	0.583	0.609	0.635	0.661	0.687	0.713	0.740	0.766	0.793	0.821	0.849	0.877	0.907	0.938	0.970	1.004	1.041	1.082	1.130	1.190	1.333
0.61	0.549	0.575	0.601	0.627	0.653	0.679	0.706	0.732	0.759	0.787	0.815	0.843	0.873	0.904	0.936	0.970	1.007	1.048	1.096	1.156	1.299
0.62	0.516	0.542	0.568	0.594	0.620	0.646	0.673	0.699	0.726	0.754	0.782	0.810	0.840	0.871	0.903	0.937	0.974	1.015	1.063	1.123	1.266
0.63	0.483	0.509	0.535	0.561	0.587	0.613	0.640	0.666	0.693	0.721	0.749	0.777	0.807	0.838	0.870	0.904	0.941	0.982	1.030	1.090	1.233
0.64	0.451	0.474	0.503	0.529	0.555	0.581	0.608	0.634	0.661	0.689	0.717	0.745	0.775	0.806	0.838	0.872	0.909	0.950	0.998	1.068	1.201
0.65	0.419	0.445	0.471	0.497	0.523	0.549	0.576	0.602	0.629	0.657	0.685	0.713	0.743	0.774	0.806	0.840	0.877	0.918	0.966	1.026	1.169
0.66	0.388	0.414	0.440	0.466	0.492	0.518	0.545	0.571	0.598	0.626	0.654	0.682	0.712	0.743	0.775	0.809	0.846	0.887	0.935	0.995	1.138
0.67	0.358	0.384	0.410	0.436	0.462	0.488	0.515	0.541	0.568	0.596	0.624	0.652	0.682	0.713	0.745	0.779	0.816	0.857	0.905	0.965	1.108
0.68	0.328	0.354	0.380	0.406	0.432	0.458	0.485	0.511	0.538	0.566	0.594	0.622	0.652	0.683	0.715	0.749	0.786	0.827	0.875	0.935	1.078
0.69	0.299	0.325	0.351	0.377	0.403	0.429	0.456	0.482	0.509	0.537	0.565	0.593	0.623	0.654	0.686	0.720	0.757	0.798	0.846	0.906	1.049
0.70	0.270	0.296	0.322	0.348	0.374	0.400	0.427	0.453	0.480	0.508	0.536	0.564	0.594	0.625	0.657	0.691	0.728	0.769	0.817	0.877	1.020
0.71	0.242	0.268	0.294	0.320	0.346	0.372	0.399	0.425	0.452	0.480	0.508	0.536	0.566	0.597	0.629	0.663	0.700	0.741	0.789	0.849	0.992
0.72	0.214	0.240	0.266	0.292	0.318	0.344	0.371	0.397	0.424	0.452	0.480	0.508	0.538	0.569	0.601	0.635	0.672	0.713	0.761	0.821	0.964
0.73	0.186	0.212	0.238	0.264	0.290	0.316	0.343	0.369	0.396	0.424	0.452	0.480	0.510	0.541	0.573	0.607	0.644	0.685	0.733	0.793	0.936
0.74	0.159	0.185	0.211	0.237	0.263	0.289	0.316	0.342	0.369	0.397	0.425	0.453	0.483	0.514	0.546	0.580	0.617	0.658	0.706	0.766	0.909
0.75	0.132	0.158	0.184	0.210	0.236	0.262	0.289	0.315	0.342	0.370	0.398	0.426	0.456	0.487	0.519	0.553	0.590	0.631	0.679	0.739	0.882
0.76	0.105	0.131	0.157	0.183	0.209	0.235	0.262	0.288	0.315	0.343	0.371	0.399	0.429	0.460	0.492	0.526	0.563	0.604	0.652	0.712	0.855
0.77	0.079	0.105	0.131	0.157	0.183	0.209	0.236	0.262	0.289	0.317	0.345	0.373	0.403	0.434	0.466	0.500	0.537	0.578	0.626	0.685	0.829
0.78	0.052	0.078	0.104	0.130	0.156	0.182	0.209	0.235	0.262	0.290	0.318	0.346	0.376	0.407	0.439	0.473	0.510	0.551	0.599	0.659	0.802
0.79	0.026	0.052	0.078	0.104	0.130	0.156	0.183	0.209	0.236	0.264	0.292	0.320	0.350	0.381	0.413	0.447	0.484	0.525	0.573	0.633	0.776
0.80	0.000	0.026	0.052	0.078	0.104	0.130	0.157	0.183	0.210	0.238	0.266	0.294	0.324	0.355	0.387	0.421	0.458	0.499	0.547	0.609	0.750
0.81		0.000	0.026	0.052	0.078	0.104	0.131	0.157	0.184	0.212	0.240	0.268	0.298	0.329	0.361	0.395	0.432	0.473	0.521	0.581	0.724
0.82			0.000	0.026	0.052	0.078	0.105	0.131	0.158	0.186	0.214	0.242	0.272	0.303	0.335	0.369	0.406	0.447	0.495	0.555	0.698
0.83				0.000	0.026	0.052	0.079	0.105	0.132	0.160	0.188	0.216	0.246	0.277	0.309	0.343	0.380	0.421	0.469	0.529	0.672
0.84					0.000	0.026	0.053	0.079	0.106	0.134	0.162	0.190	0.220	0.251	0.283	0.317	0.354	0.395	0.443	0.503	0.646
0.85						0.000	0.027	0.053	0.080	0.108	0.136	0.164	0.194	0.225	0.257	0.291	0.328	0.369	0.417	0.477	0.620
0.86							0.000	0.026	0.053	0.081	0.109	0.137	0.167	0.198	0.230	0.264	0.301	0.342	0.390	0.450	0.593
0.87								0.000	0.027	0.055	0.083	0.111	0.141	0.172	0.204	0.238	0.275	0.316	0.364	0.424	0.567
0.88									0.000	0.028	0.056	0.084	0.114	0.145	0.177	0.211	0.248	0.289	0.337	0.397	0.540
0.89										0.000	0.028	0.056	0.086	0.117	0.149	0.183	0.220	0.261	0.309	0.369	0.512
0.90											0.000	0.028	0.058	0.089	0.121	0.155	0.192	0.233	0.281	0.341	0.484
0.91												0.000	0.030	0.061	0.093	0.127	0.164	0.205	0.253	0.313	0.456
0.92													0.000	0.031	0.063	0.097	0.134	0.175	0.223	0.283	0.426
0.93														0.000	0.032	0.066	0.103	0.144	0.192	0.252	0.395
0.94															0.000	0.034	0.071	0.112	0.160	0.220	0.363
0.95																0.000	0.037	0.079	0.126	0.186	0.329
0.96																	0.000	0.041	0.089	0.149	0.292
0.97																		0.000	0.048	0.108	0.251
0.98																			0.000	0.060	0.203
0.99																				0.000	0.143
																					0.000

Table 7. Recommended Wire Sizes, Switches, and Fuses for Three-Phase, 60 Hz Capacitors

These wire sizes are based on 135% of rated current in accordance with the National Electrical Code®, Article 460.

kVAR	240V				480V				600V			
	Current (Amperes)	Wire Size ①	Fuse (Amperes)	Switch (Amperes)	Current (Amperes)	Wire Size ①	Fuse (Amperes)	Switch (Amperes)	Current (Amperes)	Wire Size ①	Fuse (Amperes)	Switch (Amperes)
0.5	1.2	14	3	30	—	—	—	—	—	—	—	—
1	2.4	14	6	30	1.2	14	3	30	1.0	14	3	30
1.5	3.6	14	6	30	1.8	14	3	30	1.4	14	3	30
2	4.8	14	10	30	2.4	14	6	30	1.9	14	6	30
2.5	6.0	14	10	30	3.0	14	6	30	2.4	14	6	30
3	7.2	14	15	30	3.6	14	6	30	2.9	14	6	30
4	9.6	14	20	30	4.8	14	10	30	3.8	14	10	30
5	12	14	20	30	6.0	14	10	30	4.8	14	10	30
6	14	14	25	30	7.2	14	15	30	5.8	14	10	30
7.5	18	12	30	30	9.0	14	15	30	7.2	14	15	30
8	19	10	35	60	9.6	14	20	30	7.7	14	15	30
10	24	10	40	60	12	14	20	30	9.6	14	20	30
12.5	30	8	50	60	15	14	25	30	12	14	20	30
15	36	8	60	60	18	12	30	30	14	14	25	30
17.5	42	6	80	100	21	10	40	60	17	12	30	30
20	48	6	80	100	24	10	40	60	19	10	35	60
22.5	54	4	100	100	27	10	50	60	22	10	40	60
25	60	4	100	100	30	8	50	60	24	10	40	60
30	72	3	125	200	36	8	60	60	29	8	50	60
35	84	2	150	200	42	6	80	100	34	8	60	60
40	96	1	175	200	48	6	80	100	38	6	80	100
45	108	1/0	200	200	54	4	100	100	43	6	90	100
50	120	2/0	200	200	60	4	100	100	48	6	100	100
60	144	3/0	250	400	72	2	125	200	58	4	100	100
75	180	250M	300	400	90	1/0	150	200	72	3	125	200
80	192	300M	350	400	96	1/0	175	200	77	3	150	200
90	216	350M	400	400	108	1/0	200	200	86	1	150	200
100	241	400M	400	400	120	2/0	200	200	96	1	175	200
120	289	(2)3/0	500	600	144	3/0	200	200	115	2/0	200	200
125	300	(2)3/0	500	600	150	3/0	250	400	120	2/0	200	200
150	361	(2)250M	600	600	180	250M	300	400	144	3/0	250	400
180	432	(2)350M	750	800	216	350M	400	400	173	250M	300	400
200	481	(2)400M	800	800	241	400M	400	400	192	300M	350	400
240	—	—	—	—	289	(2)3/0	500	600	231	400M	400	400
250	—	—	—	—	300	(2)4/0	500	600	241	400M	400	400
300	—	—	—	—	361	(2)250M	600	600	289	(2)3/0	500	600
360	—	—	—	—	432	(2)350M	750	800	346	(2)250M	600	600
400	—	—	—	—	480	(2)500M	800	800	384	(2)300M	650	800

① 90°C Copper Type THHN, XHHW, or equivalent, applied at 75°C ampacity. Rate current based on operation at rated voltage, frequency, and kVAR. Consult National Electrical Code for other wire types.
Above size based on 30°C ambient operation. (Refer to NEC Table 310.16.)

Note: Fuses furnished within capacitor assembly may be rated at higher value than shown in this table. The table is correct for field installations and reflects the manufacturer's suggested rating for overcurrent protection and disconnect means in compliance with the National Electrical Code.

Where should I install capacitors in my plant distribution system?

At the load

Because capacitors act as kVAR generators, the most efficient place to install them is directly at the motor, where kVAR is consumed.

Three options exist for installing capacitors at the motor. Use **Figure 10** through **Figure 16** and the information below to determine which option is best for each motor.

Location A—motor side of overload relay

- New motor installations in which overloads can be sized in accordance with reduced current draw
- Existing motors when no overload change is required

Location B—line side of starter

- Existing motors when overload rating surpasses code

Location C—line side of starter

- Motors that are jogged, plugged, reversed
- Multi-speed motors
- Starters with open transition and starters that disconnect/reconnect capacitor during cycle
- Motors that start frequently
- Motor loads with high inertia, where disconnecting the motor with the capacitor can turn the motor into a self-excited generator

At the service feeder

When correcting entire plant loads, capacitor banks can be installed at the service entrance, if load conditions and transformer size permit. If the amount of correction is too large, some capacitors can be installed at individual motors or branch circuits.

When capacitors are connected to the bus, feeder, motor control center, or switchboard, a disconnect and overcurrent protection must be provided.

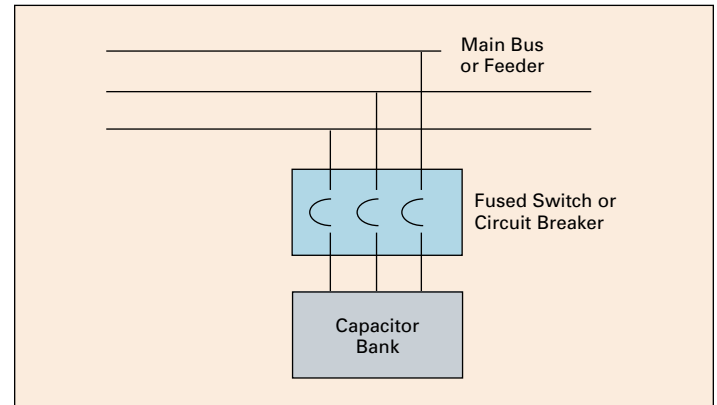


Figure 10. Installing Capacitors Online

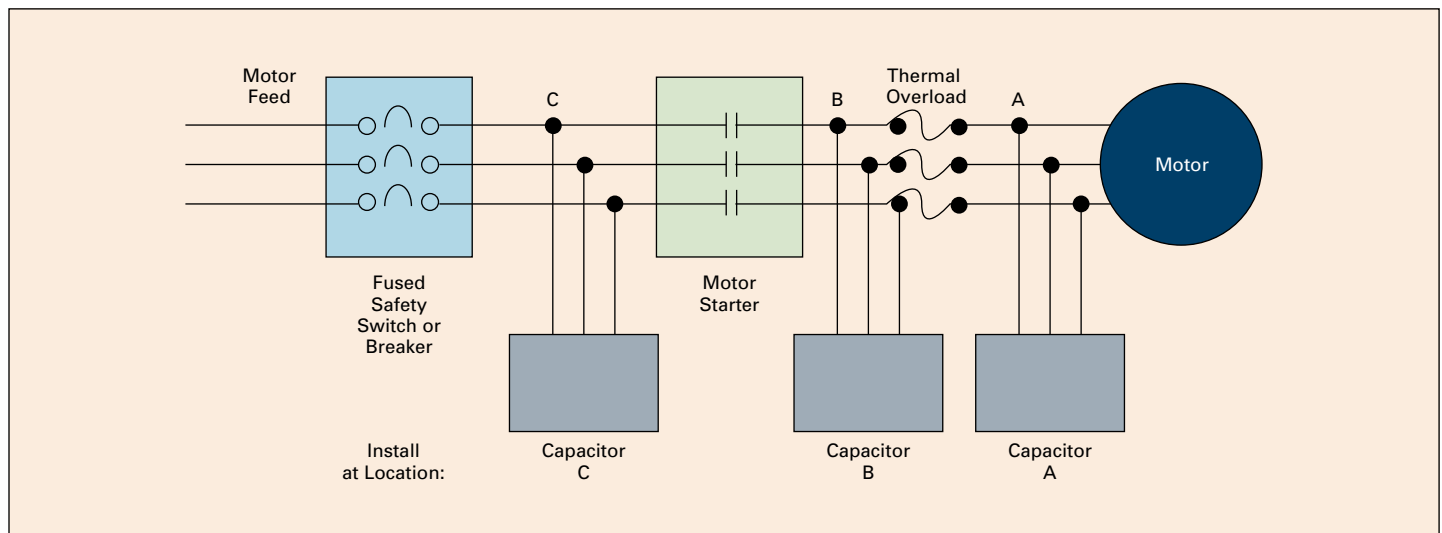


Figure 11. Locating Capacitors on Motor Circuits

Locating capacitors on reduced voltage and multi-speed motors

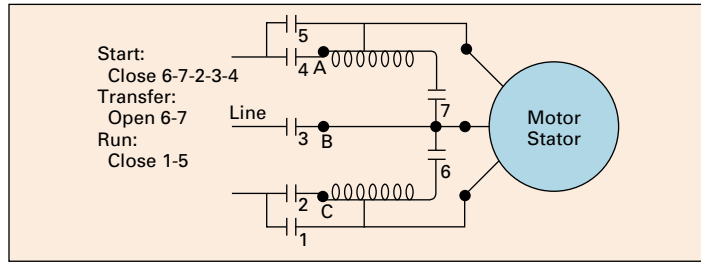


Figure 12. Autotransformer—Closed Transition

Note: Connect capacitor on motor side of starting contacts (2, 3, 4) at points A-B-C.

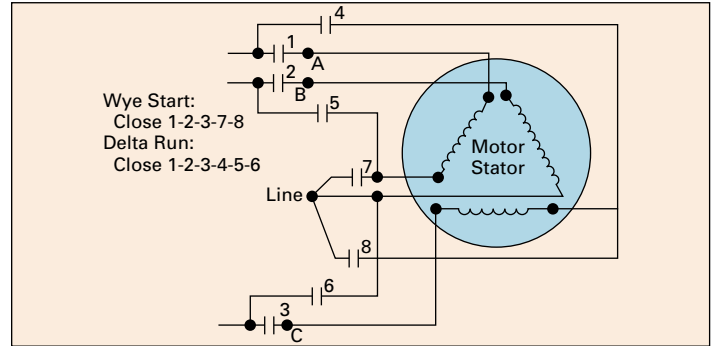


Figure 15. Wye-Delta Starting

Note: Connect capacitor on motor side of starting contacts (1, 2, 3) at points A-B-C.

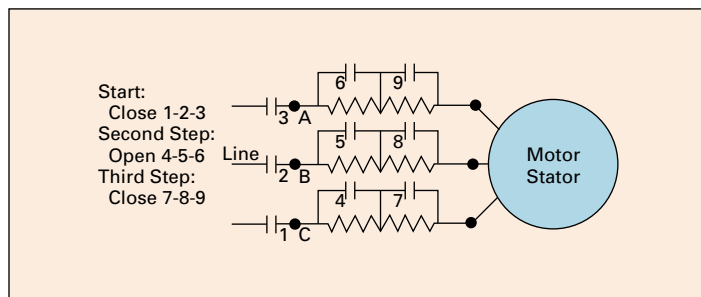


Figure 13. Series Resistance Starting

Note: Connect capacitor on motor side of starting contactor (1, 2, 3) at points A-B-C.

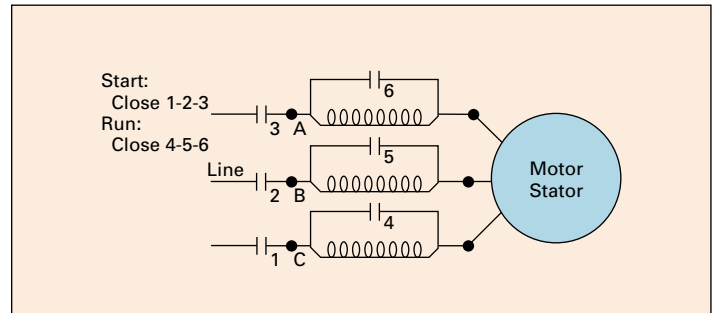


Figure 16. Reactor Starting

Note: Connect capacitor on motor side of starting contactor (1, 2, 3) at points A-B-C.

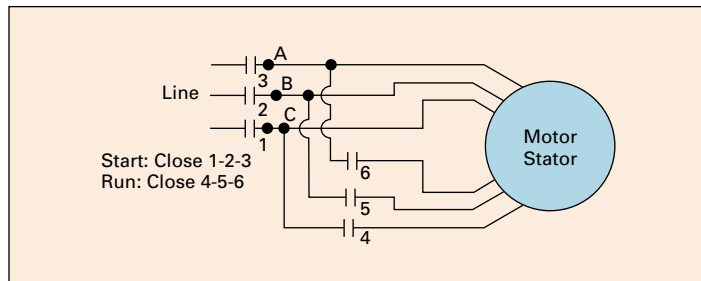


Figure 14. Part-Winding Starting

Note: Connect capacitor on motor side of starting contacts (1, 2, 3) at points A-B-C.

Can capacitors be used in nonlinear, nonsinusoidal environments?

Until recently, almost all loads were linear, with the current waveform closely matching sinusoidal voltage waveform and changing in proportion to the load. Lately, nonlinear loads—which draw current at frequencies other than 60 Hz—have increased dramatically.

Examples of linear and nonlinear devices are as follows:

Linear devices

- Motors
- Incandescent lighting
- Heating loads

Nonlinear devices

- DC drives
- Variable frequency drives
- Programmable controllers
- Induction furnaces
- Arc-type lighting
- Personal computers
- Uninterruptible power supplies (UPSs)

The increase in nonlinear loads has led to harmonic distortion in electrical distribution systems. *Although capacitors do not cause harmonics, they can aggravate existing conditions.*

Because harmonic voltages and currents are affected by all of the equipment in a facility, they are sometimes difficult to predict and model.

Capacitor banks and transformers can cause resonance

Capacitors and transformers can create dangerous resonance conditions when capacitor banks are installed at the service entrance. Under these conditions, harmonics produced by nonlinear devices can be amplified manyfold.

Problematic amplification of harmonics becomes more likely as more kVAR is added to a system that contains a significant amount of nonlinear load.

You can estimate the resonant harmonic by using this formula:

$$h = \sqrt{\frac{kVA_{sys}}{kVAR}}$$

kVA_{sys} = short-circuit capacity of the system

kVAR = amount of capacitor kVAR on the line

h = the harmonic number referred to a 60 Hz base

If h is near the values of the major harmonics generated by a nonlinear device—for example, 3, 5, 7, 11—then the resonance circuit will greatly increase harmonic distortion.

For example, if the plant has a 1500 kVA transformer with 5½% impedance, and the short-circuit rating of the utility is 48,000 kVA, then kVA_{sys} would equal 17,391 kVA.

If 350 kVAR of capacitors were used to improve power factor, h would be:

$$h = \sqrt{\frac{17,391}{350}} = \sqrt{49.7} = 7.0$$

Because h falls right on the 7th harmonic, these capacitors could create a harmful resonance condition if nonlinear devices were present in the factory. In this case, the capacitors should be applied only as harmonic filtering assemblies. For further information, see Harmonic Filter on **Page 22** of this document.

See **Page 19** (Part 2) for an additional discussion on harmonics.

What about maintenance?

Capacitors have no moving parts to wear out and require very little maintenance. Check fuses on a regular basis. If high voltages, harmonics, switching surges, or vibration exists, fuses should be checked more frequently.

Capacitors from Eaton operate warm to the touch. If the case is cold, check for blown fuses, open switches, or other power losses. Also check for bulging cases and puffed-up covers, which signal operation of the capacitor interrupter.

Code requirements for capacitors

Nameplate kVAR: Tolerance +15, –0%.

Discharge resistors: Capacitors rated at 600V and less must reduce the charge to less than 50V within 1 minute of de-energization. Capacitors rated above 600V must reduce the charge within 5 minutes.

Continuous operation: Up to 135% rated (nameplate) kVAR, including the effects of 110% rated voltage (121% kVAR), 15% capacitance tolerance, and harmonic voltages over the fundamental frequency (60 Hz).

Dielectric strength test: Twice the rated AC voltage (or a DC voltage 4.3 times the AC rating for non-metalized systems).

Overcurrent protection: Fusing between 1.65 and 2.5 times rated current to protect case from rupture. Does not preclude NEC requirement for overcurrent protection in all three ungrounded conductors.

Note: When capacitor is connected to the load side of the motor overcurrent protection, fused disconnects or breaker protection is not required. However, Eaton highly recommends fusing for all indoor applications whenever employees may be working nearby.

Useful capacitor formulas

Nomenclature:

C = Capacitance in μF
V = Voltage
A = Current
k = 1000

Additional data

Simplified voltage rise:

$$\% \text{ V.R.} = \frac{\text{kVAR (cap.)} \times \% \text{ transformer reactance}}{\text{kVA (transformer)}}$$

Losses reduction:

$$\% \text{ L.R.} = 100 - 100 \left(\frac{\text{original PF}}{\text{improved PF}} \right)^2$$

Operation at other than rated voltage and frequency:

Note: Use of voltages and frequencies above the rated values can be dangerous. Consult the factory for any unusual operating conditions.

Reduced voltage:

$$\text{Actual kVAR (output)} = \text{Rated kVAR} \left(\frac{\text{actual voltage}}{\text{rated voltage}} \right)^2$$

Reduced frequency:

$$\text{Actual kVAR} = \text{Rated kVAR} \left(\frac{\text{actual frequency}}{\text{rated frequency}} \right)$$

Examples:

Voltage reduction:

$$\text{kVAR (208)} = \text{kVAR (240)} \left(\frac{208}{240} \right)^2 = 0.75$$

(10 kVAR @ 240V = 7.5 kVAR @ 208V)

$$\text{kVAR (120)} = \text{kVAR (240)} \left(\frac{120}{240} \right)^2 = 0.25$$

(10 kVAR @ 240V = 2.5 kVAR @ 120V)

Frequency reduction:

$$\text{kVAR (50 Hz)} = \text{kVAR (60 Hz)} \left(\frac{50}{60} \right) = 0.83$$

(60 kVAR @ 480V, 60 Hz = 50 kVAR, 480V, 50 Hz)

Miscellaneous

$$\text{Power factor} = \cos \theta = \frac{\text{kW}}{\text{kVA}}$$

$$\tan \theta = \frac{\text{kVAR}}{\text{kW}} \quad (\text{See Table 6.})$$

$$\text{Single-phase kW} = \frac{V \times A \times \text{PF}}{10^3}$$

$$\text{Three-phase kW} = \frac{\sqrt{3} \times V \times A \times \text{PF}}{10^3}$$

$$\text{Single-phase kVA} = \frac{V \times A}{10^3}$$

$$\text{Three-phase kVA} = \frac{\sqrt{3} \times V \times A}{10^3}$$

$$\text{Single-phase line current (A)} = \frac{\text{kVA} \times 10^3}{V}$$

$$\text{Three-phase line current (A)} = \frac{\text{kVA} \times 10^3}{\sqrt{3} \times V}$$

$$\text{Capacitor current (A)} = (2\pi f) CV \times 10^{-6}$$

$$\text{Single-phase capacitor current} = \frac{\text{kVAR} \times 10^3}{V}$$

$$\text{Three-phase capacitor current} = \frac{\text{kVAR} \times 10^3}{\sqrt{3} \times V}$$

$$\text{kVA} = \frac{\text{kW (kW motor input)}}{\text{PF}}$$

$$(\text{kW motor input}) = \frac{\text{hp} \times 0.746}{\text{efficiency}}$$

$$\text{Approximate motor kVA} = \text{motor hp (at full load)}$$

Table 8. Standard Data

Voltage	μF / kVAR Total	Amperes / kVAR	
		Single-Phase	Three-Phase
208	61.2	4.81	2.78
240	46.0	4.17	2.41
480	11.5	2.08	1.20
600	7.37	1.67	0.96
2400	0.46	—	0.24
4160	0.153	—	0.139

Note: Above is at nominal voltage @ 60 Hz = nominal kVAR μF and current.

Part two: harmonics

Introduction

There has been much discussion and interest in recent years on the subject of power quality. Whereas in the past, power received from the electric utility and used by an industrial plant was generally a pure sinusoidal waveform—for example, clean power—more frequently today, industrial plants are finding that they have to deal with the problem of “dirty” power. Dirty power is a slang expression used to describe a variety of voltage and current contaminations on the pure sinusoidal waveform. Dirty power can come in the form of short-term transients or steady-state, continuous distortions. In addition, the sources of dirty power can be external to a plant (as might be the case if a neighboring plant is contaminating the utility’s distribution system), or the source can reside within the plant itself.

Harmonic distortion is a specific type of dirty power that is usually associated with an industrial plant’s increased use of adjustable speed drives, power supplies, and other devices that use solid-state switching. However, harmonic distortion can be generated by any of a variety of nonlinear electrical devices existing within a manufacturing plant or within nearby plants. Because harmonic distortion can cause serious operating problems in certain plant environments, it is important that the plant engineer or facilities personnel understand the fundamentals of harmonic distortion, know how to recognize the symptoms of this problem, and know what can be done to solve the problems once they are identified.

What are harmonics?

A harmonic is a component of a periodic wave having a frequency that is an integral multiple of the fundamental power line frequency of 60 Hz. For example, 300 Hz (5 × 60 Hz) is a 5th order harmonic of the fundamental frequency (**Figure 17**). **Figure 18** shows the resultant wave when the fundamental and 5th harmonic are combined. The result is harmonic distortion of the power waveform.

Harmonics typically seen on a power system can be subdivided into two distinct categories by the nature of the problems they create and the remedies they usually require.

- Those harmonic currents that are the dominant harmonic orders created by three-phase nonlinear loads—5th, 7th, 11th, 13th, and higher order odd harmonics that are not multiples of three
- Those harmonics created primarily by single-phase nonlinear loads—3rd order harmonics and higher multiples of three. These are sometimes referred to as triplen or zero-sequence harmonics and are usually accompanied by some 5th, 7th, and other higher order harmonics

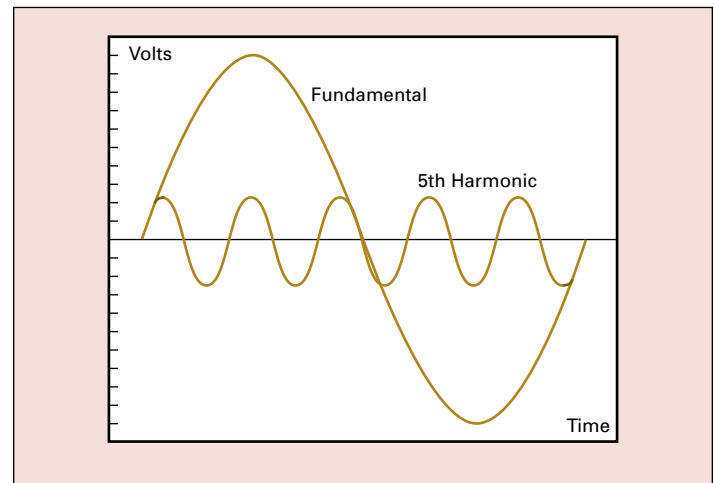


Figure 17. Fundamental and 5th Harmonic

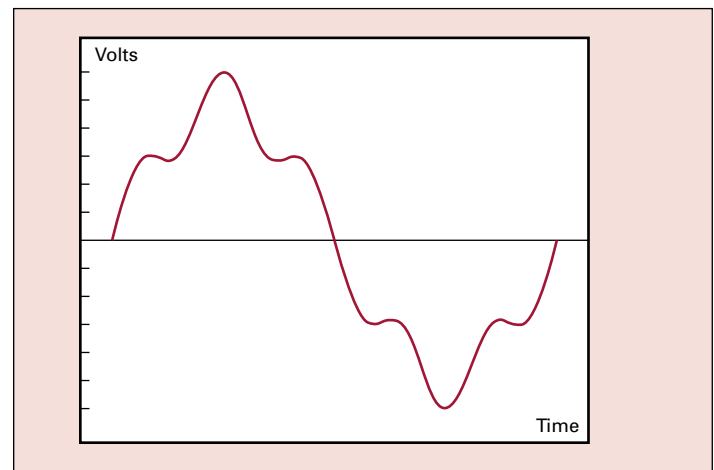


Figure 18. Fundamental and 5th Harmonic Combined

Harmonics are a steady-state phenomenon and should not be confused with short-term phenomena that last less than a few cycles. Transients, electrical disturbances, overvoltage surges, and undervoltage sags in the supplied voltage are not harmonics. Some of these short-term disturbances in voltage or current can be mitigated by transient voltage surge suppressors, line reactors, or isolation transformers. However, these devices usually have little, if any, effect on harmonic currents or voltages.

The level of voltage or current harmonic distortion existing at any one point on a power system can be expressed in terms of the total harmonic distortion (THD) of the current or voltage waveform. The THD (for a voltage waveform) is given by the following formula:

$$V_{thd} = \frac{\sqrt{V_2^2 + V_3^2 + \dots + V_n^2}}{V_1}$$

where: V_1 = fundamental voltage value

V_n ($n = 2, 3, 4, \text{etc.} \dots$) = harmonic voltage values

What are the consequences of high harmonic distortion levels?

Just as high blood pressure can create stress and serious problems in the human body, high levels of harmonic distortion can create stress and resultant problems for the utility's distribution system and the plant's distribution system, as well as all of the equipment that is serviced by that distribution system. The result may be the plant engineer's worst fear—the shutting down of important plant equipment ranging from a single machine to an entire line or process.

Equipment shutdown can be caused by a number of events. As an example, the higher voltage peaks that are created by harmonic distortion put extra stress on motor and wire insulation, which ultimately can result in insulation breakdown and failure. In addition, harmonics increase rms current, resulting in increased operating temperatures for many pieces of equipment, greatly reducing equipment life.

Table 9 summarizes some of the negative consequences that harmonics can have on typical equipment found in the plant environment. While these effects are categorized by problems created by current and voltage harmonics, current and voltage harmonic distortion usually exist together (current harmonic distortion causes voltage harmonic distortion).

Harmonic distortion disrupts plants. Of greatest importance is the loss of productivity, throughput, and, possibly, sales. These occur because of process shutdowns due to the unexpected failure of motors, drives, power supplies, or just the spurious tripping of breakers. Plant engineers realize how costly downtime can be and pride themselves in maintaining low levels of plant downtime. In addition, maintenance and repair budgets can be severely stretched. For example, every 10°C rise in the operating temperatures of motors or capacitors can cut equipment life by 50%.

Table 9. Negative Consequences of Harmonics on Plant Equipment

Equipment	Consequences
Current Harmonic Distortion Problems	
Capacitors	Blown fuses, reduced capacitor life
Motors	Reduced motor life, inability to fully load motor
Fuses/breakers	False/spurious operation, damaged components
Transformers	Increased copper losses, reduced capacity
Voltage Harmonic Distortion Problems	
Transformers	Increased noise, possible insulation failure
Motors	Mechanical fatigue
Electronic loads	Misoperation

IEEE 519

IEEE® Standard 519-1992, *IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems*, represents the most recent effort to establish a standard level of acceptable harmonic distortion levels on a power system.

Table 10 and **Table 11** summarize the voltage and current harmonic distortion limits.

Note: The current distortion limits are dependent upon the size of the customer's load relative to the available short-circuit capacity of the utility (stiffness). In this way, customers whose loads potentially have more effect on the utility system and neighboring customers are held to the tighter limits.

Table 10. End User Limits—Current Distortion Limits for General Distribution Systems End-User Limits (120–69,000V) Maximum Harmonic Current Distortion in % of I_L Individual Harmonic Order (Odd Harmonics)

I_{sc}/I_L	<11	11≤h<17	17≤h<23	23≤h<35	35≤h	TDD
<20 ①	4.0	2.0	1.5	0.6	0.3	5.0
20<50	7.0	3.5	2.5	1.0	0.5	8.0
50<100	10.0	4.5	4.0	1.5	0.7	12.0
100<1000	12.0	5.5	5.0	2.0	1.0	15.0
>1000	15.0	7.0	6.0	2.5	1.4	20.0

① All power generation equipment is limited to these values of current distortion, regardless of actual I_{sc}/I_L .

Notes: Even harmonics are limited to 25% of the odd harmonic limits above. Current distortions that result in a direct current offset—for example, half wave converters—are not allowed.

Where I_{sc} = maximum short-circuit current at PCC
and I_L = maximum demand load current (fundamental frequency component) at PCC.

Table 11. Utility Limits—Voltage Distortion Limits

Bus Voltage at PCC	Individual Voltage Distortion (%)	Total Voltage Distortion THD (%)
69 kV and below	3.0	5.0
69.001 kV–161 kV	1.5	2.5
161 kV and above	1.0	1.5

Note: High voltage systems can have up to 2.0% THD where the cause is an HVDC terminal that will attenuate by the time it is tapped for a user.

Two very important points must be made in reference to the above limitations:

- The customer is responsible for maintaining a current distortion to within acceptable levels, while the utility is responsible for limiting voltage distortion
- The limits are only applicable at the point of common coupling (PCC) between the utility and the customer. The PCC, while not explicitly defined, is usually regarded as the point at which the utility equipment ownership meets the customer's, or the metering point. Therefore, the above limits cannot be meaningfully applied to, say, distribution panels or individual equipment within a plant—the entire plant must be considered when complying with these limits

Electric utilities are currently considering financial penalties and/or service interruption for customers injecting excessive harmonics into the utility system. Therefore, while a customer may not be currently penalized for low power factor, a harmonic distortion-based penalty structure, in the manner of IEEE 519, may be forthcoming.

How are harmonics generated?

Harmonics are generated by nonlinear loads. A nonlinear load is a circuit element that draws current in a nonsinusoidal manner. Until recently, most factory loads were primarily linear, with current waveform closely matching the sinusoidal voltage waveform and changing in proportion to the load. More recently, however, factory loads with major nonlinear components have increased dramatically. **Table 12** gives typical examples of linear and nonlinear devices.

Table 12. Examples of Linear and Nonlinear Devices

Primarily Linear Devices	Devices with Major Nonlinear Components
Some motors Incandescent lighting Heating loads	DC drives Variable frequency drives Programmable controllers Induction furnaces Solid-state uninterruptible power supplies (UPSs) Arc furnaces Arc welders

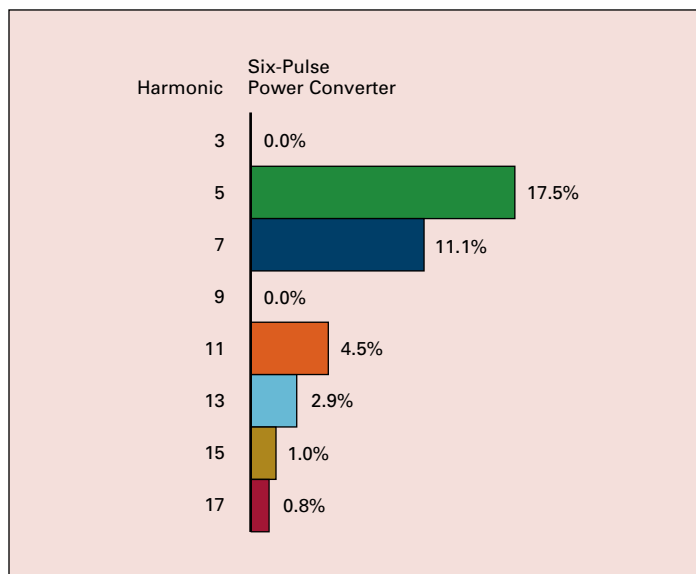


Figure 19. Harmonic Magnitude as Percentage of the Fundamental Current

Note: Harmonic currents typically injected by six-pulse VFDs.

Nonlinear devices that cause the most problems can generally be grouped into two categories—electronic power converters and arcing devices.

Electronic power converters

Electronic power converters—for example, adjustable speed drives and power supplies—are by far the largest contributors to harmonic distortion in today's plant environment. An electronic power converter changes electrical energy from one form to another, typically by rectifying the AC voltage into DC and utilizing the DC voltage directly or synthesizing a new AC voltage. This change is accomplished by using solid-state devices—silicon control rectifiers (SCRs), diodes, transistors—to periodically switch in the conducting circuits of the converter. **Figure 19** shows a typical harmonic current spectrum for a six-pulse electronic power converter. Below are some common names that are typically associated with electronic power converters.

Common names given to electronic power converters

- Adjustable speed drives
- Variable frequency drives
- SCR drives
- AC motor drives (AC/DC/AC)
- DC motor drives (AC/DC)
- Three-phase full wave rectifiers
- Three-phase full wave converters
- Six-pulse converters

As most plant engineers appreciate, there is an increased use of electronic drives due to their ability to more efficiently or precisely drive a motor or process.

Arcing devices

Arc furnaces and welders are the two types of arcing devices that cause the most harmonic distortion, although arc lighting (fluorescent, mercury vapor) will also cause small degrees of harmonic distortion.

Other equipment

Motors, generators, transformers, and arc lighting also have small nonlinear components, although the contribution of these devices to total harmonic distortion in a plant tends to be relatively small.

What do power factor correction capacitors have to do with harmonics?

A discussion of power system harmonics is incomplete without discussing the effects of power factor correction capacitors. In an industrial plant containing power factor correction capacitors, harmonic currents and voltages can be magnified considerably due to the interaction of the capacitors with the service transformer. This is referred to as *harmonic resonance* or *parallel resonance*. For a typical plant containing power factor correction capacitors, the resonant frequency (frequency at which amplification occurs) normally falls in the vicinity of the 5th to the 13th harmonic. Because nonlinear loads typically inject currents at the 5th, 7th, 11th, and 13th harmonics, a resonant or near-resonant condition will often result if drives and capacitors are installed on the same system, producing the symptoms and problems outlined in the previous section.

Note: Capacitors themselves do not cause harmonics, but only aggravate potential harmonic problems. Often, harmonic-related problems do not “show up” until capacitors are applied for power factor correction.

It is a common misconception that the problem of applying capacitors in harmonic environments is limited to problems caused for the capacitor itself—that the capacitor’s lower impedance at higher frequencies causes a current overload into the capacitor and, therefore, must be removed. However, the capacitor/harmonics problem must be viewed from a power system standpoint. The capacitor-induced increase of harmonic voltages and currents on a plant’s system may be causing problems while the capacitor itself remains within its acceptable current rating.

How do I diagnose a potential harmonics-related problem?

If a plant engineer suspects that he might have a harmonics problem, the following steps can easily be performed as an initial investigation into potential problems:

- Look for symptoms of harmonics as listed in **Table 9**. If one or more of these symptoms occurs with regularity, then the following steps should be taken
- If the plant contains power factor correction capacitors, the current into the capacitors should be measured using a “true rms” current meter. If this value is higher than the capacitor’s rated current at the system voltage (by >5% or so), the presence of harmonic voltage distortion is likely
- Conduct a paper audit of the plant’s harmonic-producing loads and system configuration. This analysis starts with the gathering of kVA or horsepower data on all the major nonlinear devices in the plant, all capacitors, and rating information on service entrance transformer(s). Eaton has specific analysis forms with instructions to guide the plant engineer in collecting this information, and engineers or sales representatives can provide assistance as needed. This data is analyzed by Eaton engineers to determine whether the conditions are present to create unfavorable levels of harmonics
- If the electrical distribution system is complex—for example, multiple service entrances, distributed capacitors—or if the paper audit is incomplete or considered to be too burdensome, the most definitive way to determine whether harmonics are causing a problem is through an on-site plant audit. This audit involves an inspection of the electrical system layout and connected loads, as well as harmonic measurements taken at strategic locations. This data can then be assembled and analyzed to obtain a clear and concise understanding of the power system. Eaton provides an engineering service to conduct these on-site plant audits

How can harmonics problems be eliminated?

When power factor correction is required in the presence of nonlinear loads, or the amount of harmonic distortion must be reduced to solve power quality problems or avoid penalties, the most reliable, lowest cost solution is often realized with the use of harmonic filters.

What is a passive harmonic filter?

A shunt harmonic filter (see **Figure 20**) is, essentially, a power factor correction capacitor combined with a series iron core reactor. A filter provides power factor correction at the fundamental frequency and becomes an inductance (like a motor) at frequencies higher than its turning point. Eaton harmonic filters are almost always tuned below the 5th harmonic. Therefore, the filter provides an inductive impedance path to those currents at harmonic frequencies created by nearly all three-phase nonlinear loads (5th, 7th, 11th, 13th, and so on). Since the filter is not capacitive at these frequencies, the plant electrical system can no longer resonate at these frequencies and cannot magnify the harmonic voltages and currents. A shunt harmonic filter therefore accomplishes three things:

- Provides power factor correction
- Prevents harmonic overvoltages due to parallel resonance
- Reduces voltage harmonic distortion and transformer harmonic loading at frequencies above its turning point

In some circumstances, a harmonic resonance condition may accrue gradually over time as capacitors and nonlinear loads are installed in a plant. In those instances, replacement of such capacitors with harmonic filters is in order to correct the problem.

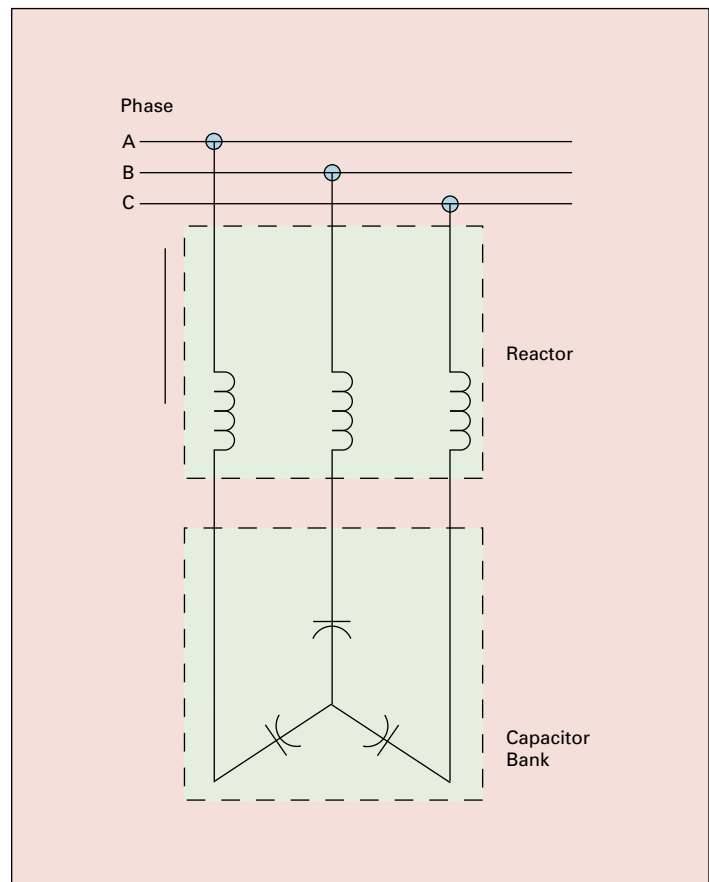


Figure 20. Shunt Harmonic Filter

Do I need to perform a system analysis to correctly apply harmonic filters?

The proper application of harmonic filters can be greatly simplified by recognizing that there are only a few pieces of pertinent information and analysis steps that need to be taken for most systems in order to correctly deal with the problem.

Eaton's approach to power system harmonic diagnosis and solutions has evolved, via years of accumulated knowledge and experience, to an approach that eliminates needless analytical complexity in the majority of circumstances. Rather, it relies on the relatively few pieces of information that are required to make the correct applications decision. If this information indicates that some type of metering and measurement is required, then only those select measurements that yield useful information will be performed, keeping the complexity and cost to a minimum without sacrificing solution correctness.

Our abilities in the area of harmonic analysis, however, extend to our state-of-the-art computerized analysis tools should the customer require the thoroughness afforded by such tools.

One of the most basic and useful pieces of information that *must* be known before attempting to correct power factor in the presence of nonlinear loads is the ratio of the total nonlinear kVA to the service transformer kVA rating. This ratio alone can often be used to determine whether harmonic filters are necessary to correct power factor or whether plain capacitors can be added without experiencing problems as follows:

- If the plant's total three-phase nonlinear load (in kVA, 1 hp = 1 kVA) is more than 25% of the main transformer capacity, harmonic filters will almost always be required for power factor correction
- If the plant's total three-phase nonlinear load is less than 15% of the main transformer capacity, capacitors can usually be applied without problems
- If the plant's total nonlinear load is between 15 and 25%, other factors should be considered

Starting with this most basic information, your Eaton sales representative will work with you to determine what additional information or measurement, if any, is required in order to recommend the correct solution to your problem.

What is Eaton's experience in harmonic filtering?

Eaton has been in the power capacitor business for 70 years, manufacturing power factor correction capacitors used in low voltage and medium voltage applications. In the 1980s, we began working with a number of customers to help resolve problems related to harmonic distortion. During that time, we developed a number of designs to incorporate harmonic filtering in both fixed and automatic capacitor banks. The success of these installations has made Eaton the leader in the field of harmonic filters.

With a fully integrated manufacturing process, we maintain the strictest quality control systems in the industry. All power capacitors are 100% tested at various stages in their manufacture and prior to shipment to ensure a long service life. In addition, Eaton provides on-site supervision and startup assistance to ensure that all capacitor and harmonic filtering assemblies are properly applied in the plant environment.

Please call **1-800-809-2772** for assistance in understanding and solving any problems that you have involving capacitors or harmonics in your facility.

Eaton is dedicated to ensuring that reliable, efficient and safe power is available when it's needed most. With unparalleled knowledge of electrical power management across industries, experts at Eaton deliver customized, integrated solutions to solve our customers' most critical challenges.

Our focus is on delivering the right solution for the application. But, decision makers demand more than just innovative products. They turn to Eaton for an unwavering commitment to personal support that makes customer success a top priority. For more information, **visit www.eaton.com/electrical**.

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Printed in USA
Publication No. SA02607001E / Z15663
August 2014



Assessing Impact of Optimally Placed Power Factor Correction Capacitors Reckoning Transient Switching Events

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Received: 9 March 2020 / Accepted: 4 October 2020 / Published online: 26 October 2020
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Abstract

Installing capacitors to correct the power factor at particular locations is one way to enhance power system reliability. This paper offers a new formulation to address the issue of optimal placing capacitors. The proposed formulation considers reliability impact, in addition to the transient switching events. This is reflected in the cost minimization objective function, where the reliability calculations are considered to gauge the impact when capacitors are installed in the power system. The formulated problem is solved using genetic algorithm (GA), to minimize costs of capacitor installation, energy loss and failure impact. The new formulation has been examined on a test network for evaluating how effective the proposed approach is. The solution also considers the impact of uncertainties as well as future growth in the system, to ensure that it is optimal. The results evidence that the proposed approach is robust and effective in enhancing system reliability in the face of uncertainties and for future growth.

Keywords Power factor correction · Shunt capacitors · Damping reactors · Energy loss minimization · Transient switching · Genetic algorithm · Monte Carlo simulation · Failure rate and reliability analysis

1 Introduction

Capacitors to correct power factor are installed for regulating voltage in electrical systems, and to minimize power and energy loss, besides avoiding penalties on account of tariff regulatory norms. However, these power factor correction capacitors will lead to a reliability impact on power systems. The world over, tariff requirements have compelled engineers to investigate optimal capacitor placement. Given

the fact that installing power factor correction capacitors in a power system has significant benefits, engineers mostly tend to overlook the reliability aspect. This may significantly impact optimization planning. Reliability calculations have to be taken note of while planning, to make certain that all possible options are considered to provide an effective, robust, and reliable optimized solution in any scenario.

Recent research has focused on optimizing power factor correction capacitor installation, in view of recent tariff regulations which only consider the real power. However, a few countries have recently started accounting for reactive power consumption also [1]. Thus, few industrial facilities are considering the installation of capacitors at the substation of the Point Common Coupling (PCC) or on other substations that is directly connected to the PCC substation. This will cause a lot of changes in power systems, some advantageous and others adverse. This change therefore should be planned carefully and must embrace all aspects [2–6]. The factors considered are: optimal size, location, cost, and voltage level.

Optimal capacitor placement planning addresses optimizing the location and size for reducing investment cost [2–17]. The capacitor placement in these research works mostly considered voltage issues and power factor, with a few also considering the impact on reliability [2]. Generally, the objec-

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tive function was to minimize cost, considering many aspects and constraints. Many techniques have been used to achieve an optimal value as desired for the objective function, such as Particle Swarm Optimization [2], Genetic Algorithm (GA), and some other evolutionary optimization methods [3–12]. The use of these techniques was to locate the optimal location and optimize the rating of the installed capacitor, with minimum cost.

There are a few papers which address how reliability is impacted when power factor correction capacitors are optimally placed. Papers [2, 13–19] discuss enhancement of the capacitor in the electrical system capacity. They have concentrated on the minimization of failure of power lines after capacitor installation, for which case studies have been presented. However, these papers discuss only the advantageous aspects of capacitor installation, whereas the negative impact has been elaborated in [20–22]. They discuss the transient switching event phenomenon and its impact on performance of the system, although no case study has been presented so far.

Installing power factor correction capacitors will have both positive and negative consequences for the system. Many such effects on reliability have been discussed. However, while earlier research has generally considered only the positive impacts in optimal capacitor placement planning, such will not be the case in this study.

This investigation offers a new formulation to optimally size and locate power factor correction capacitors, given constraints such as limiting the power factor value, maintaining the regulated voltage level, and eliminating the transient events due to capacitors switching. This investigation will include as well the resulting effect on the reliability due to the installation of the PFC capacitors. Impact on reliability is presented as a cost impact that will be added to the main objective function. Therefore, the objective function will account for the cost due to the reliability impact as well as to the low power factor penalty, energy loss minimization cost and PFC capacitors cost. Reliability impact cost will be taken to be the failure rate prior to and post installation of PFC capacitors. The objective function is optimized to get an optimum solution considering every aspect. Implementation of the proposed approach is carried out for transmission test systems. To the best of the authors' knowledge, no work exists in the literature, which addresses reliability assessment for PFC capacitors in transmission systems, also accounting for transient switching events.

The paper will start by proposed formulation and methodology in Sect. 2 followed by proposed solution in Sect. 3. Then, the test system and results discussions will be shown in Sects. 4 and 5. Finally, the conclusion will be presented in Sect. 6.

2 Proposed Formulation and Methodology

2.1 Transients Switching Events in Capacitors

Many failures have occurred recently in industrial facilities, which were presumed to have been because of the harmonics effect of these capacitors. However, detailed investigations have revealed that these failures were due to capacitor switching transients [20]. This caused the power factor to drop, hence, a rise in the bills of electricity due to the penalties. The transient switching events phenomena occurred due to the voltage variation between the substation bus and the energized capacitor. When the capacitor at zero voltage connected to a system at the base voltage, the capacitor will work to minimize the voltage of the system close zero. This abrupt reduction in the voltage of the system will cause an inrush current. Then, the system will attempt to recover the voltage, which will cause an inrush to its voltage to nearly double the base voltage. The system voltage will fluctuate until full recovery. Capacitor switching transient magnitude is governed by the capacitor charged voltage and the system voltage during energization, which should approach zero, unless it was energized prior attaining zero.

There are two ways of capacitor switching, as shown in Figs. 1 and 2; namely series capacitor switching and parallel capacitors switching, and the corresponding impact on the system is seen in Figs. 3 and 4, respectively.

As discussed earlier, transient switching events minimization is very important to protect the electrical grid and can be minimized in three ways. The first is by not energizing charged capacitors until it reaches to zero voltage. The second way is to energize capacitors after system voltage has reached zero. The third method involves an engineering solution by installing current limiting reactors to minimize the transient impact to acceptable values during switching. Details and more information on capacitors switching transients are available in [20] and [21].

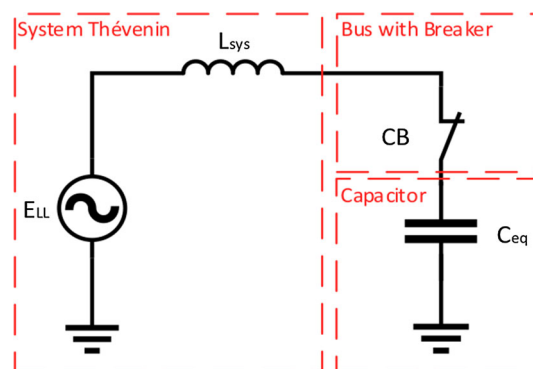


Fig. 1 Series capacitor circuit



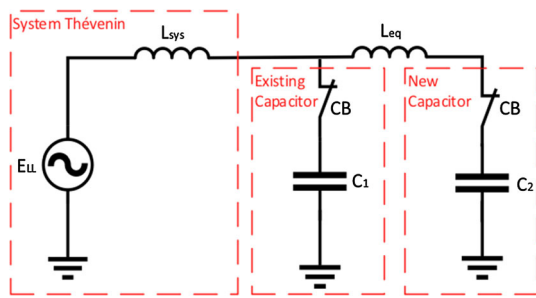


Fig. 2 Parallel capacitor circuit

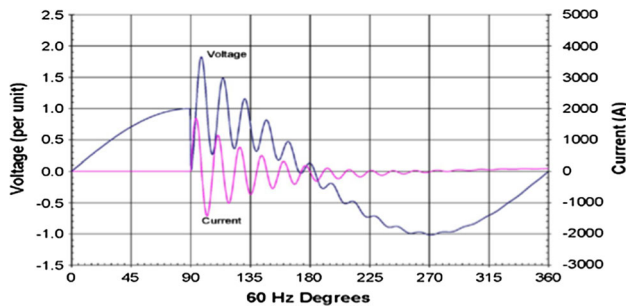


Fig. 3 Voltage impact on switching a series capacitor [21]

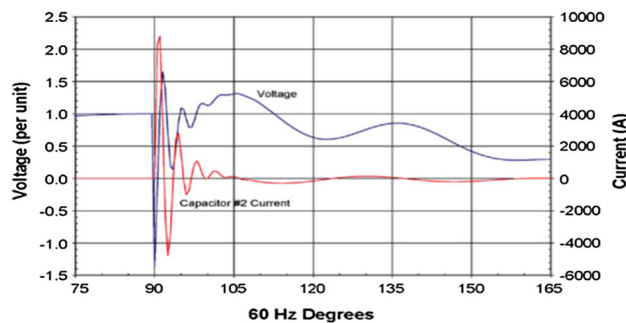


Fig. 4 Voltage impact on switching parallel capacitors [21]

In this paper, optimizing capacitor sizing and installation cost considering transient switching events are addressed, as well as their effect on the electrical system reliability. Calculations of impact on reliability too are considered. Transient switching frequency, f , and inrush current breakers limits, $i_{\max\text{peak}}$, are taken from ANSI C37.0732 and shown in Table 1. Calculation of these values for single switching and

back-to-back switching is carried out as follows:

$$i_{\max\text{peak}} = \frac{\sqrt{2}E_{LL}}{\sqrt{3}} \sqrt{\frac{C_{\text{eq}}}{L_{\text{sys}}}} \quad (1)$$

$$f = \frac{1}{2\pi \sqrt{C_{\text{eq}} L_{\text{sys}}}} \quad (2)$$

$$i_{\max\text{peak}} = \frac{\sqrt{2}E_{LL}}{\sqrt{3}} \sqrt{\frac{C_1 C_2}{L_{\text{eq}} (C_1 + C_2)}} \quad (3)$$

$$f = \frac{1}{2\pi \sqrt{\frac{C_1 C_2 L_{\text{eq}}}{(C_1 + C_2)}}} \quad (4)$$

where E_{LL} and L_{sys} are system voltage and inductance, C_{eq} , C_1 and C_2 are the capacitances as shown in Figs. 1 and 2, and L_{eq} is approximated to be the cable inductance.

The inductance and capacitance can be calculated as:

$$L = \frac{X_{\text{pu}} \times V_{\text{base}}^2}{S_{\text{base}} \times 2\pi f} \quad (5)$$

$$C = \frac{\text{VAR}_{\text{Rating}}}{2\pi f \times V^2} \quad (6)$$

2.2 Reliability Calculations

Installing a PFC capacitor will result in significant changes in the electrical grid. These changes will enhance the system reliability in terms of increasing the system capacity. This improvement is equivalent to adding a parallel line to the existing circuit, which will not only enhance the system capacity but also minimize rate of failure of power cables. The reliability cost impact may be computed as follows, by the formula for expected interruption cost (ECOST):

$$\text{ECOST}_N = L_N C_N \lambda_N \quad (7)$$

L being load, C power cost, and λ is bus N rate of failure. This rate rises for every bus following capacitor installation, because of current reduction caused by a fall in the reactive current component. This will reduce heat in the circuit, which in turn reduces the moisture absorption [2]. The ratio, α , for bus N between the old and new currents before and after

Table 1 Max. circuit breaker operating limits

Operating voltage (KV)	Max. current (KA)	Max. frequency (Hz)
$V_{\max} < 15$	15	2000
$15 < V_{\max} < 72$	16	3360
$120 < V_{\max} < 145$	16	4250
$169 < V_{\max} < 362$	20	4250



installing capacitors can be represented as follows:

$$\alpha_N = \frac{I_{\text{new}-N}}{I_{\text{old}-N}} \quad (8)$$

Then, revised rate of failure for bus N is computed by the following equation:

$$\lambda_{\text{new}-N} = \alpha_N (\lambda_{\text{old}-N} - \lambda_{\text{best}-N}) + \lambda_{\text{best}-N} \quad (9)$$

where λ_{old} is the initial rate of failure preceding the installation of the capacitor and λ_{best} is the full compensation failure rate, being approximately 85% of initial failure rate [2].

2.3 Equipment Failure Rates

Although PFC capacitors will strengthen system reliability, their switching transient negatively affects the equipment failure rate and system reliability. For resolving transient switching event issues, damping reactors can be sized suitably and installed in series with capacitors to minimize the transient effect on the system while energizing and de-energizing capacitor banks. This will add an additional cost; however, it will greatly affect the reliability of the system. Transient switching failure rate will be based on damping reactors' failure with the consideration of capacitor switching transient events. This research will simulate the breakers failure rate per year in order to get more accurate results. In previous studies, breaker failure rate was assumed as 2 f/y [23], although breakers generally fail at hi but it was done to prove the concept and now the failure rate will be simulated. Also, failure rates of capacitors, breakers and lines are needed to calculate the system reliability cost effect. Table 2 reflects failure rates used in this paper [24,25].

2.4 Monte Carlo Simulation

Monte Carlo simulation has been carried out using Table 2 data to find the circuit failure rate of each capacitor. The simulations are conducted for one hundred years, to find the rate of failure for every equipment. The rate of failure has been calculated per minute for reasons of accuracy. Then,

Table 2 Failure rates of electrical components

Component	Rate of failure	Time to repair
Circuit breaker	0.003	129
Circuit breaker (Tran.)	Will be simulated	129
Electrical capacitor	0.17443	2.3
Electrical reactor	0.04	150
Electrical cable	0.0141	40.4

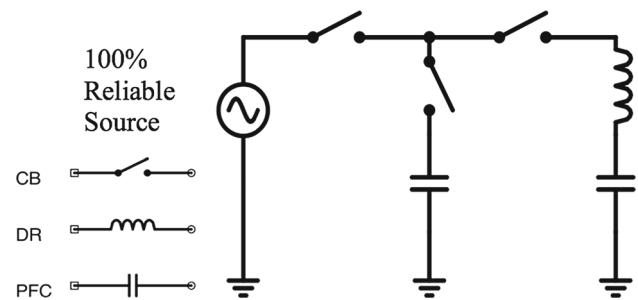


Fig. 5 Simulated circuit in Monte Carlo algorithm

it is converted to failure per year in order to determine the annual failure cost. Figure 5 shows the circuit used for Monte Carlo simulations to calculate capacitor circuits' failure rates. The series connected components' failure rates are summed together as one failure rate.

2.5 Objective Function

In problems relating to optimal design of PFC capacitors, the objective function seeks to minimize installation cost. Considering all aspects discussed above, the proposed objective function includes the installation cost of capacitors (C_{install}), the cost of the minimized energy losses (C_{ELM}) and the cost that was impacted due the reliability calculation (Failure) (C_{RC}), as follows:

$$\text{Maximize } (C_{\text{tot}}) = C_{\text{RC}} + C_{\text{ELM}} - C_{\text{install}} \quad (10)$$

In addition, another function will be calculated, which considers the cost impact and includes the penalty that will be avoided due to the low power factor. The function comprises the penalty (C_{PFC}) and the total calculated cost as given in Eq. 10. (C_{tot}):

$$\text{Maximize } (C_{\text{avoided}}) = C_{\text{tot}} + C_{\text{PFC}} \quad (11)$$

The four main cost contributors in Eqs. (10) and (11) are calculated as below:

$$C_{\text{PFC}} = k\text{var}/h \text{ cost} \times 8760 \times P(\tan(\cos^{-1} 0.95) - \tan(\cos^{-1} P_{\text{before}})) \quad (12)$$

$$C_{\text{ELM}} = (kw/h \text{ cost} \times (P_{\text{after}} - P_{\text{before}}) + k\text{var}/h \text{ cost} \times (Q_{\text{after}} - Q_{\text{before}})) \times 8760 \quad (13)$$

$$C_{\text{RC}} = (kw/h \text{ cost} \times P + k\text{var}/h \text{ cost} \times Q) \times \lambda_{\text{new}-N} \times 8760 \quad (14)$$

$$C_{\text{install}} = mH \text{ cost} \times \text{Required } mH + M\text{var cost} \times \text{Required } M\text{var} + \text{Cable Cost} + \text{Building Cost} \quad (15)$$

Table 3 Economics data

Assumed rate of discount	5.0%
Cost of capacitor (Mvar cost)	\$87500/MVAR
Inductor cost (mH cost)	\$30000/1 mH
Capacitor power cable (cable cost)	\$3200/capacitor
Capacitor building (building cost)	\$675000/capacitor
Energy cost (kwh cost)	\$0.0479/kwh
Reactive power cost (kvarh cost)	\$0.0133/kvarh

where P , Q are the real and reactive powers at each bus, while the remaining data can be found in Table 3 [23,26].

2.6 Problem Constraints

The operational constraints are the power factor, switching frequency and breaker current limit at each bus. Therefore, the problem constraints are given as follows:

$$PF_N \geq PF_{\text{Target}} \text{ for every PQ bus N} \quad (16)$$

$$V_{\min} \leq V_N \leq V_{\max} \quad (17)$$

$$f_N < f_{\max} \text{ for the operating voltage} \quad (18)$$

$$i_N < i_{\max} \text{ for the operating voltage} \quad (19)$$

Load flow analysis is applied to assess these constraints. Any solution that violates any of the aforementioned constraints is rejected. Details of bus selection and identifying optimal values are explained in the optimization section.

3 Proposed Solution Methodology

Optimization begins with initialization to use the data from the first generation for the optimization process. Then, Genetic Algorithm (GA) is employed for identifying the optimal values for the proposed objective function. Load flow analysis helps to discover the power factor value at the selected system load buses [27]. Any load bus is violating the power factor limit will be selected before the commencement of initialization. However, generation buses are excluded, assuming that the generator can supply the reactive power needed for avoiding penalties.

3.1 Initialization

Initialization commences by randomizing the selected buses' shunt capacitance. The shunt capacitance is input in the model as Mvar values. For expediting randomization and limiting the values to be close to approximate to the load

Mvar, the equation is proposed is:

$$Q_{\text{shunt}} (\text{Mvar}) = \text{rand} (0, 1) \times Q_{\text{load}} \quad (20)$$

Every single randomized value, $Q_{(\text{shunt})}$, is checked under the objective constraints and limits. This will be done on the whole population that was generated. Then, the minimum cost, as specified in the proposed objective function Eq. 10, is saved as the ideal result for guiding the optimization.

3.2 Genetic Algorithm (GA)

The initial population is employed in GA to be processed through selection of parents, crossover and mutation [28]. The new VAR values of each generation in GA are taken as the revised capacitor ratings, which will be followed by the load flow process to check the newly established generation with respect to the pre-defined constraints. The calculation will include as well the profit of each generation. The enhanced results are moved to the next generation and the bad results excluded. This selection will be determined based on the calculated profit value of each solution. This process is repeated until the maximum possible generation numbers, or the best solution does not change for the specified number of iterations.

4 Test System and Load Modeling

The case stated will be implemented on a test system to evaluate the proposed formulation and solution methodology at different scenarios. The selected system is a 5-bus test system consists of 5 loads and 3 generators. The selected test system to prove the proposed objective function is shown in Fig. 6, whereas the data are extracted from [26,29], respectively. The system voltage is considered as 69 kV, and as per ANSI C37.0732 the limits of transient are 16 kA and 3360 Hz as given in Table 1. In the case of parallel switching, inductance (L_{eq}) is selected from [11] to be 16 H, with the limit for voltage per unit being $\pm 5\%$ and the minimum power factor acceptable at the load buses is 0.95.

The case study is treated as a planning problem in order to investigate the transient effect on the reliability of the system. Table 4 reflects the planned future growth. This was taking from the Electricity and Co-Generation Regulatory Authority (ECRA) website [11]. The load growth was calculated using the historical data for the ensuing ten years. This 10-year range is split as two expansion horizons, each of 5 years. Figure 7 depicts the flowchart for the whole process summary.



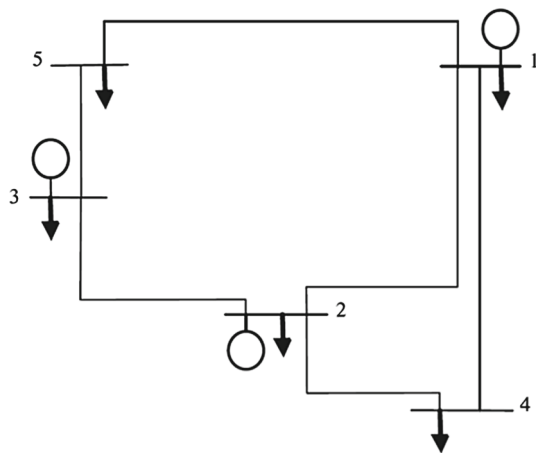


Fig. 6 5-Bus system circuit [26]

Table 4 Load growth factors for the complete cycle

Year 5	1.36
Year 10	1.84

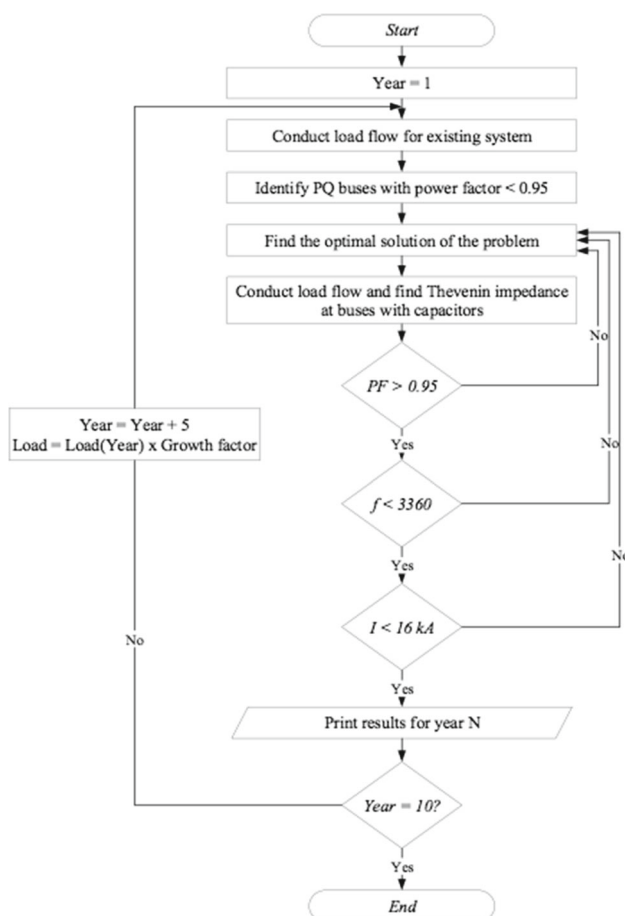


Fig. 7 Summarized flowchart of the problem

5 Results and Discussion

Starting with Monte Carlo simulation for the equipment presented in Table 2, the updated failure rate is employed to compute the cost due to reliability/failures prior to and post considering transients. So, the test cases can be defined as:

Case 1: Before considering transient switching limits.

Case 2: After considering transient switching limits.

The above two scenarios are aimed at determining the impact of switching transient on total cost, especially from reliability and failure perspectives. The circuit breaker failure rate for not considering transient events was simulated and revealed to 4.7138 f/y . Table 5 contains the failure rates derived through Monte Carlo simulation utilizing the failure rates specified in Table 2 and the simulated circuit breaker failure rate. The results comprise both cases and demonstrate whether the results violate the limits.

The load flow is executed which followed by the violated buses selection process that scans the power factor values and select the buses that are lower than the acceptable value. Then, GA is employed to find the optimal PFC capacitor size that meets the requirement constraints and maximizes the total saved payment. The procedure shown in Fig. 7 is implemented on the selected system for testing.

5.1 Test System Results

In this study, a parallel line will be added to consider the future expansion that is calculated in Table 4. Then, the load flow will be implemented and its results are shown in Tables 6 and 7 for considering and without considering the future expansion. This will be followed by checking the power factor constraints. The violated buses are selected for capacitor installation. The test is divided into two cases with/without considering transient switching constraints to prove the transient switching impact.

The first instance does not consider the transient limits, for which Table 8 gives the optimization results. Then, future expansion is considered for two 10-year cycles with 5 years each. The results for each cycle are shown in Table 8. For the first cycle had no parallel switching, and consequently transient limits remained within acceptable levels to meet ANSI standards, as shown in Table 1. The failure cost is an acceptable \$54,340, as no switching transient caused system tripping. The aggregate cost is \$2,464,000, whereas total avoided cost caused by the penalty is \$10,581,000. It is very clear that the transient frequency limits were violated (13.14 kHz & 10.73 kHz). This leads to a higher failure rate (0.0373 f/y), bringing total failure/reliability cost to \$1,780,436. For the planned 10-year duration, the total avoided cost aggregates to \$13,404,734.



Table 5 Failure rated results from Monte Carlo iterations

Case #	Not violating Tran. limit (f/y)	Violating Tran. Limit (f/y)
1	0.0042	0.0879
2	0.0042	0.0047

Table 6 Results of load flow for the original system

#	V (PU)	Load (MW)	Load (MVar)	Gen (MW)	Gen (MVar)	PF (PU)
1	1	24	11.6	116.78	25.543	0.98890
2	1	72	34.8	50	72.115	0.50787
3	1	12	5.8	65	27.746	0.92393
4	0.937	48	23.2	0	0	0.90035
5	0.954	72	34.8	0	0	0.90035

Table 7 5-Year load flow results after expanding the circuit for expected future growth

#	V (PU)	Load (MW)	Load (MVar)	Gen (MW)	Gen (MVar)	PF (PU)
1	1	32.64	15.776	199.508	24.336	0.99869
2	1	97.92	47.328	50	101.521	0.66242
3	1	16.32	7.888	65	41.769	0.82078
4	0.959	65.28	31.552	0	0	0.90035
5	0.970	97.92	47.328	0	0	0.90035

Table 8 5-Bus test system—not considering transient case

Planning cycle	1	2
Load buses	4	5
PF (PU)	0.95	
Frequency (KHz)	0.55	0.52
Current (KA)	1.10	1.55
Size (MVAR)	10.10	15.15
D. Reactor (mH)	N/A	
Inst. cost (\$)	−3,564,800	−785,830
ELM cost (\$)	1,155,200	556,440
PFC cost (\$)	13,045,000	4,604,200
Failure cost (\$)	−54,340	−1,551,046
Total cost (\$)	−2,464,000	−1,780,436
Avoided loss (\$)	10,581,000	2,823,734
Accum. Avo. Loss (\$)	10,581,000	13,404,734

The results of the other scenario, where transient limits are accounted for, are shown in Table 9. The results for the first cycle are the same, since there is no violation of switching transient constraints. However, the second cycle results are different following installation of damping reactors which avoid system tripping caused by capacitor parallel switching transient. Also, resolving transient issues using reactors helps

Table 9 5-Bus test system—considering transient case

Planning cycle	1	1
Load buses	4	5
PF (PU)	0.95	
Frequency (KHz)	0.55	0.52
Current (KA)	1.10	1.55
Size (MVAR)	10.10	15.15
D. Reactor (mH)	0	0
Inst. Cost (\$)	−3,564,800	−886,520
ELM cost (\$)	1,155,200	556,440
PFC cost (\$)	13,045,000	4,604,200
Failure cost (\$)	−54,340	−82,807
Total cost (\$)	−2,464,000	−412,890
Avoided loss (\$)	10,581,000	4,191,300
Accum. Avo. loss (\$)	10,581,000	14,773,000

restrict failure rate and improved it to 0.0047 f/y. Although, it exceeds without considering reactors failure rate, which is 0.0042 f/y. However, it is 87.4% lower than the scenario without considering the transient impact to the system in the planning phase. The total cost after installing damping reactors to avoid unplanned tripping caused by capacitor switching transient amounts to \$412,890, i.e., 53.4% less than the scenario excluding the transient events. The total cost for this cycle after incorporating the avoided penalty is \$4,191,300 and \$14,773,000 for the 10-year planning.

5.2 Reliability Issues Impacting Failure Cost

Table 10 for the foregoing case study shows the detailed analysis assessing the reliability issues that is impacting the failure cost. The failure rates acquired through Monte Carlo analysis were employed to compute failure cost. As discussed earlier, installation of capacitor banks for correcting the power factor has advantages on account of unloading the line, which is considered a positive impact. However, the capacitor itself added damping reactor to avoid transient tripping, and not installing reactors increased the failure rate. These values have not earlier been reckoned in studying reliability of PFC capacitors. This study involves analysis and discussion of such impacts. Installing capacitors leads to reduction in the main source line loading. This improves the reliability of the line while mitigating failure cost. The aggregate enhanced MW failure cost for 5-bus system is \$520



Table 10 Capacitor reliability results on 5-Bust system

Cases	1	2
MW fail cost (\$)	119,140	119,140
Mvar fail cost (\$)	15,989	15,989
MW fail cost-line (\$)	118,620	118,620
Mvar fail cost-line (\$)	15,919	15,919
Mvar fail cost-Cap. (\$)	1,605,386	137,740
Final fail cost (\$)	1,723,936	256,290

and the Mvar failure cost is \$70. The results prove that the increase occurs due to the failure rate and the PFC capacitor installation. Also, installing capacitors with or without considering transient impact has a corresponding and significant effect on the failure cost. Therefore, the concluded failure cost upon not considering transient constraints, which will cause many trips, is \$1,723,936 for 5-bus system. However, the failure cost with damping reactors installed is higher than the failure cost when line enhancement is considered. This is substantially below the failure cost without considering the said impact. The total cost after installing damping reactor will be \$256,290.

6 Conclusion

Following the recent revision of regulations and penalties for low power factor by many nations, power factor correction capacitors have been widely investigated in recent years. This paper has examined single capacitor switching as well parallel capacitor switching schemes. The study found that every parallel switching scenario will cross the ANSI limits with regard to the transient constraints in the considered test system. The proposed problem formulation addressed the capacitor reliability impact, especially of damping reactors and switching transient episodes, which have not been considered in earlier literature. Monte Carlo Analysis was employed to evaluate the failure rates for all added circuit components as well as simulating the failure rate when the transient constraints were not considered. This included capacitors, damping reactors, breakers and cables. The failure rates so derived were used in computing the new failure cost after adding the power factor correction capacitors. The results highlight the significant impact that omission of transient switching events has on plan formulation.

7 Future Work

Even though the paper included many factors to the objective function, yet, there are two things could even improve the analysis and take it to another level. First, include harmonics analysis to objective function. Even though installing the

inductors solved the harmonics issues, evaluating the harmonics and providing the best optimized induction rating could optimize the inductors sizes. Also, by integrating Fuzzy Logic Simulation (FLS) to Monte Carlo Simulation (MCS), this will speed up the process and will allow to algorithm to conduct the analysis on more complex systems with an acceptable time frame.

Acknowledgements The authors would like to express their deep appreciation and thanks to Saudi Arabian Oil Company (Saudi Aramco) and King Fahad University of Petroleum and Minerals (KFUPM) for the continues support to finalize this paper.

Compliance with ethical standards

Conflicts of interest The authors declare that there is no conflict of interest.

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Power Factor Correction Different Methods – A Review

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Abstract: Power factor improvement leads to efficient use of an electricity. power quality is one of the major requirements in power system operation and design. A power factor that is close one is good indicator for an overall power quality, especially for an electrical power system with high demand of commercial load with large amount of inductance. A poor power factor normally leads to a less efficient electrical system, and may also be less economically efficient for system operators and end consumers. Therefore, power factor improvement plays a crucial role in the efficient system operation and electricity consumption cost reduction. This paper compares different methodologies used by researcher for power factor correction. Different methods, power factor improved to which level, value of capacitance used for compensation.

Keywords: Reactive power, Power Factor Correction, Power Factor, load compensation.

1. Introduction

Generally, demand of electricity and economic competition, industries are now forced to improve on the efficiency to have success in global market. Unbalance and poor power factor are the major contributing factors which directly influence the operational cost for both supply utilities and consumers of electricity.

The distribution systems are being faced with poor power quality problems such as excessive neutral current, increase in reactive power burden, voltage unbalance and distortion, low power factor, decrease in efficiency and pollution to other consumers connected to the same point of common coupling due to the unbalanced loads connected to the distribution network. A low PF requires an increased capacity in both generation and transmission to accommodate the same amount of active power component caused by inductive loads [1]. Therefore, to avoid the expensive installation from the expansion of additional capacity, utilities usually apply a penalty for poor PF by charging a demand charge component (based on KVA) in a period of time to the customers. On the other hand, a low PF means a higher electricity bill for the same amount of active power consumption (KW) for an end consumer.

Consequently, demand saving can be achieved by improving a site's PF, so it is important to identify an effective method for

the most cost-effective way to promote the PF initiatives to the industrial electricity consumers. Various studies on PFC are performed and reported in literature [2] Corrective measures such as utilizing onsite synchronous machines and installation of PFC capacitor banks to locally support the reactive power support are analyzed both technically and economically. Moreover, a PFC of large current line commutated converters using variable series capacitors are studied in [1].

In [4] pic microcontroller is used to detect leading or lagging power factor accordingly compensation is provided. Capacitive and inductive banks are used for the compensation of power factor according to nature of load which is determined based on microcontroller algorithm. After power factor compensation the proposed method improved apparent power approximately from 18 to 40 percent.

In [5] line to line voltage keep constant using compensation. Unbalanced loads are quite common in a three- phase network and this is one of the major causes of voltage unbalance in low voltage distribution networks. The traditional three-phase compensators are mainly used for reactive power elimination without the neutral current elimination while the susceptances calculation are also based on the load admittance which is difficult to measure. A hybrid compensator containing star and delta segments can be used for neutral current elimination, load balancing and power factor improvement. In this paper, a mathematical model is derived based on the phase and sequence components of the load current using symmetrical components theory for load balancing, power factor correction and neutral current elimination. The validation of the proposed model is done through MATLAB simulation.

In [3] a superconducting reactor is implemented using high quality Q factor coil. Shunt capacitors are deployed for power factor correction (PFC) to reduce the load reactive power and to provide voltage support. Nonlinear loads, such as variable speed drives, can inject harmonics into the network. If the line impedance value produces a resonance with the PFC capacitor and the injected frequency coincides with the resonant frequency, an overvoltage is produced across the capacitor, which can lead to failure or explosion. To protect the PFC capacitor, a reactor can be connected in series with the PFC capacitor and tuned at the harmonic frequency of the system

resonance. This paper proposes the use of a high temperature-superconducting reactor (HTSR) as the tuned reactor. The reactor will have an extremely high-quality factor (Q) compared to the normal reactor that can never be manufactured commercially with such a high Q. The performance of the HTSR reactor in terms of its ability to protect the capacitor from overvoltage-age and to reduce power losses has been investigated. The results are compared with those using the conventional (low Q) reactor and show that the HTSR can significantly improve filter performance and reduce power losses in the filter.

2. Methods used

Power quality improvement using multiple FACTS (flexible ac transmission systems) device [2] uses following methods.

A. SVC:

A shunt connected static var generator or absorber whose output is adjusted to exchange capacitive or Inductive current so as to maintain or control specific parameters of the electrical power system (typically bus voltages).

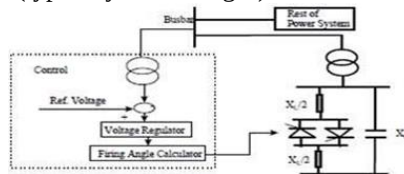


Fig.1. Schematic diagram of SVC

B. TCSC

A capacitive reactance compensator which, consist of a series capacitor bank shunted by a thyristor- controlled reactor in order to provide a smoothly variable series capacitive reactance.

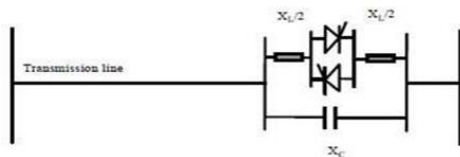


Fig. 2. Schematic diagram of TCSC

C. Multi-type facts system

Among the power quality problems like sag, swell, harmonic etc., voltage sag is the most severe disturbances in the distribution system. To overcome these problems, the concept of custom power devices is introduced lately. One of those devices is the Multi-Type flexible alternating current transmission system which is the most efficient and effective modern custom power device used in power distribution networks. Multi-type FACTS is a Recently proposed series connected solid state device that injects voltage into the system in order to regulate the load side voltage. It is generally installed in a distribution system between the supply and the critical load feeder at the point of common coupling (PCC).

D. Principle Operation of Multi-Type Facts Device

A Multi-type FACTS is a solid-state power electronics switching device consisting of either GTO or IGBT, a capacitor bank as an energy storage device and injection transformers. It is linked in series between a distribution system and a load that shown in Figure.

The basic idea of the Multi-type FACTS is to inject a controlled voltage generated by a forced commuted converter in a series to the bus voltage by means of an injecting transformer. A DC to AC inverter regulates this voltage by sinusoidal PWM technique. All through normal operating condition, the Multi-type FACTS injects only a small voltage to compensate for the voltage drop of the injection transformer and device losses. However, when voltage sag occurs in the distribution system, the Multi-type FACTS control system calculates and synthesizes the voltage required to preserve output voltage to the load by injecting a controlled voltage with a certain magnitude and phase angle into the distribution system to the critical load.

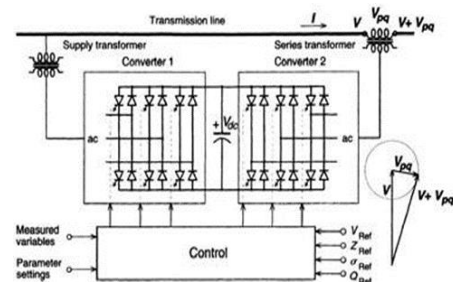


Fig. 3. Schematic diagram of Multi- type FACTS

In protecting PFC capacitors from overvoltage caused by harmonics and system resonance using high temperature superconducting reactors uses following methods [3].

Shunt capacitors are deployed for power factor correction (PFC) to reduce the load reactive power and to provide voltage support. Nonlinear loads, such as variable speed drives, can inject harmonics into the network. If the line impedance value produces a resonance with the PFC capacitor and the injected frequency coincides with the resonant frequency, an overvoltage is produced across the capacitor, which can lead to failure or explosion. To protect the PFC capacitor, a reactor can be connected in series with the PFC capacitor and tuned at the harmonic frequency of the system resonance. This paper proposes the use of a high temperature- superconducting reactor (HTSR) as the tuned reactor. The reactor will have an extremely high-quality factor (Q) compared to the normal reactor that can never be manufactured commercially with such a high Q. The performance of the HTSR reactor in terms of its ability to protect the capacitor from overvoltage-age and to reduce power losses has been investigated.

The results are compared with those using the conventional (low Q) reactor and show that the HTSR can significantly improve filter performance and reduce power losses in the filter.

In Pic Microcontroller Based Power Factor Correction for both Leading and Lagging Loads using compensation method [4] following methodology were used.

In figure 4 block diagram of whole system is shown. The main purpose is to detect the zero crossing of the voltage and current and then switching of capacitive and inductive banks based on microcontroller algorithm. The voltage is first stepped down using potential transformers and the current is stepped down using current transformer whose rating is decided based on maximum rating of your load. These two waves of voltage and current are passed through zero cross detectors (ZCD). The waves that appear across the output of the ZCD are the square waves and their amplitude approaches almost to the biasing of the operational amplifier. These two waves are then fed to microcontroller so that it can measure the phase delay between the voltage and current waveforms and then show the power factor accordingly based on the proposed algorithm. The microcontroller then based on number of counts decides the power factor and displays it on LCD. The measurement of voltage involves conversion from AC to DC using bridge rectifiers as it is further fed to ADC of microcontroller which further displays it on LCD.

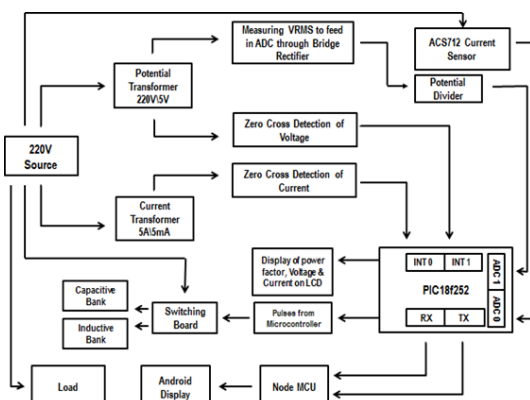


Fig. 4. Block diagram of PIC based PFC.

The current was calculated using current sensor ACS712 5A to 5mA and it is then fed to microcontroller ADC and it is then calculated based on algorithm.

After the zero cross detection based on microcontroller algorithm it is decided that either it is capacitive or inductive load and finally the microcontroller triggers the required capacitive or inductive banks through relay-based switching circuitry in order to compensate the power factor.

In load compensation in a three phase four wire distribution

System considering unbalance, neutral current elimination and power factor improvement following methodology were used [5].

Compensation involves the modification of an electrical characteristics of transmission and distribution lines to improve its power transfer capability without violating the overall stability of the system. Reactive power compensation involves two aspects: Load compensation and voltage support, the load

compensation involves the balancing of the current drawn from the supply, improvement in power factor, better voltage regulation, etc. of large fluctuating loads while voltage support involves the reduction in voltage fluctuation at a point in the transmission network

In general, load compensation involves two major acts; one is the load balancing while the other is power factor correction. The combination of the two acts determine the needed reactive power for the compensation. Several methods have been developed to solve the problems of unbalanced load and poor power factor correction through load compensation. It has been established that the installation of compensation devices at the load side is effective for controlling the three phase unbalanced loads in power distribution system.

In a three-phase system, Steinmetz proved that the voltage unbalance caused by unbalanced current due to a resistive load connected between two phases can be removed by connecting capacitive and inductive elements between other two phases as shown in Figure. 5.

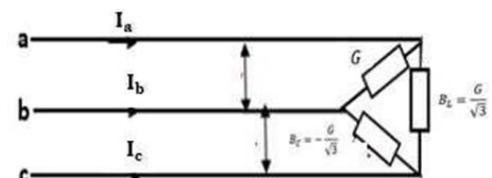


Fig. 5. The Steinmetz method of load balancing

This method was later generalized to three-phase loads and this has been used for reactive power compensation, load balancing and power factor improvement but most of the methods assumed the admittance of the load is known or can be measured, in which neither is possible practically thereby limiting the applications

Also, due to advancement in technology, some power electronics-controlled devices have been developed, such as Active Power Filters (APF), Distribution Static Synchronous Compensator (DSTATCOM), Dynamic Voltage Restorer (DVR), Unified Power Quality Conditioner (UPQC) etc. which are used for load balancing, reactive power compensation and power factor improvement but these devices are expensive and have complex control

The hybrid shunt compensator proposed in this paper performs three major functions: reactive power compensation, load balancing and power factor improvement using both the sequence and phase components of the load current and the validation of the model is achieved through MATLAB simulation.

3. Conclusions

Case study on the long-term effect of power factor correction on the industrial load. A site with a poor power factor and high peak demand is selected for demonstration. With 12-month of the data collection and analysis, the 150 kVar PFC unit was selected to achieve the optimal outcome. The PFC unit was

installed in August 2016 and the performance was carefully monitored and its analysis was carried out in this paper after 10 months. As a result, the data shows there was a significant inductive load reduction and the PF was able to be improved from 0.87 to 0.98 on average.

The presented topology illustrates the operation and control of Multi-type FACTS. The system is extended by adding a series VSC in an adjacent feeder. The device is connected between two or more feeders coming from different substation. The performance of the Multi-type FACTS has been evaluated under various disturbance conditions such as voltage sag/swell in either feeder, fault and load change in one of the feeders. In case of voltage sag, the phase angle of the bus voltage in which the shunt VSC is connected plays an important role as it gives the measure of the real power required by the load. The Multi-type FACTS can mitigate voltage sag in Feeder for long duration between two adjacent feeders which are not connected.

Protecting PFC Capacitors investigates the benefits of applying HTSR to protect the PFC capacitor from overvoltage due to harmonics and system resonance. The results from the simulation show that the HTSR would greatly help in the design of the tuned filter. The use of HTSR will significantly reduce the impact of a parallel resonance between the PFC capacitor and the system inductance. Further, the HTSR with a very low resistance could reduce significantly the power loss, improve the tuned filter performance and protect the PFC capacitor from the overvoltage due to system resonance. It is to be noted that the simulated system is very small and therefore the power loss reduction is quite small, but for an actual industrial application where the load is in MW range, therefore it is expected that a significant reduction in power loss can be achieved by the use of HTSR that will provide a substantial economic savings. Also, the Q value of the HTSR can be much higher than the chosen value (10000) used in this study. A small-scale experimental setup using the LabVolt training system was developed in the laboratory. A conventional reactor module is used as the tuned reactor with a Q factor of 96.4. The observed results from the experimental setup validate the simulation performance of the filters. An HTS coil with a resistance of $1\mu\Omega$ ($Q > 10000$) is

currently being constructed and based on the above experimental results, one through this method. The proposed method is more user-friendly power factor controlling system by continuously monitoring load at every instant and then the PIC microcontroller improves the power factor using compensation method.

Load Compensation leads to load compensation method using a hybrid compensator in a three-phase four wire network through a mathematical model derived from the combination of phase and sequence components of the load current considering load balancing, power factor correction and neutral current elimination. useful application of MATLAB/Simulink for the study of load compensation which has useful application in both low and medium voltage networks. However, the proposed method only applies to linear loads and verification through simulation while the future work shall focus on the experimental validation of the proposed model. By combining all these result a new system can be designed with gap given in these systems.

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Shenzhen ZKT Technology Co., Ltd.

1/F, No. 101, Building B, No. 6, Tangwei Community Industrial Avenue,
Fuhai Street, Bao'an District, Shenzhen, China



Certificate of Compliance

Certificate Number: ZKT-2305243783C

Certificate's Holder : Dongguan Wednesday Technology Co.,Ltd.
Room 301,Building 2,No.142,Middle Sili Road,Tangxia Town,
Dongguan City, Guangdong Province

Manufacturer : Dongguan Wednesday Technology Co.,Ltd.
Room 301,Building 2,No.142,Middle Sili Road,Tangxia Town,
Dongguan City, Guangdong Province

Trade Mark : N/A

Product : Power saver

Model(s) : SD008
SD001, SD002, SD003, SD004, SD005, SD006, SD007, SD009,
SD010

Test Standard : EN 55032:2015+A1:2020, EN 55035:2017+A11:2020
EN IEC 61000-3-2:2019/A1:2021,
EN 61000-3-3:2013/A2:2021/AC:2022-01
EN 61000-4-2:2009, EN IEC 61000-4-3:2020,
EN 61000-4-4:2012, EN 61000-4-5:2014+A1:2017,
EN 61000-4-6:2014/AC:2015, EN 61000-4-8:2010,
EN IEC 61000-4-11:2020

This Attestation of Compliance is issued on a voluntary basis for electrical equipment below the voltage limits of EMC Directive 2014/30/EU. The essential requirement are fulfilled accordingly based on the technical specifications applicable at the time of issuance. See also notes overleaf. It is only valid in connection with the test report number: ZKT-2305243783E.



This Certificate of Conformity is based on single evaluation of the submitted sample(s) of the above mentioned product. It does not imply an assessment of the whole product and relevant Directives to be observed.



TEST REPORT

Report Number.....: **ZKT-2305243783E**

Date of Test.....: May. 24, 2023 to May. 30, 2023

Date of issue.....: May. 30, 2023

Total number of pages.....: 35

Test Result: PASS

Testing Laboratory.....: **Shenzhen ZKT Technology Co., Ltd.**

Address: 1/F, No. 101, Building B, No. 6, Tangwei Community Industrial Avenue, Fuhai Street, Bao'an District, Shenzhen, China

Applicant's name: **Dongguan Wednesday Technology Co.,Ltd.**

Address: Room 301,Building 2,No.142,Middle Sili Road,Tangxia Town, Dongguan City, Guangdong Province

Manufacturer's name: **Dongguan Wednesday Technology Co.,Ltd.**

Address: Room 301,Building 2,No.142,Middle Sili Road,Tangxia Town, Dongguan City, Guangdong Province

Test specification:

Standard.....: EN 55032:2015+A1:2020, EN 55035:2017+A11:2020
EN IEC 61000-3-2:2019/A1:2021,
EN 61000-3-3:2013/A2:2021/AC:2022-01
EN 61000-4-2:2009, EN IEC 61000-4-3:2020,
EN 61000-4-4:2012, EN 61000-4-5:2014+A1:2017,
EN 61000-4-6:2014/AC:2015, EN 61000-4-8:2010,
EN IEC 61000-4-11:2020

Test procedure.....: /

Non-standard test method: N/A

Test Report Form No.....: TRF-EL-144 V0

Test Report Form(s) Originator.....: ZKT Testing

Master TRF: Dated: 2020-01-06

This device described above has been tested by ZKT, and the test results show that the equipment under test (EUT) is in compliance with the 2014/30/EU Directive requirements. And it is applicable only to the tested sample identified in the report.

This report shall not be reproduced except in full, without the written approval of ZKT, this document may be altered or revised by ZKT, personal only, and shall be noted in the revision of the document.

Product name.....: **Power saver**

Trademark: N/A

Model/Type reference.....: SD008

SD001, SD002, SD003, SD004, SD005, SD006, SD007, SD009, SD010

Ratings.....: Rated voltage: 90-250V~
Rated frequency: 50/60Hz
Rated Power: 6W
Useful load: 30KW

**Testing procedure and testing location:****Testing Laboratory**.....: **Shenzhen ZKT Technology Co., Ltd.**Address.....: 1/F, No. 101, Building B, No. 6, Tangwei Community
Industrial Avenue, Fuhai Street, Bao'an District,
Shenzhen, China

Tested by (name + signature).....: Jim Liu

Reviewer (name + signature).....: Jackson Fang

Approved (name + signature).....: Lake Xie





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1. VERSION

Report No.	Version	Description	Approved
ZKT-2305243783E	Rev.01	Initial issue of report	May. 30, 2023



2. GENERAL INFORMATION

2.1 Description of Device (EUT)

EUT : Power saver

Trademark : N/A

Model Number : SD008
SD001, SD002, SD003, SD004, SD005, SD006, SD007, SD009, SD010

Model Difference : Only for different model name

Power Supply : Rated voltage: 90-250V~
Rated frequency: 50/60Hz
Rated Power: 6W
Useful load: 30KW

The highest frequency of the internal sources of the EUT is (less than 108)MHz:

- ☒ less than 108 MHz, the measurement shall only be made up to 1 GHz.
- ☐ between 108 MHz and 500 MHz, the measurement shall only be made up to 2 GHz.
- ☐ between 500 MHz and 1 GHz, the measurement shall only be made up to 5 GHz.
- ☐ above 1 GHz, the measurement shall be made up to 5 times the highest frequency or 6 GHz, whichever is less.

Note: N/A

2.2 Tested System Details

None.

2.3 Test Facility

Site Description

Name of Firm : Shenzhen ZKT Technology Co., Ltd.

Site Location : 1/F, No. 101, Building B, No. 6, Tangwei Community Industrial Avenue, Fuhai Street, Bao'an District, Shenzhen, China

2.4 MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the Product as specified in CISPR 16-4-2. This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2.

Test item	Value (dB)
Conducted Emission (150K-30MHZ)	3.20
Radiated disturbance30MHz-1000MHz	4.80
Radiated disturbance1000MHz-6000MHz	5.10



2.5 Test Instrument Used

Conducted emissions Test

Item	Kind of Equipment	Manufacturer	Type No.	Serial No.	Firmware Version	Last calibration	Calibrated until
1	LISN	R&S	ENV216	101471	N/A	Oct. 21, 2022	Oct. 20, 2023
2	LISN	CYBERTEK	EM5040A	E1850400149	N/A	Oct. 21, 2022	Oct. 20, 2023
3	Test Cable	N/A	C-01	N/A	N/A	Oct. 21, 2022	Oct. 20, 2023
4	Test Cable	N/A	C-02	N/A	N/A	Oct. 21, 2022	Oct. 20, 2023
5	Test Cable	N/A	C-03	N/A	N/A	Oct. 21, 2022	Oct. 20, 2023
6	EMI Test Receiver	R&S	ESCI3	101393	4.42 SP3	Oct. 28, 2022	Oct. 27, 2023
7	Triple-Loop Antenna	N/A	RF300	N/A	N/A	Oct. 28, 2022	Oct. 27, 2023
8	Absorbing Clamp	DZ	ZN23201	15034	N/A	Oct. 31, 2022	Oct. 30, 2023
9	EMC Software	Frad	EZ-EMC	Ver.EMC-CO N 3A1.1	N/A	\	\

Radiation emissions& Radio Test equipment

Item	Equipment	Manufacturer	Type No.	Serial No.	Firmware Version	Last calibration	Calibrated until
1	Spectrum Analyzer (9kHz-26.5GHz)	KEYSIGHT	9020A	MY55370835	A.17.05	Oct. 28, 2022	Oct. 27, 2023
2	Spectrum Analyzer (10kHz-39.9GHz)	R&S	FSV40-N	100363	1.71 SP2	Oct. 28, 2022	Oct. 27, 2023
3	EMI Test Receiver (9kHz-7GHz)	R&S	ESCI7	101169	4.32	Oct. 28, 2022	Oct. 27, 2023
4	Bilog Antenna (30MHz-1500MHz)	Schwarzbeck	VULB9168	N/A	N/A	Nov. 02, 2022	Nov. 01, 2023
5	Horn Antenna (1GHz-18GHz)	Agilent	AH-118	071145	N/A	Nov. 01, 2022	Oct. 31, 2023
6	Horn Antenna (15GHz-40GHz)	A.H.System	SAS-574	588	N/A	Oct. 28, 2022	Oct. 27, 2023
7	Loop Antenna	TESEQ	HLA6121	58357	N/A	Nov. 01, 2022	Oct. 31, 2023
8	Amplifier (30-1000MHz)	EM Electronics	EM330 Amplifier	060747	N/A	Nov. 15, 2022	Nov. 14, 2023
9	Amplifier (1GHz-26.5GHz)	Agilent	8449B	3008A00315	N/A	Oct. 28, 2022	Oct. 27, 2023
10	Amplifier (500MHz-40GHz)	全聚达	DLE-161	097	N/A	Oct. 28, 2022	Oct. 27, 2023
11	Test Cable	N/A	R-01	N/A	N/A	Oct. 28, 2022	Oct. 27, 2023
12	Test Cable	N/A	R-02	N/A	N/A	Oct. 28, 2022	Oct. 27, 2023
13	Test Cable	N/A	R-03	N/A	N/A	Oct. 28, 2022	Oct. 27, 2023
14	Test Cable	N/A	RF-01	N/A	N/A	Oct. 28, 2022	Oct. 27, 2023
15	Test Cable	N/A	RF-02	N/A	N/A	Oct. 28, 2022	Oct. 27, 2023
16	Test Cable	N/A	RF-03	N/A	N/A	Oct. 28, 2022	Oct. 27, 2023



17	D.C. Power Supply	LongWei	TPR-6405D	N/A	N/A	\	\
18	EMC Software	Frad	EZ-EMC	Ver.EMC-CO N 3A1.1	N/A	\	\
19	Turntable	MF	MF-7802BS	N/A	N/A	\	\
20	Antenna tower	MF	MF-7802BS	N/A	N/A	\	\

Harmonic / Flicker Test

Item	Kind of Equipment	Manufacturer	Type No.	Serial No.	Firmware Version	Last calibration	Calibrated until
1	Harmonic & Flicker	HTEC Instruments	AC2000A	548549	1.21	Nov. 02, 2022	Nov. 01, 2023
2	AC Power Source	/	HPHF4010	JN102209079 5	DAL40	Oct. 28, 2022	Oct. 27, 2023

Electrostatic discharge Test

Item	Kind of Equipment	Manufacturer	Type No.	Serial No.	Firmware Version	Last calibration	Calibrated until
1	ESD TEST GENERATOR	HTEC	HESD16	N/A	004307	Oct. 21, 2022	Oct. 20, 2023

EFT and Surge and Voltage dips and interruptions Test

Item	Kind of Equipment	Manufacturer	Type No.	Serial No.	Firmware Version	Last calibration	Calibrated until
1	Surge Generator	HTEC	HCOMPACT 5	N/A	V1.3.4	Oct. 21, 2022	Oct. 20, 2023
2	DIPS Generator	HTEC	HV1P16T	202101	V1.3.4	Nov. 15, 2022	Nov. 14, 2023
3	EFT/B Generator	HTEC	HCOMPACT 5	N/A	V1.3.4	Oct. 21, 2022	Oct. 20, 2023
4	EFT/B Clamp	HTEC	H3C	N/A	N/A	Oct. 28, 2022	Oct. 27, 2023

For Magnetic Field Immunity Test

Item	Kind of Equipment	Manufacturer	Type No.	Serial No.	Firmware Version	Last calibration	Calibrated until
1	Generator	HTEC	HFMG 100	202602	V2.1-182802	Oct. 28, 2022	Oct. 27, 2023

Radio-frequency fields Immunity Test

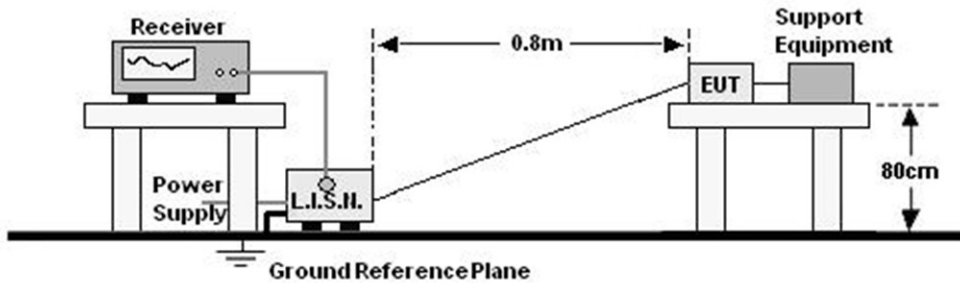
Item	Kind of Equipment	Manufacturer	Type No.	Serial No.	Firmware Version	Last calibration	Calibrated until
1	Signal Generator	Teseq	NSG4070-75	31477	V1.30	Oct. 28, 2022	Oct. 27, 2023
2	CDN	SCHWARZBECK	CDN M2/M3PE 16A	00128	N/A	Oct. 28, 2022	Oct. 27, 2023



3. CONDUCTED EMISSIONS

3.1 Block Diagram Of Test Setup

For mains ports:



3.2 Limit

Limits for Conducted emissions at the mains ports of Class B MME

Frequency range (MHz)	Limits dB(μ V)	
	Quasi-peak	Average
0,15 to 0,50	66 to 56*	56 to 46*
0,50 to 5	56	46
5 to 30	60	50

Notes: 1. *Decreasing linearly with logarithm of frequency.
2. The lower limit shall apply at the transition frequencies.

3.3 Test procedure

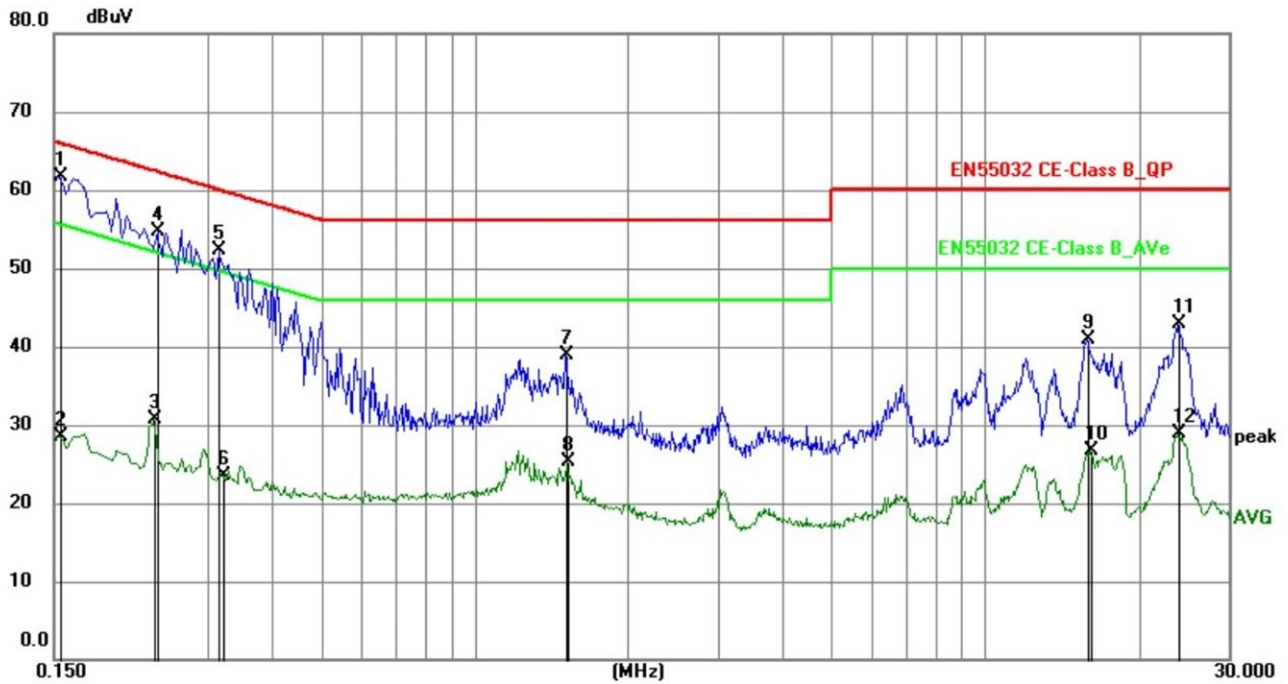
For mains ports:

- The Product was placed on a nonconductive table 0.8 m above the horizontal ground reference plane, and 0.4 m from the vertical ground reference plane, and connected to the main through Line Impedance Stability Network (L.I.S.N).
- The RBW of the receiver was set at 9 kHz in 150 kHz ~ 30MHz with Peak and AVG detector in Max Hold mode. Run the receiver's pre-scan to record the maximum disturbance generated from Product in all power lines in the full band.
- For each frequency whose maximum record was higher or close to limit, measure its QP and AVG values and record.



3.4 Test Result

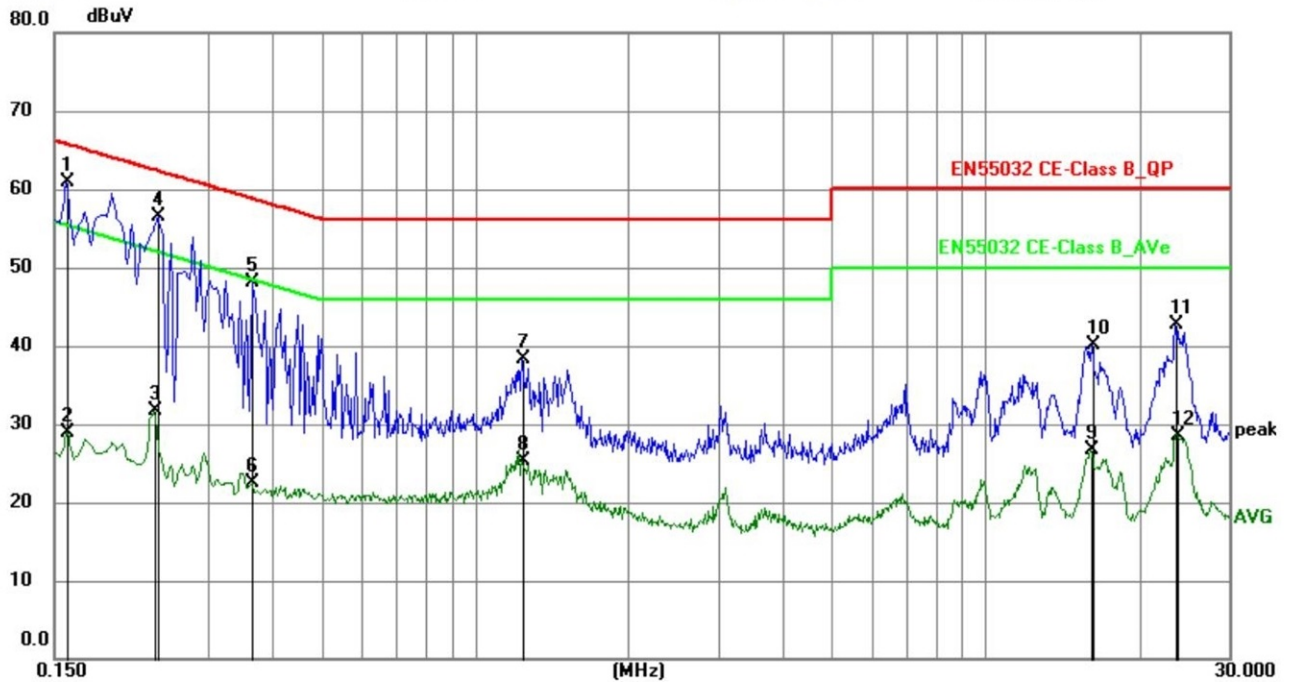
Conducted emissions at the Mains Ports Test Data			
Temperature:	24.9 °C	Relative Humidity:	42%
Pressure:	1009hPa	Phase :	Line
Test Voltage :	AC 230V/50Hz	Test Mode:	Working



No.	Frequency (MHz)	Reading (dBuV)	Factor (dB)	Level (dBuV)	Limit (dBuV)	Margin (dB)	Detector	P/F	Remark
1	0.1544	41.30	20.50	61.80	65.76	-3.96	QP	P	
2	0.1544	8.05	20.50	28.55	55.76	-27.21	AVG	P	
3	0.2355	9.99	20.67	30.66	52.25	-21.59	AVG	P	
4	0.2400	33.94	20.67	54.61	62.10	-7.49	QP	P	
5	0.3165	31.71	20.63	52.34	59.80	-7.46	QP	P	
6	0.3209	2.91	20.63	23.54	49.68	-26.14	AVG	P	
7	1.5089	18.01	20.81	38.82	56.00	-17.18	QP	P	
8	1.5224	4.53	20.81	25.34	46.00	-20.66	AVG	P	
9	15.8505	19.22	21.61	40.83	60.00	-19.17	QP	P	
10	16.0800	5.03	21.61	26.64	50.00	-23.36	AVG	P	
11	23.9370	21.01	21.80	42.81	60.00	-17.19	QP	P	
12	23.9370	7.04	21.80	28.84	50.00	-21.16	AVG	P	



Conducted emissions at the Mains Ports Test Data			
Temperature:	24.9℃	Relative Humidity:	42%
Pressure:	1009hPa	Phase :	Neutral
Test Voltage :	AC 230V/50Hz	Test Mode:	Working



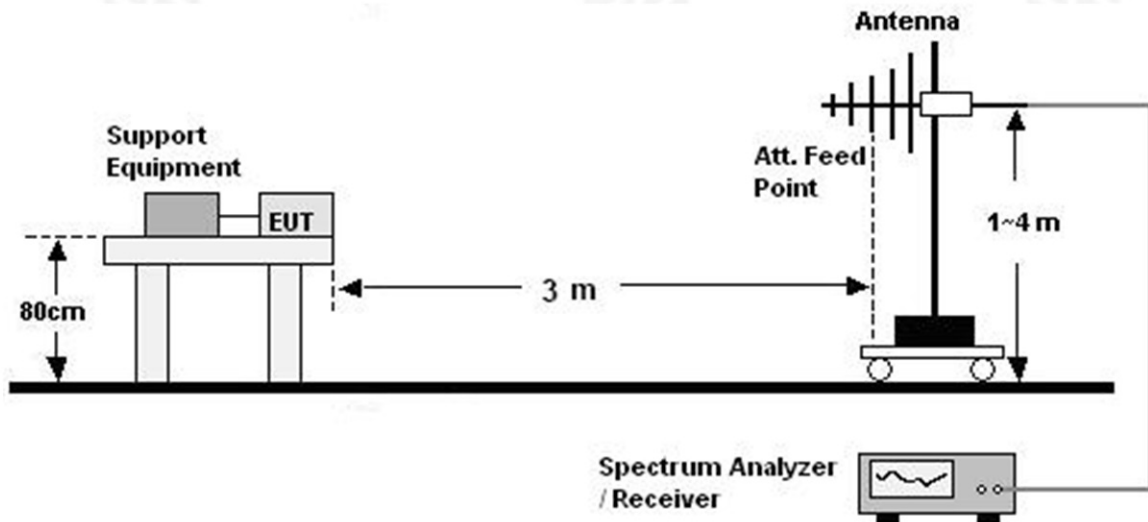
No.	Frequency (MHz)	Reading (dBuV)	Factor (dB)	Level (dBuV)	Limit (dBuV)	Margin (dB)	Detector	P/F	Remark
1	0.1590	40.23	20.62	60.85	65.52	-4.67	QP	P	
2	0.1590	8.21	20.62	28.83	55.52	-26.69	AVG	P	
3	0.2355	10.98	20.78	31.76	52.25	-20.49	AVG	P	
4	0.2400	35.78	20.78	56.56	62.10	-5.54	QP	P	
5	0.3660	27.30	20.74	48.04	58.59	-10.55	QP	P	
6	0.3660	1.82	20.74	22.56	48.59	-26.03	AVG	P	
7	1.2389	17.50	20.81	38.31	56.00	-17.69	QP	P	
8	1.2389	4.57	20.81	25.38	46.00	-20.62	AVG	P	
9	16.0620	5.08	21.53	26.61	50.00	-23.39	AVG	P	
10	16.1565	18.66	21.53	40.19	60.00	-19.81	QP	P	
11	23.5950	20.93	21.72	42.65	60.00	-17.35	QP	P	
12	23.7210	6.87	21.73	28.60	50.00	-21.40	AVG	P	



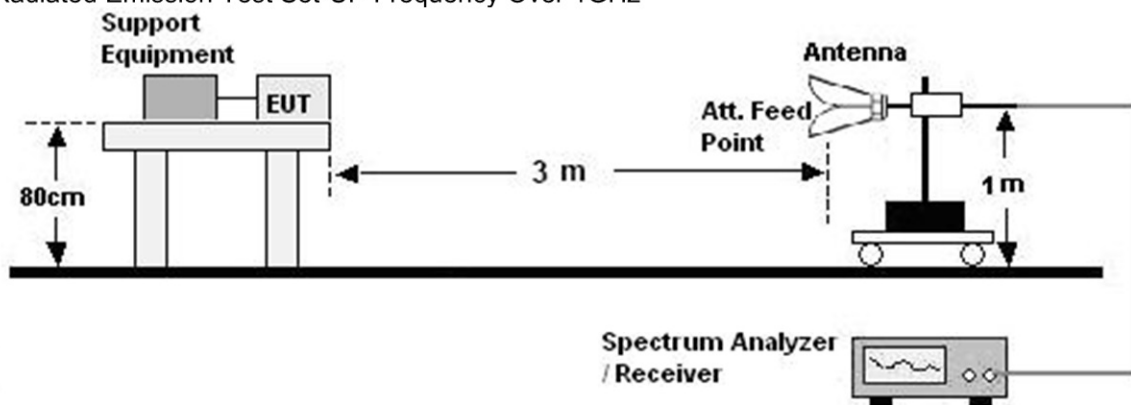
4. RADIATED EMISSIONS TEST

4.1 Block Diagram Of Test Setup

(A) Radiated Emission Test Set-UP Frequency 30MHz-1GHz



(B) Radiated Emission Test Set-UP Frequency Over 1GHz



4.2 Limits

Limits for radiated disturbance of Class B MME

Frequency (MHz)	Quasi-peak limits at 3m dB(μ V/m)
30-230	40
230-1000	47

FREQUENCY (MHz)	Class B (at 3m) dBuV/m	
	Peak	Avg
1000-3000	70	50
3000-6000	74	54



4.3 Test Procedure

30MHz ~ 1GHz:

- a. The Product was placed on the nonconductive turntable 0.8 m above the ground in a semi anechoic chamber.
- b. Set the spectrum analyzer/receiver in Peak detector, Max Hold mode, and 120 kHz RBW. Record the maximum field strength of all the pre-scan process in the full band when the antenna is varied between 1~4 m in both horizontal and vertical, and the turntable is rotated from 0 to 360 degrees.
- c. For each frequency whose maximum record was higher or close to limit, measure its QP value: vary the antenna's height and rotate the turntable from 0 to 360 degrees to find the height and degree where Product radiated the maximum emission, then set the test frequency analyzer/receiver to QP Detector and specified bandwidth with Maximum Hold Mode, and record the maximum value.

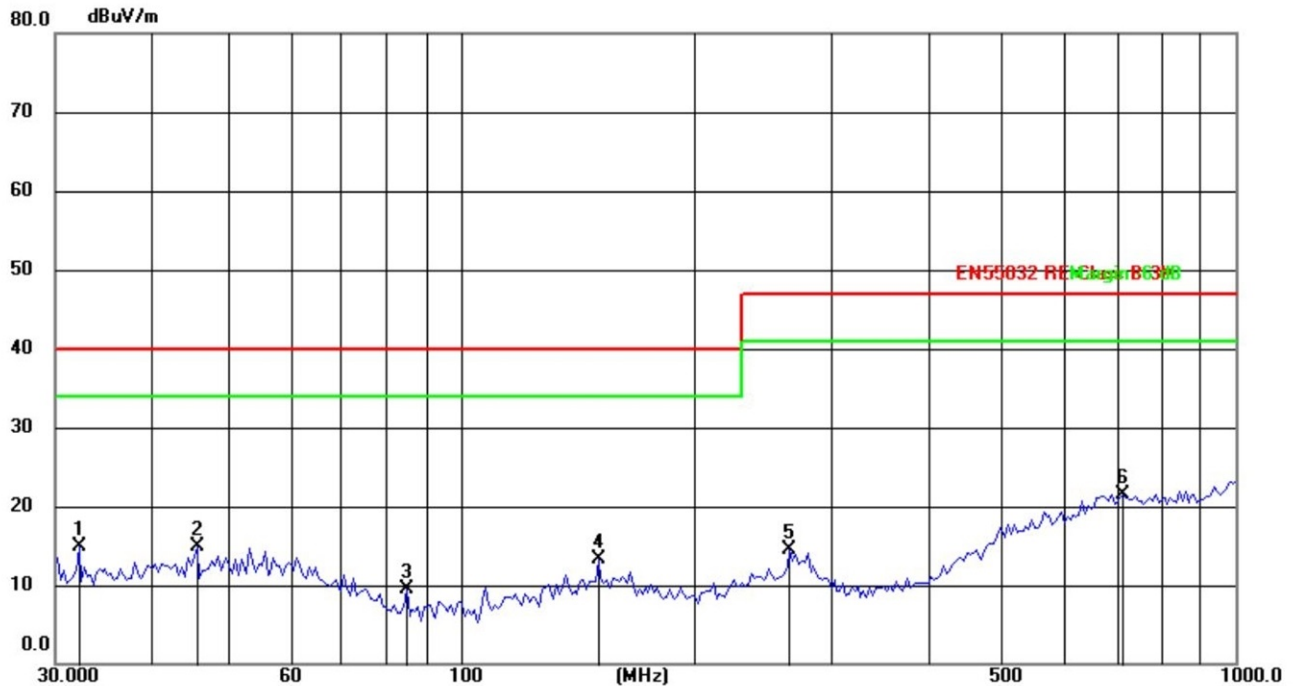
Above 1GHz:

- a. The Product was placed on the non-conductive turntable 0.8 m above the ground in a full anechoic chamber..
- b. Set the spectrum analyzer/receiver in Peak detector, Max Hold mode, and 1MHz RBW. Record the maximum field strength of all the pre-scan process in the full band when the antenna is varied in both horizontal and vertical, and the turntable is rotated from 0 to 360 degrees.
- c. For each frequency whose maximum record was higher or close to limit, measure its AV value: rotate the turntable from 0 to 360 degrees to find the degree where Product radiated the maximum emission, then set the test frequency analyzer/receiver to AV value and specified bandwidth with Maximum Hold Mode, and record the maximum value.



4.4 Test Results

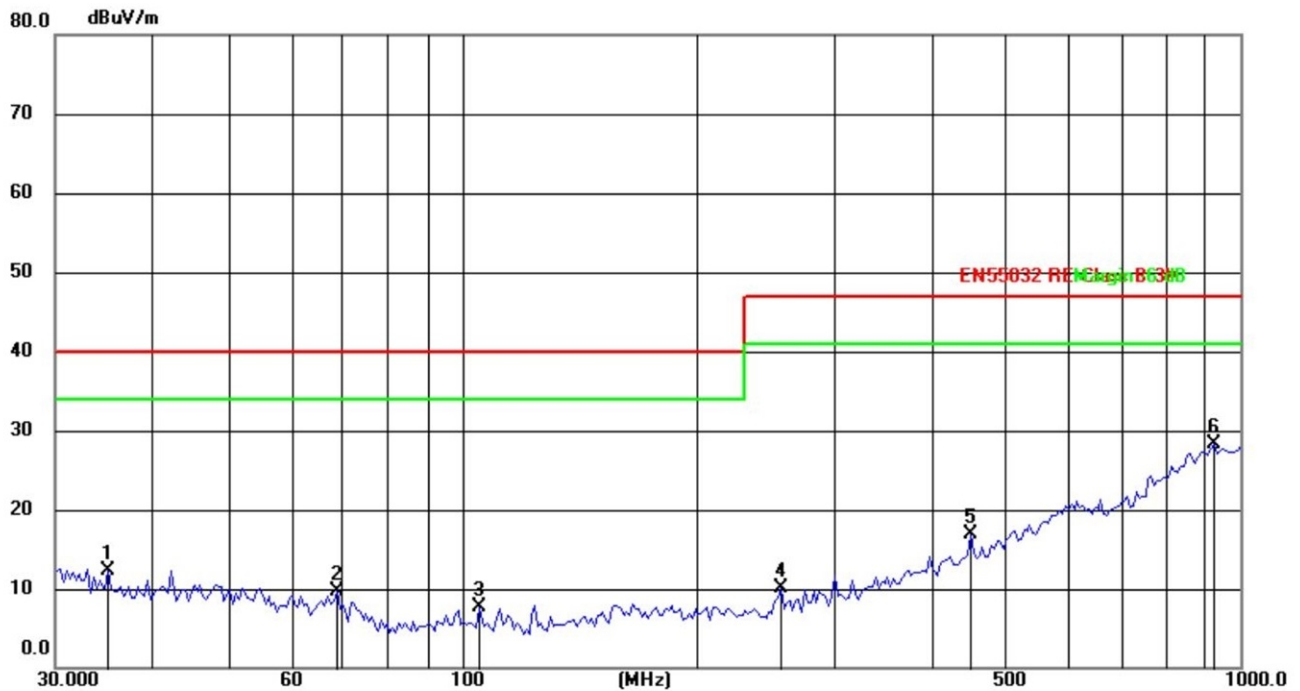
Radiated Emissions Test Data			
Temperature:	23.8℃	Relative Humidity:	42%
Pressure:	1009hPa	Phase :	Horizontal
Test Voltage :	AC 230V/50Hz	Test Mode:	Working



No.	Frequency (MHz)	Reading (dBuV)	Factor (dB/m)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Height (cm)	Azimuth (deg.)	P/F	Remark
1	32.1794	29.50	-14.58	14.92	40.00	-25.08	QP				
2	45.6947	29.00	-14.08	14.92	40.00	-25.08	QP				
3	85.1486	29.40	-19.84	9.56	40.00	-30.44	QP				
4	150.5377	29.93	-16.54	13.39	40.00	-26.61	QP				
5	266.1419	29.59	-15.18	14.41	47.00	-32.59	QP				
6	716.6820	28.29	-6.74	21.55	47.00	-25.45	QP				



Radiated Emissions Test Data			
Temperature:	23.8℃	Relative Humidity:	42%
Pressure:	1009hPa	Phase :	Vertical
Test Voltage :	AC 230V/50Hz	Test Mode:	Working

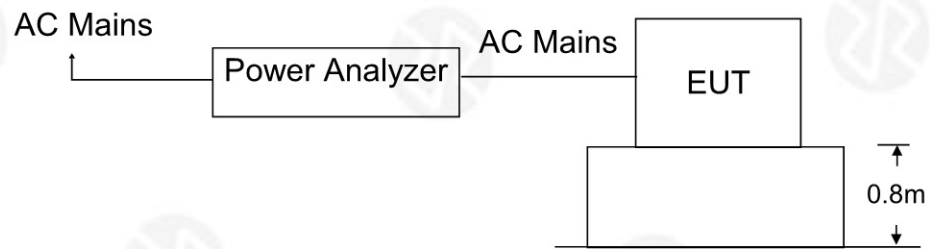


No.	Frequency (MHz)	Reading (dBuV)	Factor (dB/m)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Height (cm)	Azimuth (deg.)	P/F	Remark
1	35.1277	29.96	-17.58	12.38	40.00	-27.62	QP				
2	68.9929	28.89	-19.24	9.65	40.00	-30.35	QP				
3	105.0873	28.95	-21.26	7.69	40.00	-32.31	QP				
4	256.9712	29.86	-19.76	10.10	47.00	-36.90	QP				
5	450.3447	30.28	-13.30	16.98	47.00	-30.02	QP				
6	924.1345	28.96	-0.61	28.35	47.00	-18.65	QP				



5. HARMONIC CURRENT EMISSION TEST

5.1 Block Diagram of Test Setup



5.2 Test Standard

EN IEC 61000-3-2:2019/A1:2021

5.3 Operating Condition of EUT

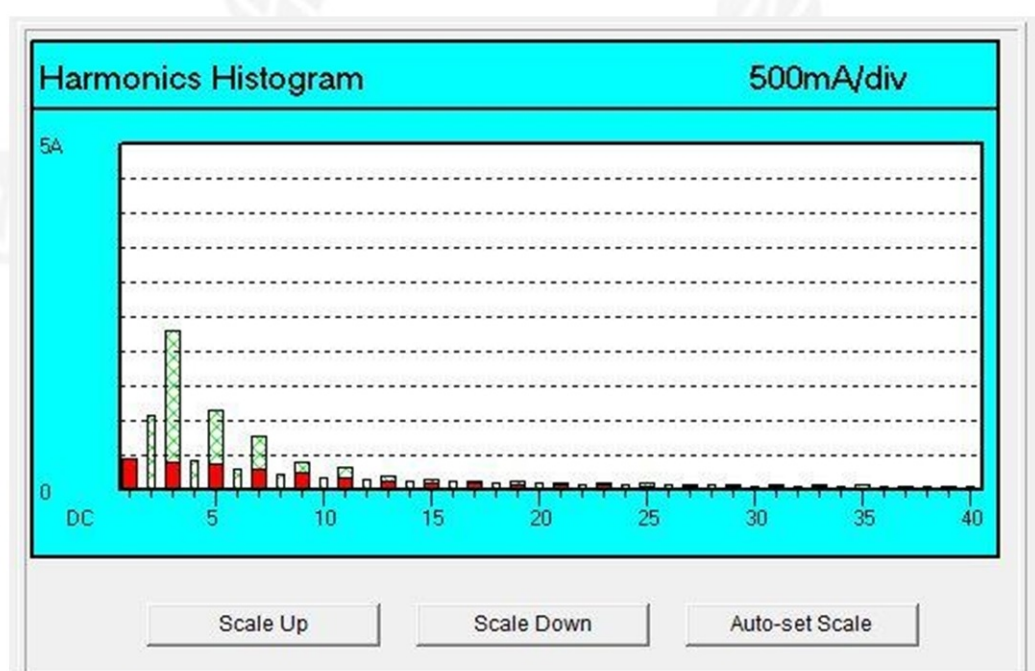
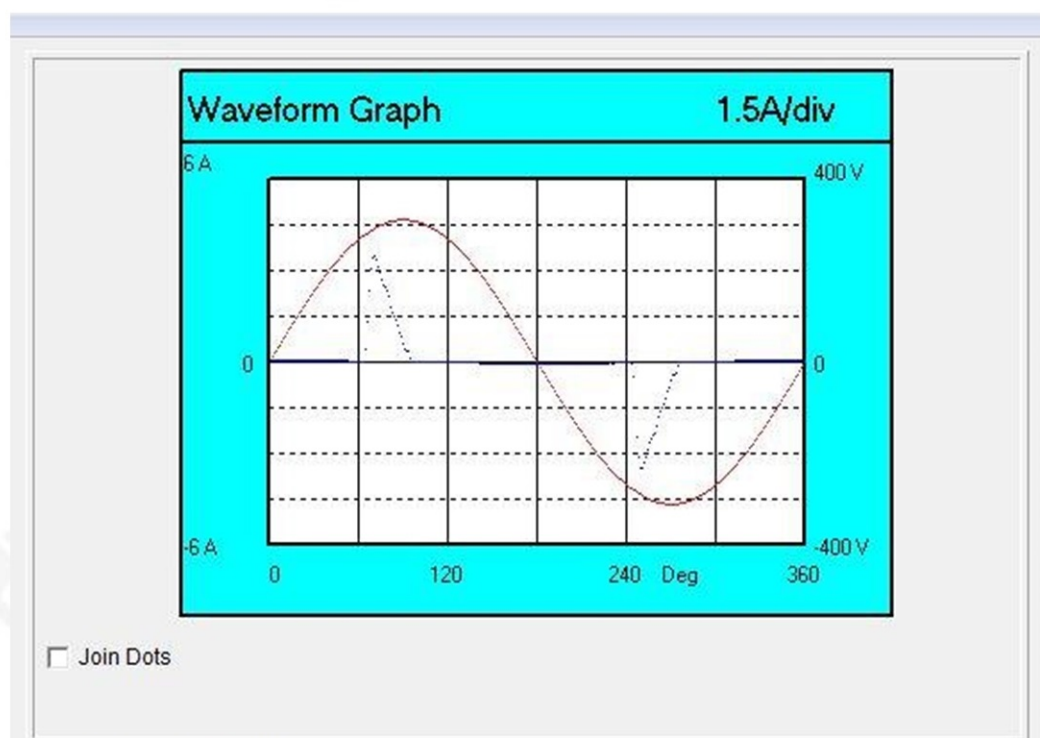
- 5.3.1 Setup the EUT as shown in Section 6.1.
- 5.3.2 Turn on the power of all equipment.
- 5.3.3 Let the EUT work in test mode and test it.

5.4 Test Procedure

The power cord of the EUT is connected to the output of the test system. Turn on the power of the EUT and use the test system to test the harmonic current level.

5.5 Test Results

PASS
Please refer to the following page.





N	Filtered	Limit	Avg.	%Limit	Max.	%Limit	N	Filtered	Limit	Avg.	%Limit	Max.	%Limit
1	446.7			-		-	2	2.3	1080.0	2.5	0.2	2.8	0.3
3	411.8	2300.0	411.3	17.9	411.8	17.9	4	2.3	430.0	2.4	0.6	2.6	0.6
5	366.4	1140.0	366.0	32.1	366.6	32.2	6	2.3	300.0	2.5	0.8	2.6	0.9
7	306.9	770.0	306.5	39.8	307.3	39.9	8	2.1	230.0	2.6	1.1	2.8	1.2
9	241.3	400.0	241.0	60.3	241.8	60.5	10	2.3	184.0	2.6	1.4	3.0	1.6
11	179.6	330.0	179.3	54.3	180.1	54.6	12	2.5	153.3	2.7	1.8	3.0	2.0
13	130.7	210.0	130.4	62.1	131.0	62.4	14	2.5	131.4	2.8	2.1	3.2	2.4
15	101.6	150.0	101.2	67.5	101.7	67.8	16	2.5	115.0	2.8	2.4	3.2	2.8
17	89.7	132.3	89.4	67.6	90.0	68.0	18	2.5	102.2	2.8	2.7	3.2	3.1
19	84.3	118.4	84.0	70.9	84.5	71.4	20	2.5	92.0	2.7	2.9	3.2	3.5
21	76.9	107.1	76.7	71.6	77.3	72.2	22	2.6	83.6	2.7	3.2	3.0	3.6
23	66.8	97.8	66.7	68.2	67.0	68.5	24	2.5	76.7	2.6	3.4	3.0	3.9
25	56.6	90.0	56.4	62.7	56.8	63.1	26	2.5	70.8	2.5	3.5	2.8	4.0
27	49.2	83.3	49.0	58.8	49.4	59.3	28	2.5	65.7	2.5	3.8	2.8	4.3
29	45.3	77.6	45.0	58.0	45.4	58.5	30	2.3	61.3	2.4	3.9	2.6	4.2
31	42.6	72.6	42.4	58.4	42.7	58.8	32	1.9	57.5	2.1	3.7	2.5	4.3
33	39.0	68.2	38.7	56.7	39.0	57.2	34	1.7	54.1	2.0	3.7	2.3	4.3
35	34.1	64.3	33.9	52.7	34.1	53.0	36	1.6	51.1	1.8	3.5	2.1	4.1
37	29.3	60.8	29.1	47.9	29.3	48.2	38	1.4	48.4	1.6	3.3	1.9	3.9
39	25.7	57.7	25.5	44.2	25.7	44.5	40	1.4	46.0	1.6	3.5	1.7	3.7
P	155.3	251.4	154.5	61.5	155.5	61.9					-		-



6. VOLTAGE FLUCTUATIONS & FLICKER TEST

6.1 Block Diagram of Test Setup

Same as Section 6.1.

6.2 Test Standard

EN 61000-3-3:2013/A2:2021/AC:2022-01

6.3 Operating Condition of EUT

Same as Section 5.3.. The power cord of the EUT is connected to the output of the test system. Turn on the power of the EUT and use the test system to test the harmonic current level.

Flicker Test Limit

Test items	Limits
Pst	1.0
dc	3.3%
dmax	4.0%
dt	Not exceed 3.3% for 500ms

6.4 Test Procedure

The power cord of the EUT is connected to the output of the test system. Turn on the power of the EUT and use the test system to test the harmonic current level.

6.5 Test Results

PASS

Please refer to the following page.



Flicker Test Data			
Temperature:	24.5 °C	Relative Humidity:	54%
Pressure:	1009hPa	Test Mode:	ON
Test Voltage :	AC 230V/50Hz		

Voltage Fluctuation	Limit	Value
Relative Voltage Change Characteristic Tmax (dc>3%)	500 ms	0 ms
Maximum Relative Voltage Change d _{max}	4%	0.00
	6%	/
	7%	/
Relative Steady-state Voltage Change dc	3.3%	0.00

Flicker	Limit	Value
Short-term Flicker Indicator P _{st}	1.0	0.064
Long-term Flicker Indicator P _{lt}	0.65	/



7. IMMUNITY TEST OF GENERAL THE PERFORMANCE CRITERIA

Product Standard	EN 55035:2017+A11:2020 clause 5
CRITERION A	The equipment shall continue to operate as intended without operator intervention. No degradation of performance, loss of function or change of operating state is allowed below a performance level specified by the manufacturer when the equipment is used as intended. The performance level may be replaced by a permissible loss of performance. If the minimum performance level or the permissible performance loss is not specified by the manufacturer, then either of these may be derived from the product description and documentation, and by what the user may reasonably expect from the equipment if used as intended.
CRITERION B	During the application of the disturbance, degradation of performance is allowed. However, no unintended change of actual operating state or stored data is allowed to persist after the test. After the test, the equipment shall continue to operate as intended without operator intervention; no degradation of performance or loss of function is allowed, below a performance level specified by the manufacturer, when the equipment is used as intended. The performance level may be replaced by a permissible loss of performance. If the minimum performance level (or the permissible performance loss), or recovery time, is not specified by the manufacturer, then either of these may be derived from the product description and documentation, and by what the user may reasonably expect from the equipment if used as intended.
CRITERION C	Loss of function is allowed, provided the function is self-recoverable, or can be restored by the operation of the controls by the user in accordance with the manufacturer's instructions. A reboot or re-start operation is allowed. Information stored in non-volatile memory, or protected by a battery backup, shall not be lost.

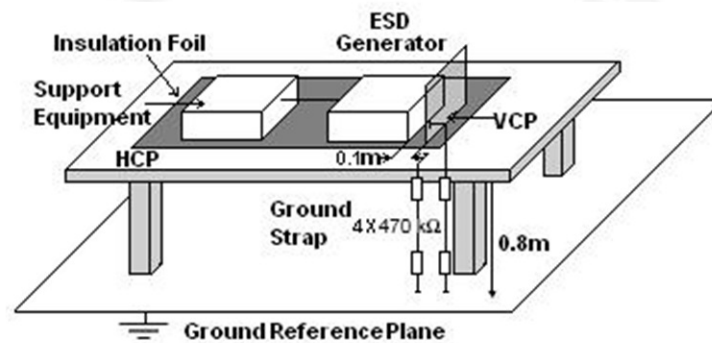


8. ELECTROSTATIC DISCHARGE (ESD)

8.1 Test Specification

Test Port	: Enclosure port
Discharge Impedance	: 330 ohm / 150 pF
Discharge Mode	: Single Discharge
Discharge Period	: one second between each discharge

8.2 Block Diagram of Test Setup



8.3 Test Procedure

- Electrostatic discharges were applied only to those points and surfaces of the Product that are accessible to users during normal operation.
- The test was performed with at least ten single discharges on the pre-selected points in the most sensitive polarity.
- The time interval between two successive single discharges was at least 1 second.
- The ESD generator was held perpendicularly to the surface to which the discharge was applied and the return cable was at least 0.2 meters from the Product.
- Contact discharges were applied to the non-insulating coating, with the pointed tip of the generator penetrating the coating and contacting the conducting substrate.
- Air discharges were applied with the round discharge tip of the discharge electrode approaching the Product as fast as possible (without causing mechanical damage) to touch the Product. After each discharge, the ESD generator was removed from the Product and re-triggered for a new single discharge. The test was repeated until all discharges were complete.
- At least ten single discharges (in the most sensitive polarity) were applied to the center of one vertical edge of the Vertical Coupling Plane in sufficiently different positions that the four faces of the Product were completely illuminated. The VCP (dimensions 0.5m x 0.5m) was placed vertically to and 0.1 meters from the Product.



8.4 Test Results

Discharge Method	Discharge Position	Voltage ($\pm$ kV)	Min. No. of Discharge per polarity (Each Point)	Required Level	Performance Criterion
Contact Discharge	Conductive Surfaces	4	10	B	A
	Indirect Discharge HCP	4	10	B	A
	Indirect Discharge VCP	4	10	B	A
Air Discharge	Slots, Apertures, and Insulating Surfaces	8	10	B	A
Note: N/A					



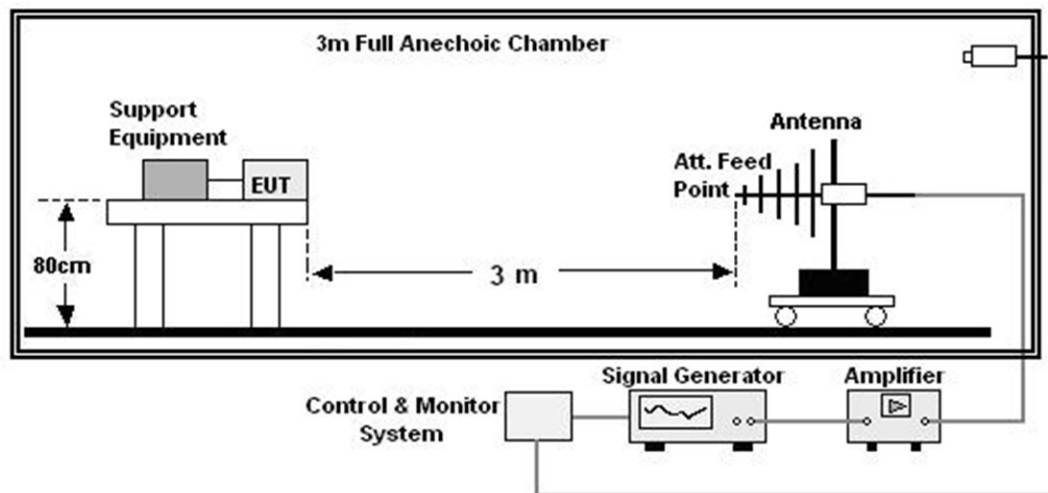
9. CONTINUOUS RF ELECTROMAGNETIC FIELD DISTURBANCES(RS)

9.1 Test Specification

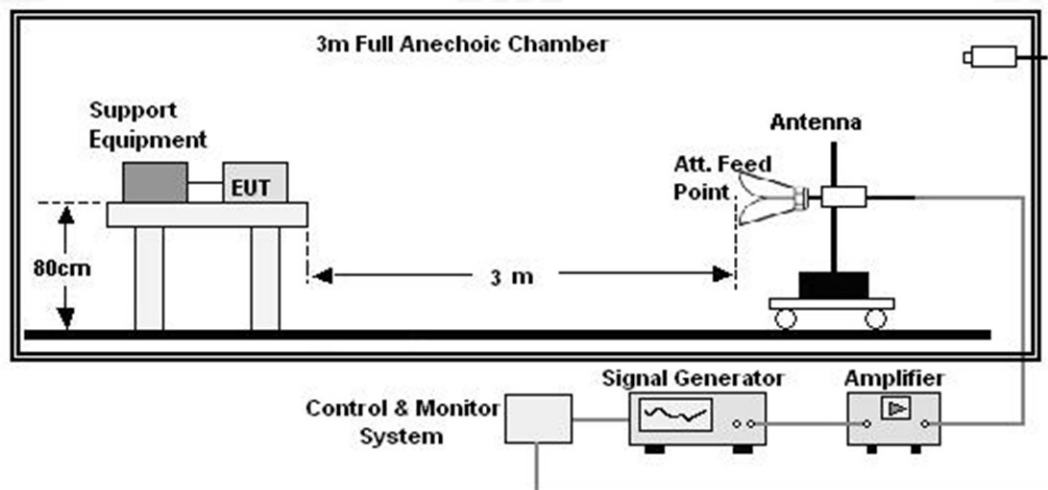
Test Port	: Enclosure port
Step Size	: 1%
Modulation	: 1kHz, 80% AM
Dwell Time	: 1 second
Polarization	: Horizontal & Vertical

9.2 Block Diagram of Test Setup

Below 1GHz:



Above 1GHz:





9.3 Test Procedure

- a. The testing was performed in a fully-anechoic chamber. The transmit antenna was located at a distance of 3 meters from the Product.
- b. The frequency range is swept from 80MHz to 1000MHz, 1800MHz, 2600MHz, 3500MHz, 5000MHz, with the signal 80% amplitude modulated with a 1 kHz sine wave, and the step size was 1%.
- c. The dwell time at each frequency shall not be less than the time necessary for the EUT to be exercised and to be able to respond, but should not exceed 5 s at each of the frequencies during the scan.
- d. The test was performed with the Product exposed to both vertically and horizontally polarized fields on each of the four sides.
- e. For Broadcast reception function: Group 2 not apply in this test.

9.4 Test Results

Frequency	Position	Field Strength (V/m)	Required Level	Performance Criterion
80 - 1000MHz, 1800MHz, 2600MHz, 3500MHz, 5000MHz	Front, Right, Back, Left	3	A	A
Note: The EUT is the testing item(s) was (were) fulfilled by subcontracted lab SHENZHEN HAIYUN TESTING CO.,LTD				



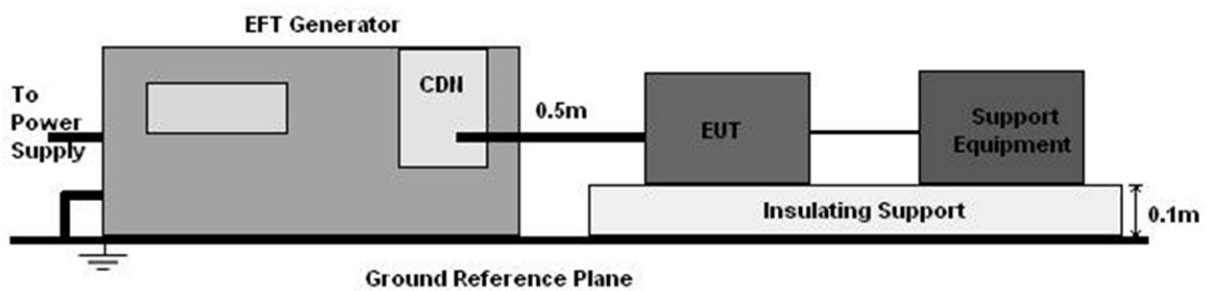
10. ELECTRICAL FAST TRANSIENTS/BURST (EFT)

10.1 Test Specification

Test Port	: input a.c. power port
Impulse Frequency	: 5 kHz
Impulse Wave-shape	: 5/50 ns
Burst Duration	: 15 ms
Burst Period	: 300 ms
Test Duration	: 2 minutes per polarity

10.2 Block Diagram of EUT Test Setup

For input a.c. power port:



10.3 Test Procedure

- The Product and support units were located on a non-conductive table above ground reference plane.
- A 0.5m-long power cord was attached to Product during the test.

10.4 Test Results

Coupling	Voltage (kV)	Polarity	Required Level	Performance Criterion
AC Mains L-N	1.0	$\pm$	B	A
AC Mains L	1.0	$\pm$	B	A
AC Mains N	1.0	$\pm$	B	A
Note: N/A				

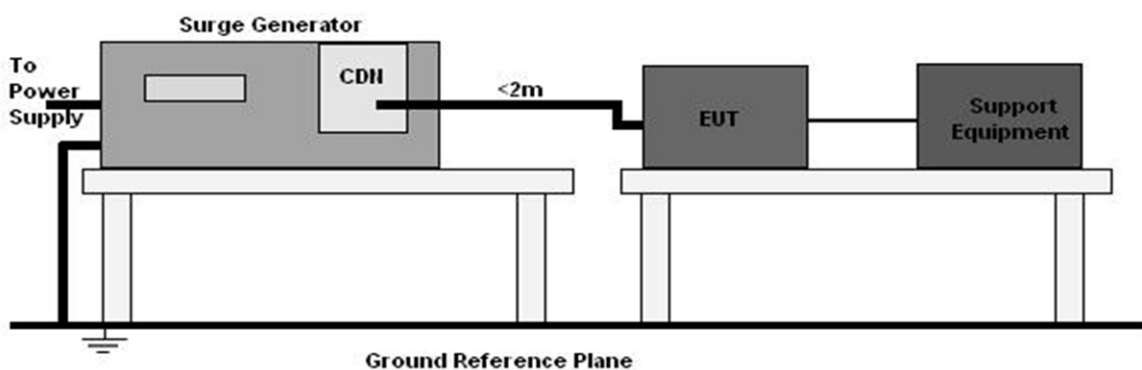


11. SURGES IMMUNITY TEST

11.1 Test Specification

Test Port	: input a.c. power port
Wave-Shape	: Open Circuit Voltage - 1.2 / 50 us Short Circuit Current - 8 / 20 us
Pulse Repetition Rate	: 1 pulse / min.
Phase Angle	: 0° / 90° / 180° / 270°
Test Events	: 5 pulses (positive & negative) for each polarity

11.2 Block Diagram of EUT Test Setup



11.3 Test Procedure

- The surge is to be applied to the Product power supply terminals via the capacitive coupling network. Decoupling networks are required in order to avoid possible adverse effects on equipment not under test that may be powered by the same lines, and to provide sufficient decoupling impedance to the surge wave.
- The power cord between the Product and the coupling/decoupling networks shall be 2 meters in length (or shorter). Interconnection line between the Product and the coupling/decoupling networks shall be 2 meters in length (or shorter).

11.4 Test Result

Coupling Line	Voltage (kV)	Phase Angle	Required Level	Performance Criterion
L - N	+1	90°	B	A
	-1	270°	B	A
Note: N/A				



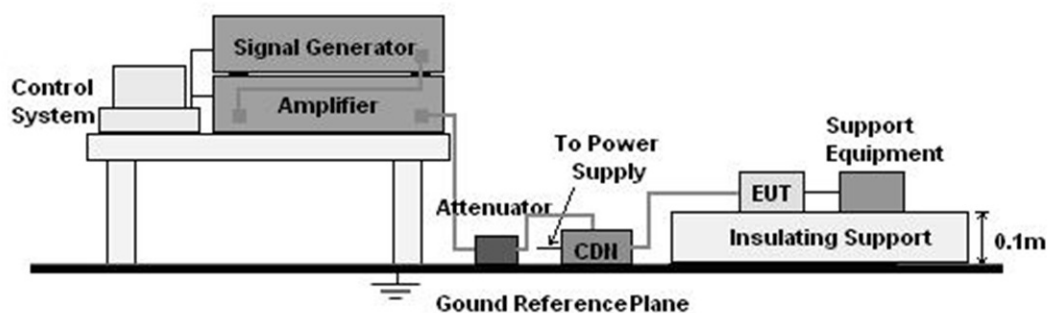
12. CONTINUOUS INDUCED RF DISTURBANCES (CS)

12.1 Test Specification

Test Port	: input a.c. power port
Step Size	: 1%
Modulation	: 1kHz, 80% AM
Dwell Time	: 1 second

12.2 Block Diagram of EUT Test Setup

For input a.c. power port:



12.3 Test Procedure

For input a.c. power port:

- The Product and support units were located at a ground reference plane with the interposition of a 0.1 m thickness insulating support and the CDN was located on GRP directly.
- The frequency range is swept from 150 kHz to 10MHz, 10MHz to 30MHz, 30MHz to 80MHz with the signal 80% amplitude modulated with a 1 kHz sine wave, and the step size was 1% of fundamental.
- The dwell time at each frequency shall be not less than the time necessary for the Product to be able to respond.

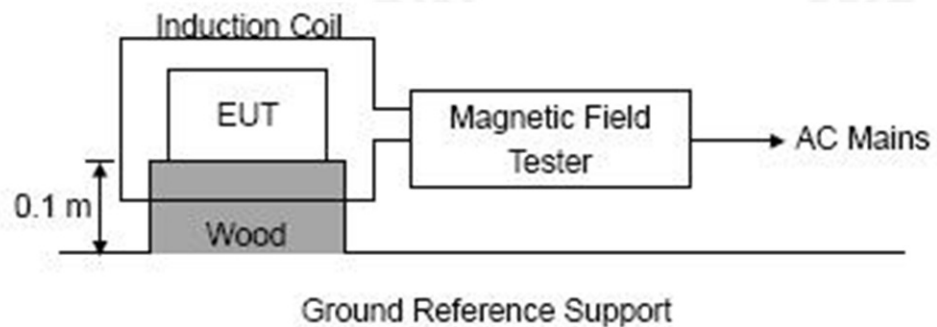
12.4 Test Result

Inject Line	Frequency (MHz)	Voltage Level (V r.m.s.)	Required Level	Performance Criterion
a.c. port	0.15 - 10	3	A	A
	10 to 30	3 to 1	A	A
	30 to 80	1	A	A
Note: The EUT is the testing item(s) was (were) fulfilled by subcontracted lab SHENZHEN HAIYUN TESTING CO.,LTD				



13. MAGNETIC FIELD IMMUNITY TEST

13.1 Block Diagram of Test Setup



13.2 Test Standard

EN 55035:2017+A11:2020, EN61000-4-8:2010
Severity Level 1 at 1A/m

13.3 Severity Levels and Performance Criterion

13.3.1 Severity level

Level	Magnetic Field Strength A/m
1.	1
2.	3
3.	10
4.	30
5.	100
X.	Special

13.3.2 Performance criterion: B

- A. The equipment shall continue to operate as intended without operator intervention. No degradation of performance or loss of function is allowed below a performance level specified by the manufacturer when the equipment is used as intended. The performance level may be replaced by a permissible loss of performance. If the minimum performance level or the permissible performance loss is not specified by the manufacturer, then either of these may be derived from the product description and documentation, and by what the user may reasonably expect from the equipment if used as intended.
- B. After the test, the equipment shall continue to operate as intended without operator intervention. No degradation of performance or loss of function is allowed, after the application of the phenomena below a performance level specified by the manufacturer, when the equipment is used as intended. The performance level may be replaced by a permissible loss of performance. During the test, degradation of performance is allowed. However, no change of



operating state or stored data is allowed to persist after the test.
If the minimum performance level (or the permissible performance loss) is not specified by the manufacturer, then either of these may be derived from the product description and documentation, and by what the user may reasonably expect from the equipment if used as intended.

- C. Loss of function is allowed, provided the function is self-recoverable, or can be restored by the operation of the controls by the user in accordance with the manufacturer's instructions. Functions, and/or information stored in non-volatile memory, or protected by a battery backup, shall not be lost.

13.4 EUT Configuration on Test

The configuration of EUT is listed in Section 2.9.

13.5 Operating Condition of EUT

Same as conducted emission test, which is listed in Section 2.9 except the test set up replaced as Section 12.1.

13.6 Test Procedure

The EUT shall be subjected to the test magnetic field by using the induction coil of standard dimensions (1m*1m) and shown in Section 10.1. The induction coil shall then be rotated by 90° in order to expose the EUT to the test field with different orientations.

13.7 Test Results

PASS

Please refer to the following page.

MS Test Data					
Temperature:	24.5℃		Humidity:		53%
Power Supply:	AC230V/50Hz		Test Mode:		On
Environmental Phenomena	Test specification	Units	Coil Orientation	Performance Criterion	Result
Magnetic Field	1	A/m	X	A	PASS
			Y	A	PASS
			Z	A	PASS
Note: N/A					

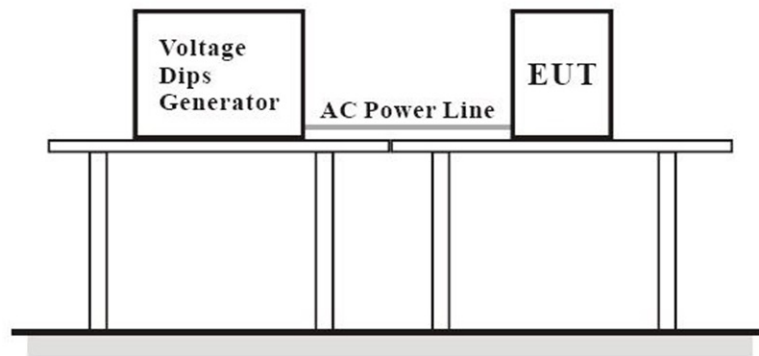


14. VOLTAGE DIPS AND INTERRUPTIONS (DIPS)

14.1 Test Specification

Test Port : input a.c. power port
Phase Angle : 0°, 180°
Test cycle : 3 times

14.2 Block Diagram of EUT Test Setup



14.3 Test Procedure

- The Product and support units were located on a non-conductive table above ground floor.
- Set the parameter of tests and then perform the test software of test simulator.
- Conditions changes to occur at 0 degree crossover point of the voltage waveform.

14.4 Test Result

Test Level % U_T	Voltage dips in % U_T	Duration (ms)	Required Level	Performance Criterion
< 5	≥95	10	B	A
70	30	500	C	A
Voltage Interruptions:				
< 5	≥95	5000	C	C*
Note: N/A				



15. EUT PHOTOGRAPHS

EUT photo 1

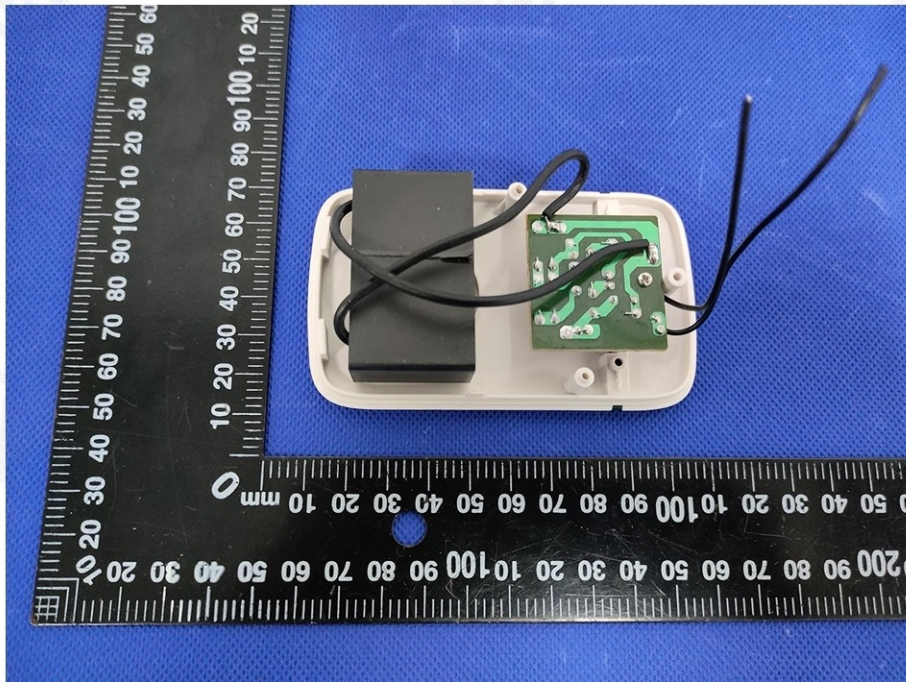


EUT photo 2

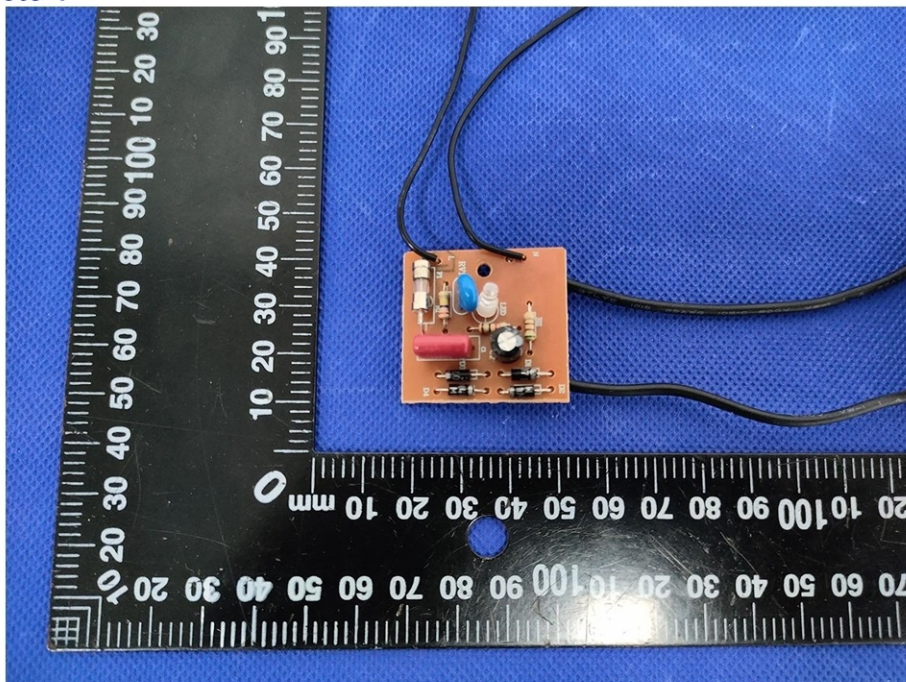




EUT Photo 3

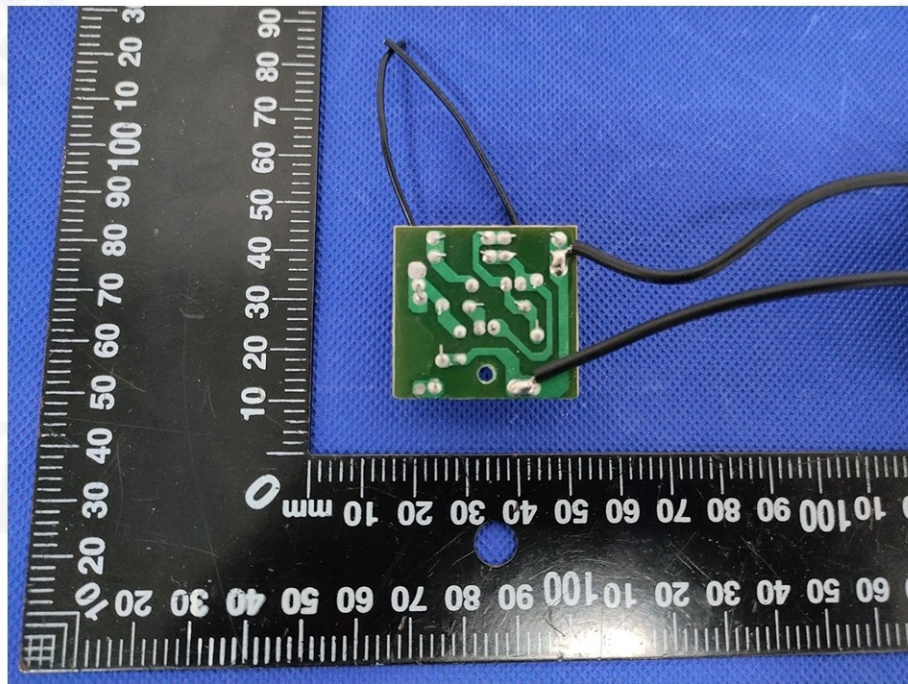


EUT Photo 4





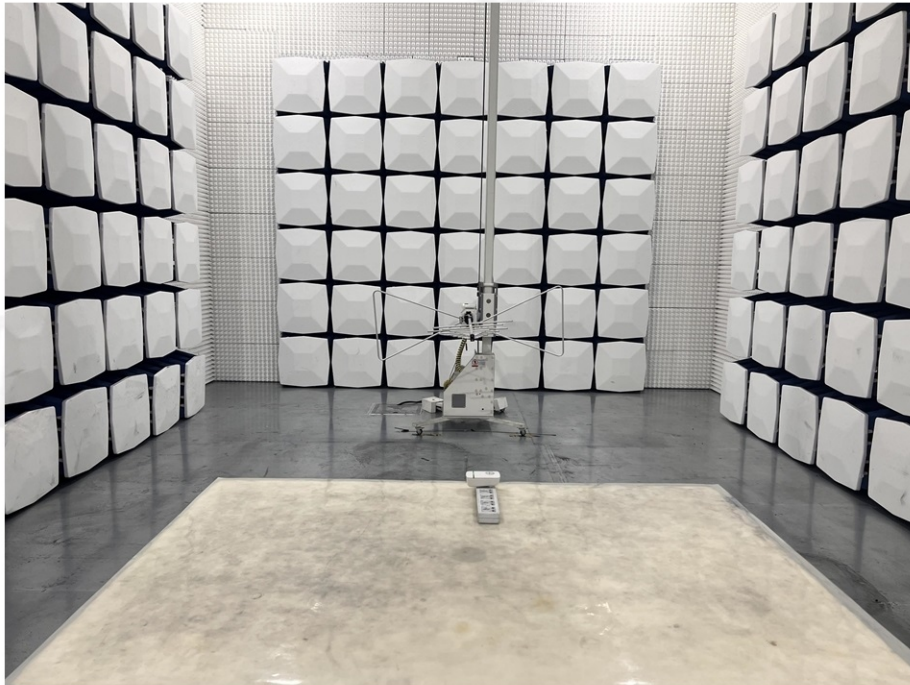
EUT Photo 5





16. EUT TEST PHOTOGRAPHS

RE



CE



***** END OF REPORT *****

Shenzhen ZKT Technology Co., Ltd.

1/F, No. 101, Building B, No. 6, Tangwei Community Industrial Avenue,
Fuhai Street, Bao'an District, Shenzhen, China



Certificate of Compliance

Certificate Number: ZKT-2305243784C

Certificate's : Dongguan Wednesday Technology Co.,Ltd.
Holder Room 301,Building 2,No.142,Middle Sili Road,Tangxia
Town, Dongguan City, Guangdong Province
Manufacturer : Dongguan Wednesday Technology Co.,Ltd.
Room 301,Building 2,No.142,Middle Sili Road,Tangxia
Town, Dongguan City, Guangdong Province
Trade Mark : N/A
Product : Power saver
Model(s) : SD008
SD001,SD002,SD003,SD004,SD005,
SD006,SD007,SD009,SD010
Test Standard : EN 60335-1:2012+A11:2014+A13:2017+A1:2019
+A2:2019+A14:2019+A15:2021

This Attestation of Compliance is issued on a voluntary basis for electrical equipment below the voltage limits of Low Voltage Directive 2014/35/EU. The essential requirement are fulfilled accordingly based on the technical specifications applicable at the time of issuance. See also notes overleaf. It is only valid in connection with the test report number: ZKT-2305243784S.



This Certificate of Conformity is based on single evaluation of the submitted sample(s) of the above mentioned product. It does not imply an assessment of the whole product and relevant Directives to be observed.



TEST REPORT EN 60335-1 Part 1: Safety of household and similar electrical appliances	
Report Number.....:	ZKT-2305243784S
Date of issue.....:	May 30, 2023
Total number of pages.....:	58
Testing Laboratory.....:	Shenzhen ZKT Technology Co., Ltd.
Address.....:	1/F, No. 101, Building B, No. 6, Tangwei Community Industrial Avenue, Fuhai Street, Bao'an District, Shenzhen, China
Applicant's name.....:	Dongguan Wednesday Technology Co.,Ltd.
Address.....:	Room 301,Building 2,No.142,Middle Sili Road,Tangxia Town, Dongguan City, Guangdong Province(Jiemeng Industrial Park), Wujiang District, Shaoguan City, Guangdong Province
Test specification	
Standard.....:	EN 60335-1:2012+A11:2014+A13:2017+A1:2019 +A2:2019+A14:2019+A15:2021
Test procedure	CE-LVD
Non-standard test method	N/A
Test Report Form	
Test Report Form No.....:	IEC60335_1V
Test Report Form(s) Originator.....:	Nemko AS
Master TRF.....:	Dated 2014-02
This test report is specially limited to the above client company and product model only. It may not be duplicated without prior written consent of ZKT Test.	
Test item description.....:	Power saver
Trademark.....:	N/A
Manufacturer.....:	Same as applicant
Model/Type reference.....:	SD008 SD001,SD002,SD003,SD004,SD005, SD006,SD007,SD009,SD010
Ratings.....:	Rated voltage: 90-250V~ Rated frequency: 50/60Hz Rated Power: 6W Useful load: 30KW

**Testing procedure and testing location:****Testing Laboratory**.....: **Shenzhen ZKT Technology Co., Ltd.**Address.....: 1/F, No. 101, Building B, No. 6, Tangwei Community
Industrial Avenue, Fuhai Street, Bao'an District, Shenzhen,
China

Date of Test.....: May 24, 2023 to May 30, 2023

Tested by (name + signature).....: Peter Huang

Reviewed by (name + signature).....: Simon Gong

Approved by (name + signature).....: Awen He



**List of Attachments (including a total number of pages in each attachment):**

-- Attachment I: 2 pages for Photo documentation.

Summary of testing:**Tests performed (name of test and test clause):**

-- EN 60335-1:2012+A11:2014+A13:2017
+A1:2019+A2:2019+A14:2019+A15:2021

The submitted samples were found to comply with the requirements of above specification.

Testing location:

1/F, No. 101, Building B, No. 6, Tangwei
Community Industrial Avenue, Fuhai Street, Bao'an
District, Shenzhen, China

Copy of marking plate

The artwork below may be only a draft. The use of certification marks on a product must be authorized by the respective NCBs that own these marks.

(Additional requirements for markings. See 1.7 NOTE)

Power saver

Model: SD008

Rated voltage: 90-250V~

Rated frequency: 50/60Hz

Rated Power: 6W

Useful load: 30KW



Manufacturer: Dongguan Wednesday Technology Co.,Ltd.

Address: Room 301,Building 2,No.142,Middle Sili Road,Tangxia Town,
Dongguan City, Guangdong Province

Made in China

Remark on above marking:

- 1, The height of UKCA symbols is more than 5 mm;
- 2, The height of WEEE symbols is more than 7 mm;



Test item particulars..... :	
Classification of installation and use..... : Movable equipment	
Supply Connection..... : Connect to AC mains	
Possible test case verdicts: - test case does not apply to the test object..... : N/A - test object does meet the requirement..... : P (Pass) - test object does not meet the requirement..... : F (Fail)	
Testing..... :	
Date of receipt of test item..... : May 24, 2023	
Date (s) of performance of tests..... : May 24, 2023 to May 30, 2023	
General remarks: "(See Enclosure #)" refers to additional information appended to the report. "(See appended table)" refers to a table appended to the report. Throughout this report a ☐ comma / ☒ point is used as the decimal separator.	
Manufacturer's Declaration per sub-clause 4.2.5 of IEC 60335-1:	
The application for obtaining a CB Test Certificate includes more than one factory location and a declaration from the Manufacturer stating that the sample(s) submitted for evaluation is (are) representative of the products from each factory has been provided.....:	☐ Yes ☒ Not applicable
When differences exist; they shall be identified in the General product information section.	
General product information: 1.The internal structure of the product is consistent, and the naming is different	



EN 60335-1			
Clause	Requirement Test	Result - Remark	Verdict
5	GENERAL CONDITIONS FOR THE TESTS		-
	Tests performed according to cl. 5, e.g. nature of supply, sequence of testing, etc.		P

6	CLASSIFICATION		-
6.1	Protection against electric shock: Class I, II, III	Class II appliance	P
6.2	Protection against harmful ingress of water	IPX0	N

7	MARKING		-
7.1	Rated voltage or voltage range (V)	90-250V	P
	Single-phase appliances: 230 V covered	230V	P
	Multi-phase appliances: 400 V covered	Single-phase appliances	N
	Nature of supply	~	P
	Rated frequency or frequency range (Hz)	50Hz	P
	Rated input or rated current		N
	Manufacturer's or responsible vendor's name, trademark or identification mark	Dongguan Wednesday Technology Co.,Ltd.	P
	Model or type reference	SD008	P
	Symbol for Class II		N
	IP number	IPX0	N
	Symbol IEC 60417-5036, for the enclosure of electrically-operated water valves in external hose-sets for connection of an appliance to the water mains		N
7.2	Warning for stationary appliances	No such stationary appliance	N
	Warning placed in vicinity of terminal cover	Not placed in vicinity of terminal cover	N
7.3	Range of rated values correctly marked	90-250V~	P
7.4	Voltage setting clearly discernible	No such setting	N
7.5	Marking of rated input for each rated voltage		P
	Marking for upper and lower limits of rated input		P
7.6	Correct symbols used	See marking label	P
7.7	Correct connection diagram, fixed to the appliance		N
7.8	Not for type Z attachment:	type Z attachment	N
	- marking of terminals for the neutral conductor (N)		N
	- marking of earthing terminals		N
	- marking not placed on removable parts		N



EN 60335-1			
Clause	Requirement Test	Result - Remark	Verdict
	- marking of terminal for single-pole protective device		N
7.9	Marking or placing of switches which may cause a hazard		N
7.10	Indications of switches and regulating devices by use of figures, letters or other		N
	The figure 0 indicates only OFF position, unless no confusion with the OFF position		N
7.11	Indication for direction of adjustment of controls		P
7.12	Instructions for safe use provided	Please see product manual	P
7.12.1	Sufficient details for installation or maintenance supplied		P
7.12.2	Stationary appliances not fitted with means for disconnection from the supply mains having a contact separation in all poles that provide full disconnection under overvoltage category III, the instructions state that means for disconnection must be incorporated in the fixed wiring in accordance with the wiring rules		N
7.12.3	Insulation of the fixed wiring in contact with parts exceeding 50 K during clause 11; instructions stating that the fixed wiring must be protected		N
7.12.4	Information with regard to built-in:	No built-in appliance	N
	- dimensions of space		N
	- dimensions and position of supporting means		N
	- distances between parts and surrounding structure		N
	- dimensions of ventilation openings and arrangement		N
	- connection to supply mains and interconnection of separate components		N
	- allow disconnection of the appliance after installation, by accessible plug or a switch in the fixed wiring, unless		N
	a switch complying with 24.3		N
7.12.5	Replacement cord, type X attachment		N
	Replacement cord, type Y attachment		N
	Replacement cord, type Z attachment		P
7.12.6	Caution in the instructions for heating appliances with a non-self-resetting thermal cut-out		N
7.12.7	Instructions for fixed appliances stating how the appliance is to be fixed		N
7.12.8	Instructions for appliances connected to the water mains:		N
	- max. inlet water pressure (Pa):		N



EN 60335-1			
Clause	Requirement Test	Result - Remark	Verdict
	- min. inlet water pressure, if necessary (Pa):		N
	Instructions concerning new and old hose-sets for appliances connected to the water mains by detachable hose-sets		N
7.13	Instructions and other texts in official language	In English	P
7.14	Marking easily legible and durable	After testing, legible and durable	P
7.15	Marking on a main part		P
	Marking clearly discernible from the outside, if necessary after removal of a cover		P
	For portable appliances, cover can be removed or opened without a tool		N
	For stationary appliances, name, trademark or identification mark and model or type reference visible after installation		N
	For fixed appliances, name, trademark or identification mark and model or type reference visible after installation according to the instructions		N
	Indications for switches and controls placed on or near the components. Marking not on parts which can be positioned or repositioned in such a way that the marking is misleading		N
7.16	Marking of a possible replaceable thermal link or fuse link clearly visible with regard to replacing the link		N

8	PROTECTION AGAINST ACCESS TO LIVE PARTS		-
8.1	Adequate protection against accidental contact with live parts		P
8.1.1	All positions; detachable parts removed		P
	Removal of lamps: protection against contact with live parts	No such lamps	N
	Use of test probe B of IEC 61032: no contact with live parts		P
8.1.2	Use of test probe 13 of IEC 61032 through openings in class 0 appliances and class II appliances/ constructions: no contact with live parts		P
	Test probe 13 also applied through openings in earthed metal enclosures having a non-conductive coating: no contact with live parts		N
8.1.3	Use of test probe: no contact with live parts of visible glowing heating elements	No visible glowing heating elements	N



EN 60335-1			
Clause	Requirement Test	Result - Remark	Verdict
8.1.4	Accessible part not considered live if:		P
	- extra-low a.c. voltage: peak values not exceeding 42,4 V		N
	- extra-low d.c. voltage: not exceeding 42,4 V		N
	- or separated from live parts by protective impedance, d.c. current not exceeding 2 mA		N
	- or separated from live parts by protective impedance, a.c. peak value not exceeding 0,7 mA		N
	- for peak value 42,4 V up to and including 450 V capacitance not exceeding 0,1 μ F		P
	- for peak value 450 V up to and including 15 kV capacitance not exceeding 0,1 μ F		N
	- for voltages over 15 kV, the energy of the discharge shall not exceed 350 mJ		N
8.1.5	Live parts protected at least by basic insulation before installation or assembly:		P
	- built-in appliances		N
	- fixed appliances		N
	- separate units		P
8.2	Class II appliances and constructions adequately protected against accidental contact with basic insulation and metal parts separated from live parts with only basic insulation		P
	Only possible to touch parts separated from live parts by double or reinforced insulation		P

10	POWER INPUT AND CURRENT		-
10.1	Power input at normal operating temperature, rated voltage and normal operation not deviating from rated power input by more than shown in table 1	(see appended table)	P
	Test for an appliance with one or more rated voltage ranges		N
10.2	Current at normal operating temperature, rated voltage and normal operation not deviating from rated current by more than shown in table 2	(see appended table)	N
	Test for an appliance with one or more rated voltage ranges		N

11	HEATING		-
11.1	No excessive temperatures in normal use	Comply with requirements	P
11.2	Placing and mounting of appliance as described		P



EN 60335-1			
Clause	Requirement Test	Result - Remark	Verdict
11.3	Temperature rises determined by thermocouples or resistance method	By thermocouples method	P
11.4	Heating appliances operated under normal operation at 1,15 times rated power input		N
11.5	Motor-operated appliances operated under normal operation at most unfavourable voltage between 0,94 and 1,06 times rated voltage		P
11.6	Combined appliances operated under normal operation, supply voltage at most unfavourable voltage between 0,94 and 1,06 times rated voltage		N
11.8	Temperature rises not exceeding values in table 3	(see appended tables)	P
	Sealing compound does not flow out		P
	Protective devices do not operate, except		P
	components in protective electronic circuits tested for the number of cycles specified in 24.1.4		N

13	LEAKAGE CURRENT AND ELECTRIC STRENGTH AT OPERATING TEMPERATURE		-
13.1	Leakage current not excessive and electric strength adequate		P
	Heating appliances operated at 1.15 times the rated power input (W)..... :		N
	Motor-operated appliances and combined appliances supplied at 1.06 times the rated voltage (V)..... :		P
	Protective impedance and radio interference filters disconnected before carrying out the tests		N
13.2	For class 0, class II and class III appliances, and class II constructions, leakage current measured by means of the circuit described in figure 4 of IEC 60990		P
	For class 0I and class I appliances, a low impedance ammeter may be used		N
	Leakage current measurements..... :		N
13.3	The appliance is disconnected from the supply		P
	Electric strength tests according to table 4.....:		P
	No breakdown during the tests		P

14	TRANSIENT OVERVOLTAGES		-
	Appliances withstand the transient overvoltages to which they may be subjected		N



EN 60335-1			
Clause	Requirement Test	Result - Remark	Verdict
	Clearances having a value less than specified in table 16 subjected to an impulse voltage test, the test voltage specified in table 6		N
	No flashover during the test, unless of functional insulation		N
	In case of flashover of functional insulation, the appliance complies with clause 19 with the clearance short circuited		N

15	MOISTURE RESISTANCE		-
15.1	Enclosure provides the degree of moisture protection according to classification of appliance		P
	Compliance checked as specified in 15.1.1, taking into account 15.1.2, followed by the electric strength test of 16.3		P
	No trace of water on insulation which can result in a reduction of clearances and creepage distances below values specified in clause 29		P
15.1.1	Appliances, other than IPX0, subjected to tests as specified in IEC 60529:	IPX0	N
	Water valves in external hoses for connection of an appliance to the water mains tested as specified for IPX7 appliances		N
15.1.2	Hand-held appliance turned continuously through the most unfavourable positions during the test		P
	Built-in appliance installed according to the manufacturer's instruction		P
	Appliances placed or used on the floor or table placed on a horizontal unperforated support		N
	Appliances normally fixed to a wall and appliances with pins for insertion into socket-outlets are mounted on a wooden board		N
	For IPX3 appliances, the base of wall mounted appliances is placed at the same level as the pivot axis of the oscillating tube		N
	For IPX4 appliances, the horizontal centre line of the appliance is aligned with the pivot axis of the oscillating tube		N
	However, for appliances normally used on the floor or table, the movement is limited to two times 90° for a period of 5 min, the support being placed at the level of the pivot axis of the oscillating tube		N
	Appliances normally fixed to a ceiling are mounted underneath a horizontal unperforated support, the pivot axis of the oscillating tube located at the level of the underside of the support		N



EN 60335-1			
Clause	Requirement Test	Result - Remark	Verdict
	For IPX4 appliances, the movement of the tube is limited to two times 90° from the vertical for a period of 5 min		N
	Wall-mounted appliances, take into account the distance to the floor stated in the instructions		N
	Appliances with type X attachment fitted with a flexible cord as described		N
	Detachable parts tested as specified		N
15.2	Spillage of liquid does not affect the electrical insulation		P
	Appliances with type X attachment fitted with a flexible cord as described		N
	Appliances incorporating an appliance inlet tested with or without an connector, whichever is most unfavourable		P
	Detachable parts removed		N
	Overfilling test with additional amount of water, over a period of 1 min (I):		N
	The appliance withstands the electric strength test of 16.3		P
	No trace of water on insulation that can result in a reduction of clearances and creepage distances below values specified in clause 29		P
	spillage tests with a deviation (°) from the normal position:		N
15.3	Humidity treatment for 48 h	93%, 25 °C	P
	Withstanding the test of Cl. 16		P

16	LEAKAGE CURRENT AND ELECTRIC STRENGTH		-
16.1	No excessive leakage current and adequate insulation and electric strength (tests 16.2 and 16.3)		P
	Leakage current not excessive and electric strength adequate		P
	Protective impedance disconnected from live parts before carrying out the tests		N
	Tests carried out at room temperature and not connected to the supply		P
16.2	Single-phase appliances: test voltage 1.06 times rated voltage (V)..... :		P
	Three-phase appliances: test voltage 1.06 times rated voltage divided by $\sqrt{3}$ (V)..... :		N
	Leakage current measurements..... :	(see appended table)	P



EN 60335-1			
Clause	Requirement Test	Result - Remark	Verdict
16.3	Electric strength tests according to table 7.....:	(see appended table)	P
	Test voltage applied between the supply cord and inlet bushing and cord guard and cord anchorage as specified.....:	(see appended table)	P
	No breakdown during the tests		P

17	OVERLOAD PROTECTION OF TRANSFORMERS AND ASSOCIATED CIRCUITS		P
	No excessive temperatures in transformer or associated circuits in event of short-circuits likely to occur in normal use		P
	Appliance supplied with 1,06 or 0,94 times rated voltage and the most unfavourable short-circuit or overload likely to occur in normal use applied		P
	Temperature rise of insulation of the conductors of safety extra-low voltage circuits not exceeding the relevant value specified in table 3 by more than 15 K		P
	Temperature of the winding not exceeding the value specified in table 8		P
	however limits do not apply to fail-safe transformers complying with sub-clause 15.5 of IEC 61558-1		N

18	ENDURANCE		-
	Requirements and tests are specified in part 2 when necessary		N

19	ABNORMAL OPERATION		-
19.1	The risk of fire or mechanical damage under abnormal or careless operation obviated		P
	Electronic circuits so designed and applied that a fault will not render the appliance unsafe		P
	Appliances incorporating contactors or relays subjected to the test of 19.14, being carried out before the tests of 19.11		N
19.2	Test of appliance with heating elements with restricted heat dissipation; test voltage (V): power input of 0,85 times rated power input		N
19.3	Test of 19.2 repeated; test voltage (V): power input of 1,24 times rated power input		N



EN 60335-1			
Clause	Requirement Test	Result - Remark	Verdict
19.4	Test conditions as in Cl. 11, the power input being 1,15 times rated power input, any control limiting the temperature during tests of Cl. 11 short-circuited		N
19.5	Test of 19.4 repeated on Class 0I and I appliances with tubular sheathed or embedded heating elements. No short-circuiting, but one end of the element connected to the elements sheath		N
	The test repeated with reversed polarity and the other end of the heating element connected to the sheath		N
	The test is not carried out on appliances intended to be permanently connected to fixed wiring and on appliances where an all-pole disconnection occurs during the test of 19.4		N
19.6	The working voltage of the PTC heating element is increased by 5% and the appliance is operated until steady conditions are re-established. The voltage is then increased in similar steps until 1,5 times working voltage is reached or until the PTC heating element ruptures		N
19.7	Stalling test by locking the rotor if the locked rotor torque is smaller than the full load torque or locking moving parts of other appliances		P
	Locked rotor, motor capacitors open-circuited or short-circuited, if required		N
	Locked rotor, capacitors open-circuited one at a time		N
	Test repeated with capacitors short-circuited one at a time, if required		N
	Appliances with timer or programmer supplied with rated voltage for each of the tests, for a period equal to the maximum period allowed		N
	Other appliances supplied with rated voltage for a period as specified		N
	Winding temperatures not exceeding values specified in table 8		P
19.8	Three-phase motors operated at rated voltage with one phase disconnected	No such three-phase motors	N
19.9	Running overload test on appliances incorporating motors intended to be remotely or automatically controlled or liable to be operated continuously		N
	Winding temperatures not exceeding values as specified		N
19.10	Series motor operated at 1,3 times rated voltage for 1 min	No such series motor	N
	Parts not ejected from the appliance during test		N



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Clause	Requirement Test	Result - Remark	Verdict
19.11	Electronic circuits, compliance checked by evaluation of the fault conditions specified in 19.11.2 for all circuits or parts of circuits, unless they comply with the conditions specified in 19.11.1		P
	Appliances incorporating a protective electronic circuit subjected to the tests of 19.11.3 and 19.11.4		N
	Appliances having a switch with an off position obtained by electronic disconnection, or a switch placing the appliance in a stand-by mode, subjected to the tests of 19.11.4		P
	Appliances incorporating an electronic circuit that relies upon a programmable component to function correctly, subjected to the test of 19.11.4.8		N
19.11.1	Before applying the fault conditions a) to f) in 19.11.2, it is checked if circuits or parts of circuit meet both of the following conditions:		-
	- the electronic circuit is a low-power circuit, that is, the maximum power at low-power points does not exceed 15 W according to the tests specified		N
	- the protection against electric shock, fire hazard, mechanical hazard or dangerous malfunction in other parts of the appliance does not rely on the correct functioning of the electronic circuit		N
19.11.2	Fault conditions applied one at a time, the appliance operated under conditions specified in cl. 11, but supplied at rated voltage, the duration of the tests as specified:		-
	a) short circuit of functional insulation if clearances or creepage distances are less than the values specified in 29		N
	b) open circuit at the terminals of any component		P
	c) short circuit of capacitors, unless they comply with IEC 60384-14		N
	d) short circuit of any two terminals of an electronic component, other than integrated circuits. This fault condition is not applied between the two circuits of an optocoupler		N
	e) failure of triacs in the diode mode		N
	f) failure of an integrated circuit		P
	g) failure of an electronic power switching device		P
19.11.3	If the appliance incorporates a protective electronic circuit which operates to ensure compliance with clause 19, the relevant test is repeated with a single fault simulated, as indicated in a) to f) of 19.11.2		N



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Clause	Requirement Test	Result - Remark	Verdict
	During and after each test the following is checked:		P
	- the temperature rise of the windings do not exceed the values specified in table 8		N
	- the appliance complies with the conditions specified in 19.13		P
	- any current flowing through protective impedance not exceeding the limits specified in 8.1.4		N
	If a conductor of a printed board becomes open-circuited, the appliance is considered to have withstood the particular test, provided all three of the following conditions are met:		-
	- the material of the printed circuit board withstands the burning test of annex E		N
	- any loosened conductor does not reduce the clearances or creepage distances between live parts and accessible metal parts below the values specified in cl. 29		N
	- the appliance withstands the tests of 19.11.2 with open-circuited conductor bridged		N
19.11.4	Appliances having a device with an off position obtained by electronic disconnection, or		N
	a device that can be placed in the stand-by mode,		N
	subjected to the tests of 19.11.4.1 to 19.11.4.7		N
	Appliances incorporating a protective electronic circuit subjected to the tests of 19.11.4.1 to 19.11.4.7, except that		N
	appliances operated for 30 s or 5 min during the test of 19.7 are not subjected to the tests for electromagnetic phenomena.		N
19.11.4.1	The appliance is subjected to electrostatic discharges in accordance with IEC 61000-4-2, test level 4		N
19.11.4.2	The appliance is subjected to radiated fields in accordance with IEC 61000-4-3, test level 3		N
19.11.4.3	The appliance is subjected to fast transient bursts in accordance with IEC 61000-4-4, test level 3 or 4 as specified		N
19.11.4.4	The power supply terminals of the appliance subjected to voltage surges in accordance with IEC 61000-4-5, test level 3 or 4 as specified		N
	Earthed heating elements in class I appliances disconnected		N
19.11.4.5	The appliance is subjected to injected currents in accordance with IEC 61000-4-6, test level 3		N



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Clause	Requirement Test	Result - Remark	Verdict
19.11.4.6	The appliance is subjected to the Class 3 voltage dips and interruptions in accordance with IEC 61000-4-11		N
19.11.4.7	The appliance is subjected to mains signals in accordance with IEC 61000-4-13, test level class 2		N
19.11.4.8	The appliance is supplied at rated voltage and operated under normal operation. After 60s the power supply is reduces to a level such that the appliance ceases to respond or a programmable component cease to operate.		N
	The appliance continues to operate normally or requires a manual operation to restart		N
19.12	If the safety of the appliance for any of the fault conditions specified in 19.11.2 depends on the operation of a miniature fuse-link complying with IEC 127, the test is repeated, measuring the current flowing through the fuse-link; measured current (A); rated current of the fuse-link (A) :		N
19.13	During the tests the appliance does not emit flames, molten metal, poisonous or ignitable gas in hazardous amounts	Comply with requirement	P
	Temperature rises not exceeding the values shown in table 7		P
	Enclosures not deformed to such an extent that compliance with Cl. 8 is impaired		P
	Appliance still operable and complying with 20.2		N
	Appliance, other than Class III, withstands the electric strength test of 16.3, however, the test voltage being:		-
	- basic insulation: 1250 V		P
	- supplementary insulation: 1750 V		N
	- reinforced insulation: 3000 V		P
	After operation or interruption of a control, clearances and creepage distances across the functional insulation withstanding the electric strength test of 16.3. the test voltage being twice the working voltage		P
	The appliance does not undergo a dangerous malfunction, and		P
	no failure of protective electronic circuits, if the appliance is still operable		N
	Appliances tested with an electronic switch in the off position, or in the stand-by mode:		N
	- do not become operational, or		N
	- if they become operational, do not result in a dangerous malfunction during or after the tests of 19.11.4		N



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Clause	Requirement Test	Result - Remark	Verdict
19.14	Appliances operated under the conditions of Clause 11. Contactors or relays contacts operating under the conditions of clause 11 short-circuited		N

20	STABILITY AND MECHANICAL HAZARDS		-
20.1	Adequate stability		P
	Tilting test through an angle of 10° (appliance placed on an inclined plane/horizontal plane); appliance does not overturn		P
	Tilting test repeated on appliances with heating elements, angle of inclination increased to 15		N
	Possible heating test in overturned position; temperature rise does not exceed values shown in table 9		N
20.2	Moving parts adequately arranged or enclosed as to provide protection against personal injury	No hazards moving parts	N
	Protective enclosures, guards and similar parts are non-detachable		N
	Adequate mechanical strength and fixing of protective enclosures		N
	Self-resetting thermal cut-outs and overcurrent protective devices not causing a hazard, if unexpectedly reclosed		N
	Not possible to touch dangerous moving parts with test finger		N

21	MECHANICAL STRENGTH		-
21.1	Appliance has adequate mechanical strength and is constructed as to withstand rough handling		P
	Checked by applying blows to the appliance in accordance with test probe of IEC 60068-2-75, spring hammer test, impact energy 0,5 J		P
	If necessary, supplementary or reinforced insulation subjected to the electric strength test of 16.3		N
	If necessary, repetition of groups of three blows on a new sample		N
21.2	Accessible parts of solid insulation having strength to prevent penetration by sharp implements		P
	The insulation is tested as specified, unless		N
	the thickness of supplementary insulation is at least 1 mm and reinforced insulation is at least 2 mm		P



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Clause	Requirement Test	Result - Remark	Verdict
22	CONSTRUCTION		-
22.1	Appliance marked with the first numeral of the IP system: relevant requirements of IEC 529 are fulfilled	IPX0	N
22.2	Stationary appliance: means to provide all-pole disconnection from the supply provided, the following means being available:		-
	- a supply cord fitted with a plug		N
	- a switch complying with 24.3		N
	- a statement in the instruction sheet that a disconnection incorporated in the fixed wiring is to be provided		N
	- an appliance coupler		P
	Single-phase Class I appliance with heating elements, intended to be permanently connected to fixed wiring, incorporating single-pole switches or single-pole protective devices for the disconnection of the heating element(s): the switches/devices being connected in the phase conductor		N
22.3	Appliance provided with pins: no undue strain on socket-outlets		N
	Applied torque not exceeding 0,25 Nm		N
	Pull force of 50N to each pin after the appliance has being placed in the heating cabinet; when cooled to room temperature the pins are not displaced by more than 1mm		N
	Each pin subjected to a torque of 0.4Nm; the pins are not rotating unless rotating does not impair compliance with the standard		N
22.4	Appliance for heating liquids and appliance causing undue vibration not provided with pins for insertion into socket-outlets		N
22.5	No risk of electric shock when touching the pins of the plug		N
22.6	Electrical insulation not affected by condensing water or leaking liquid		P
	Electrical insulation of Class II appliances not affected in case of a hose rupture or seal leak		N
22.7	Appliances containing liquid or gases in normal use shall be against the risk of excessive pressure		P
22.8	Electrical connections not subject to pulling during cleaning of compartments to which access can be gained without the aid of a tool, and which are likely to be cleaned in normal use	No such compartments	N



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Clause	Requirement Test	Result - Remark	Verdict
22.9	Insulation, internal wiring, windings, commutators and slip rings not exposed to oil, grease or similar substances	Comply with requirements	P
	Adequate insulating properties of oil or grease to which insulation is exposed	No such parts	N
22.10	Not possible to reset voltage-maintained non-self-resetting thermal cut-outs by the operation of an automatic switching device incorporated within the appliance		N
	Non-self resetting thermal motor protectors have a trip-free action, unless		N
	they are voltage maintained		N
	Location or protection of reset buttons of non-self-resetting controls is so that accidental resetting is unlikely		N
22.11	Reliable fixing of non-detachable parts which provide the necessary degree of protection against electric shock, moisture or contact with moving parts		P
	Obvious locked position of snap-in devices used for fixing such parts		P
	No deterioration of the fixing properties of snap-in devices used in parts which are likely to be removed during installation or servicing		N
	Tests		N
22.12	Handles, knobs etc. fixed in a reliable manner		P
	Fixing in wrong position of handles, knobs etc. indicating position of switches or similar components not possible		P
	Axial force 15 N applied to parts, the shape of which being so that an axial pull is unlikely to be applied		P
	Axial force 30 N applied to parts, the shape of which being so that an axial pull is likely to be applied		N
22.13	Unlikely that handles, when gripped as in normal use, make the operators hand touch parts having a temperature rise exceeding the value specified for handles which are held for short periods only		P
22.14	No ragged or sharp edges creating a hazard for the user in normal use, or during user maintenance		P
	No exposed pointed ends of self tapping screws etc., liable to be touched by the user in normal use or during user maintenance		P



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Clause	Requirement Test	Result - Remark	Verdict
22.15	Storage hooks and the like for flexible cords smooth and well rounded	No such device	N
22.16	Automatic cord reels cause no undue abrasion or damage to the sheath of the flexible cord, no breakage of conductors strands, no undue wear of contacts	No such devices	N
	Cord reel tested with 6000 operations, as specified		N
	Electric strength test of 16.3, voltage of 1000 V applied		N
22.17	Spacers not removable from the outside by hand or by means of a screwdriver or a spanner	No such construction	N
22.18	Current-carrying parts and other metal parts resistant to corrosion under normal conditions of use		P
22.19	Driving belts not used as electrical insulation		N
22.20	Direct contact between live parts and thermal insulation effectively prevented, unless material used is non-corrosive, non-hygroscopic and non-combustible	No thermal insulation	N
22.21	Wood, cotton, silk, ordinary paper and fibrous or hygroscopic material not used as insulation, unless impregnated		N
	This requirement does not apply to magnesium oxide and mineral ceramic fibres used for the electrical insulation of heating elements		P
22.22	Asbestos not used in the construction of the appliance	No asbestos	P
22.23	Oils containing polychlorinated biphenyl (PCB) not used	No oils	N
22.24	Bare heating elements adequately supported		N
	In case of rupture, the heating conductor is unlikely to come in contact with earthed metal parts or accessible metal parts		N
22.25	Sagging heating conductors cannot come into contact with accessible metal parts	No such parts	N
22.26	The insulation between parts operating at safety extra-low voltage and other live parts complies with the requirements for double or reinforced insulation		N
22.27	Parts connected by protective impedance separated by double or reinforced insulation	No such protective impedance	N
22.28	Metal parts of Class II appliances conductively connected to gas pipes or in contact with water: separated from live parts by double or reinforced insulation	No such construction	N



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Clause	Requirement Test	Result - Remark	Verdict
22.29	Class II appliances permanently connected to fixed wiring so constructed that the required degree of protection against electric shock is maintained after installation		N
22.30	Parts serving as supplementary or reinforced insulation fixed so that they cannot be removed without being seriously damaged, or		P
	so constructed that they cannot be replaced in an incorrect position, and so that if they are omitted, the appliance is rendered inoperable or manifestly incomplete		P
22.31	Creepage distances and clearances over supplementary and reinforced insulation not reduced below values specified in 29.1 as a result of wear		P
	Creepage distances and clearances over supplementary or reinforced insulation not reduced to less than 50% of values specified in 29.1 if wires, screws etc. becomes loose		P
22.32	Supplementary and reinforced insulation designed or protected against deposition of dirt or dust		P
	Ceramic material not tightly sintered, similar material or beads alone not used as supplementary or reinforced insulation		N
	Supplementary insulation of natural or synthetic rubber resistant to ageing, or arranged and dimensioned so that creepage distances are not reduced below values specified in 29.1	No such device	N
	Oxygen bomb test at 70 °C for 96 h and 16 h at room temperature		N
22.33	Conductive liquids which are or may become accessible in normal use are not in direct contact with live parts	No such conductive liquids	P
	Electrodes not used for heating liquids		P
	Conductive liquids are not in direct contact with basic insulation or reinforced insulation in Class II constructions		N
	Conductive liquids in direct contact with live parts shall not be in contact with reinforced insulation for Class II constructions		N
22.34	Shafts of operating knobs, handles, levers etc. not live, unless the shaft is not accessible when the part is removed		N
22.35	Handles, levers and knobs, held or actuated in normal use, not becoming live in the event of an insulation fault		N



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Clause	Requirement Test	Result - Remark	Verdict
	Such parts being of metal, and their shafts or fixings are likely to become live in the event of an insulation fault, they are either adequately covered by insulation material, or their accessible parts are separated from their shafts or fixings by supplementary insulation		N
	This requirement does not apply to handles, levers and knobs on stationary appliances other than those of electrical components, provided they are either reliably connected to an earthing terminal or earthing contact, or separated from live parts by earthed metal		N
22.36	Handles continuously held in the hand in normal use are so constructed that when gripped as in normal use, the operators hand is not likely to touch metal parts, unless they are separated from live parts by double or reinforced insulation	No hand-held appliance	N
22.37	Capacitors in Class II appliances not connected to accessible metal parts, unless complying with 22.42	No such capacitors	N
	Metal casings of capacitors in Class II appliances separated from accessible metal parts by supplementary insulation, unless complying with 22.42		N
22.38	Capacitors not connected between the contacts of a thermal cut-out		N
22.39	Lamp holders used only for the connection of lamps		N
22.40	Motor-operated appliances and combined appliances intended to be moved while in operation, or having accessible moving parts, fitted with a switch to control the motor. The actuating member of the switch being easily visible and accessible		P
	Unless the appliance can operate continuously, automatically or remotely without giving rise to a hazard, appliances for remote operation being fitted with a switch. The actuating member of the switch being easily visible and accessible.		N
22.41	No components, other than lamps, containing mercury		P
22.42	Protective impedance consisting of at least two separate components		N
	Values specified in 8.1.4 not exceeded if any one of the components are short-circuited or open-circuited		N
22.43	Appliances adjustable for different voltages, accidental changing of the setting of the voltage unlikely to occur		N



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Clause	Requirement Test	Result - Remark	Verdict
22.44	Appliances shall not have an enclosure that is shaped or decorated like a toy		P
22.45	When air is used as reinforced insulation, clearances not reduced below the values specified in 29.1.4 due to deformation as a result of an external force applied to the enclosure		N
22.46	Software used in protective electronic circuits is software class B or C :		N
22.47	Appliances connected to the water mains withstand the water pressure expected in normal use		N
	No leakage from any part, including any inlet water hose		N
22.48	Appliances connected to the water mains constructed to prevent backsiphonage of non-potable water		N
22.49	For remote operation, the duration of operation shall be set before the appliance can be started, unless		P
	the appliance switches off automatically or can operate continuously without hazard		N
22.50	Controls incorporated in the appliance take priority over controls actuated by remote operation		N
22.51	A control on the appliance being manually adjusted to the setting for remote operation before the appliance can be operated in this mode		P
	There is a visual indication showing that the appliance is adjusted for remote operation		P
	Manual setting and visual indication not necessary on appliances that can operate as follows, without giving rise to a hazard:		P
	- operate continuously,		N
	- operate automatically, or		N
	- be operated remotely		P
22.52	Socket-outlets on appliances accessible to the user in accordance with the socket-outlet system used in the country in which the appliance is sold		N

23	INTERNAL WIRING		-
23.1	Wireways smooth and free from sharp edges		P
	Wires protected against contact with burrs, cooling fins etc.		P
	Wire holes in metal well rounded or provided with bushings		N



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Clause	Requirement Test	Result - Remark	Verdict
	Wiring effectively prevented from coming into contact with moving parts		N
23.2	Beads etc. on live wires cannot change their position, and are not resting on sharp edges or corners	No such materials	N
	Beads inside flexible metal conduits contained within an insulating sleeve		N
23.3	Electrical connections and internal conductors movable relatively to each other not exposed to undue stress		N
	Flexible metallic tubes not causing damage to insulation of conductors	No flexible metallic tubes	N
	Open-coil springs not used		N
	Adequate insulating lining provided inside a coiled spring, the turns of which touch one another		N
	No damage after 10 000 flexings		N
	Electric strength test, 1000 V between live parts and metal parts		N
23.4	Bare internal wiring sufficiently rigid and fixed	No such bare internal wire	N
23.5	The basic insulation of internal wiring withstanding the electrical stress likely to occur in normal use		P
	No breakdown when a voltage of 2000 V is applied for 15 min between the conductor and metal foil wrapped around the insulation		P
23.6	Sleeving used as supplementary insulation on internal wiring retained in position by positive means		P
23.7	Only the colour combination green/yellow used for earthing conductors		P
23.8	Aluminium wires not used for internal wiring		P
23.9	No lead-tin soldering of stranded conductors where they are subject to contact pressure, unless		P
	clamping means so constructed that there is no risk of bad contact due to cold flow of the solder		N
23.10	The insulation and sheath of internal wiring, incorporated in external hoses for the connection of an appliance to the water mains, at least equivalent to that of light polyvinyl chloride sheathed flexible cord (60227 IEC 52)		N

24	COMPONENTS		-
24.1	Components comply with safety requirements in relevant IEC standards		P
	List of components	(see appended table)	P



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Clause	Requirement Test	Result - Remark	Verdict
	Components not tested and found to comply with relevant IEC standard for the number of cycles specified are tested in accordance with 24.1.1 to 24.1.9		N
	Components not tested and found to comply with relevant IEC standard, components not marked or not used in accordance with its marking, tested under the conditions occurring in the appliance		P
	Lampholders and starterholders not being tested and found to comply with the relevant IEC standard, tested as a part of the appliance and additionally according to the gauging and interchangeability requirements of the relevant IEC standard		N
24.1.1	Capacitors likely to be permanently subjected to the supply voltage and used for radio interference suppression or for voltage dividing, complying with IEC 60384-14, or		N
	tested according to annex F		N
24.1.2	Safety isolating transformers complying with IEC 61558-2-6, or		N
	tested according to annex G		N
24.1.3	Switches complying with IEC 61058-1, the number of cycles of operation being at least 10 000, or		N
	tested according to annex H		N
	If the switch operates a relay or contactor, the complete switching system is subjected to the test		N
24.1.4	Automatic controls complying with IEC 60730-1 with relevant part 2. The number of cycles of operation being:		-
	- thermostats:		N
	- temperature limiters:		N
	- self-resetting thermal cut-outs:		N
	- voltage maintained non-self-resetting thermal cut-outs:		N
	- other non-self-resetting thermal cut-outs:		N
	- timers:		N
	- energy regulators:		N
	Thermal motor protectors are tested in combination with their motor under the conditions specified in Annex D		N
	For water valves containing live parts and that are incorporated in external hoses for connection of an appliance to the water mains, the degree of protection declared for subclause 6.5.2 of IEC 60730-2-8 is IPX7		N



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Clause	Requirement Test	Result - Remark	Verdict
24.1.5	Appliance couplers complying with IEC 60320-1		N
	However, appliances classified higher than IPX0, the appliance couplers complying with IEC 60320-2-3		N
	Interconnection couplers complying with IEC 60320-2-2		N
24.1.6	Small lamp holders similar to E10 lampholders complying with IEC 60238, the requirements for E10 lampholders being applicable		N
24.1.7	If the remote operation of the appliance is via a telecommunication network, the relevant standard for the telecommunication interface circuitry in the appliance is IEC 62151		N
24.1.8	The relevant standard for thermal links is IEC 60691. Thermal links not complying with IEC 60691 are considered to be an intentionally weak part for the purposes of Clause 19		N
24.1.9	Relays, other than motor starting relays, tested as part of the appliance		N
	They are also tested in accordance with Clause 17 of IEC 60730-1, the number of operations in 24.1.4 selected according to the relay function in the appliance:		N
24.2	No switches or automatic controls in flexible cords		N
	No devices causing the protective device in the fixed wiring to operate in the event of a fault in the appliance		N
	No thermal cut-outs which can be reset by soldering		N
24.3	Switches intended for all-pole disconnection of stationary appliances are directly connected to the supply terminals and having a contact separation in all poles, providing full disconnection under overvoltage category III conditions		N
24.4	Plugs and socket-outlets for extra-low voltage circuits and heating elements, not interchangeable with plugs and socket-outlets listed in IEC 60083 or IEC 60906-1 or with connectors and appliance inlets complying with the standard sheets of IEC 60320-1		N
24.5	Capacitors in auxiliary windings of motors marked with their rated voltage and capacitance and used accordingly		N
	Voltage across capacitors in series with a motor winding does not exceed 1,1 times rated voltage, when the appliance is supplied at 1,1 times rated voltage under minimum load		N



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Clause	Requirement Test	Result - Remark	Verdict
24.6	Working voltage of motors connected to the supply mains and having basic insulation that is inadequate for the rated voltage of the appliance, not exceeding 42V		N
	In addition, the motors are complying with the requirements of Annex I		N
24.7	Hose-sets for connection of appliances to the water mains, complying with IEC 61770 and supplied with the appliance		N

25	SUPPLY CONNECTION AND EXTERNAL FLEXIBLE CORDS		-
25.1	Appliance not intended for permanent connection to fixed wiring, means for connection to the supply:		P
	- supply cord fitted with a plug		P
	- an appliance inlet having at least the same degree of protection against moisture as required for the appliance		N
	- pins for insertion into socket-outlets		N
25.2	Appliance not provided with more than one means of connection to the supply mains		P
	Stationary appliance for multiple supply may be provided with more than one means of connection, provided electric strength test of 1250 V for 1 min between each means of connection causes no breakdown		N
25.3	Connection of supply conductors for appliance intended to be permanently connected to fixed wiring possible after the appliance has been fixed to its support		N
	Appliance provided with a set of terminals for the connection of cables or fixed wiring, cross-sectional areas specified in 26.6		N
	Appliance provided with a set of terminals allowing the connection of a flexible cord		N
	Appliance provided with a set of supply leads accommodated in a suitable compartment		N
	Appliance provided with a set of terminals and cable entries, conduit entries, knock-outs or glands, allowing connection of appropriate type of cable or conduit		N
25.4	Cable and conduit entries, rated current of appliance not exceeding 16 A, dimension according to table 10		N
	Introduction of conduit or cable does not reduce clearances or creepage distances below values specified in 29		N



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Clause	Requirement Test	Result - Remark	Verdict
25.5	Method for assemble supply cord with the appliance:		-
	- type X attachment		N
	- type Y attachment		P
	- type Z attachment, if allowed in part 2		N
	Type X attachment, other than those with a specially prepared cord, not used for flat twin tinsel cords		N
25.6	Plugs fitted with only one flexible cord		P
25.7	Supply cords being one of the following types:		-
	- rubber sheathed (at least 60245 IEC 53)		N
	- polychloroprene sheathed (at least 60245 IEC 57)		N
	- cross-linked polyvinyl chloride sheathed (at least 60245 IEC 87)		N
	Polyvinyl chloride sheathed: Not used if they are likely to touch metal parts having a temperature rise exceeding 75K during the test of Clause 11.		N
	- light polyvinyl chloride sheathed cord (at least 60227 IEC 52), appliances not exceeding 3 kg		N
	- ordinary polyvinyl chloride sheathed cord (at least 60227 IEC 53), other appliances		P
	Heat resistant polyvinyl chloride sheathed: Not used for type X attachment other than specially prepared cords.		N
	- Heat-resistant light polyvinyl chloride sheathed cord (at least 60227 IEC 56), appliances not exceeding 3 kg		N
	- heat-resistant polyvinyl chloride sheathed cord (60227 IEC 57), other appliances		N
25.8	Nominal cross-sectional area of supply cords according to table 11; rated current (A); cross-sectional area (mm ²):	0.5mm ²	P
25.9	Supply cord not in contact with sharp points or edges		P
25.10	Green/yellow core for earthing purposes in Class I appliance		P
25.11	Conductors of supply cords not consolidated by lead-tin soldering where they are subject to contact pressure, unless		P
	clamping means so constructed that there is no risk of bad contacts due to cold flow of the solder		N
25.12	Moulding the cord to part of the enclosure does not damage the insulation of the supply cord		N



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Clause	Requirement Test	Result - Remark	Verdict
25.13	Inlet opening so shaped as to prevent damage to the supply cord		N
	Unless the enclosure at the inlet opening is of insulation material, a non-detachable lining or bushing complying with 29.3 for supplementary insulation provided		N
	If unsheathed supply cord, a similar additional bushing or lining is required, unless		N
	the appliance is class 0		N
25.14	Supply cords adequately protected against excessive flexing		N
	Flexing test:		N
	- applied force (N):		N
	- number of flexings:		N
	The test does not result in:		N
	- short circuit between the conductors		N
	- breakage of more than 10% of the strands of any conductor		N
	- separation of the conductor from its terminal		N
	- loosening of any cord guard		N
	- damage, within the meaning of the standard, to the cord or the cord guard		N
	- broken strands piercing the insulation and becoming accessible		N
25.15	Conductors of the supply cord relieved from strain, twisting and abrasion by use of cord anchorage		P
	The cord cannot be pushed into the appliance to such an extent that the cord or internal parts of the appliance can be damaged		P
	Pull and torque test of supply cord, values shown in table 10: pull (N); torque (not on automatic cord reel) (Nm):	60N, 0.25Nm	P
	Max. 2 mm displacement of the cord, and conductors not moved more than 1 mm in the terminals	1.6mm	P
	Creepage distances and clearances not reduced below values specified in 29.1		P
25.16	Cord anchorages for type X attachments constructed and located so that:		N
	- replacement of the cord is easily possible		N
	- it is clear how the relief from strain and the prevention of twisting are obtained		N



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Clause	Requirement Test	Result - Remark	Verdict
	- they are suitable for different types of cord		N
	- cord cannot touch the clamping screws of cord anchorage if these screws are accessible, unless separated from accessible metal parts by supplementary insulation		N
	- the cord is not clamped by a metal screw which bears directly on the cord		N
	- at least one part of the cord anchorage securely fixed to the appliance, unless part of a specially prepared cord		N
	- screws which have to be operated when replacing the cord do not fix any other component, if applicable		N
	- if labyrinths can be bypassed the test of 25.15 is nevertheless withstood		N
	- for Class 0, 0I and I appliances: they are of insulating material or are provided with an insulating lining, unless a failure of the insulation of the cord does not make accessible metal parts live		N
	- for Class II appliances: they are of insulating material, or if of metal, they are insulated from accessible metal parts by supplementary insulation		N
25.17	Adequate cord anchorages for type Y and Z attachment		P
25.18	Cord anchorages only accessible with the aid of a tool, or		P
	so constructed that the cord can only be fitted with the aid of a tool		P
25.19	Type X attachment, glands not used as cord anchorage in portable appliances		N
	Tying the cord into a knot or tying the cord with string not used		N
25.20	Conductors of the supply cord for type Y and Z attachment adequately additionally insulated		P
25.21	Space for supply cord for type X attachment or for connection of fixed wiring constructed to permit checking of conductors with respect to correct positioning and connection before fitting any cover, no risk of damage to the conductors when fitting the cover, no contact with accessible metal parts if a conductor becomes loose, etc.		N
	For portable appliances, the uninsulated end of a conductor prevented from any contact with accessible metal parts, unless the end of the cord is such that the conductors are unlikely to slip free		N
25.22	Appliance inlet:		-



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Clause	Requirement Test	Result - Remark	Verdict
	- live parts not accessible during insertion or removal		N
	- connector can be inserted without difficulty		N
	- the appliance is not supported by the connector		N
	- is not for cold conditions if temp. rise of external metal parts exceeds 75 K, unless the supply cord is not likely to touch such metal parts		N
25.23	Interconnection cords comply with the requirements for the supply cord, except as specified		N
	If necessary, electric strength test of 16.3		N
25.24	Interconnection cords not detachable without the aid of a tool if compliance with the standard is impaired when they are disconnected		N
25.25	Dimensions of pins compatible with the dimensions of the relevant socket-outlet. Dimensions of pins and engagement face in accordance with the relevant plug in IEC 60083		N

26	TERMINALS FOR EXTERNAL CONDUCTORS		-
26.1	Appliances provided with terminals or equally effective devices for connection of external conductors		P
	Terminals only accessible after removal of a non-detachable cover		P
	However, earthing terminals may be accessible if a tool is required to make the connections and means are provided to clamp the wire independently from its connection		N
26.2	Appliances with type X attachment and appliances for connection to fixed wiring provided with terminals in which connections are made by means of screws, nuts or similar devices, unless the connections are soldered		N
	Screws and nuts serve only to clamp supply conductors, except		N
	internal conductors, if so arranged that they are unlikely to be displaced when fitting the supply conductors		N
	If soldered connections used, the conductor so positioned or fixed that reliance is not placed on soldering alone		N
	Soldering alone used, barriers provided, clearances and creepage distances satisfactory if the conductor becomes free at the soldered joint		N



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Clause	Requirement Test	Result - Remark	Verdict
26.3	Terminals for type X attachment and for connection to fixed wiring so constructed that the conductor is clamped between metal surfaces with sufficient contact pressure and without damaging the conductor		N
	Terminals for type X attachment and those for connection to fixed wiring so fixed that when tightening or loosening the clamping means:		N
	- the terminal does not loosen		N
	- internal wiring is not subjected to stress		N
	- clearances and creepage distances are not reduced below the values in 29		N
	Compliance checked by inspection and by the test of subclause 9.6 of IEC 60999-1, the torque applied being equal to two-thirds of the torque specified. Nominal diameter of thread (mm); screw category; torque (Nm):		N
26.4	Terminals for type X attachment, except those with a specially prepared cord, and those for connection to fixed wiring, no special preparation of conductors required, and so constructed or placed that conductors prevented from slipping out		N
26.5	Terminals for type X attachment so located or shielded that if a wire of a stranded conductor escapes, no risk of accidental connection to other parts that result in a hazard		N
	Stranded conductor test, 8 mm insulation removed		N
	No contact between live parts and accessible metal parts and, for class II constructions, between live parts and metal parts separated from accessible metal parts by supplementary insulation only		N
26.6	Terminals for type X attachment and for connection to fixed wiring suitable for connection of conductors with required cross-sectional area according to table 13; rated current (A); nominal cross-sectional area (mm ²):		N
	Terminals only suitable for a specially prepared cord		N
26.7	Terminals for type X attachment accessible after removal of a cover or part of the enclosure		N
26.8	Terminals for the connection to fixed wiring, including the earthing terminal, located close to each other		N
26.9	Terminals of the pillar type constructed and located as specified		N



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Clause	Requirement Test	Result - Remark	Verdict
26.10	Terminals with screw clamping and screwless terminals not used for flat twin tinsel cords, unless conductors ends fitted with a device suitable for screw terminals		N
	Pull test of 5 N to the connection		N
26.11	For type Y and Z attachment: soldered, welded, crimped and similar connections may be used		P
	For Class II appliances: the conductor so positioned or fixed that reliance is not placed on soldering, welding or crimping alone		N
	For Class II appliances: soldering, welding or crimping alone used, barriers provided, clearances and creepage distances satisfactory if the conductor becomes free		N

27	PROVISION FOR EARTHING		P
27.1	Accessible metal parts of Class 0I and I appliances, permanently and reliably connected to an earthing terminal or contact of the appliance inlet		P
	Earthing terminals not connected to neutral terminal		P
	Class 0, II and III appliance have no provision for earthing		N
	Safety extra-low voltage circuits not earthed, unless protective extra-low voltage circuits		N
27.2	Clamping means adequately secured against accidental loosening		P
	Terminals used for the connection of external equipotential bonding conductors allow connection of conductors of 2.5 to 6 mm ² , and		N
	do not provide earthing continuity between different parts of the appliance		N
	Conductors cannot be loosened without the aid of a tool		N
27.3	For detachable parts that are plugged into another part of the appliance, and having an earth connection, the earth connection made before and separated after current-carrying connections when removing the part		P
	For appliances with supply cord, current-carrying conductors become taut before earthing conductor, if the cord slips out of the cord anchorage		P
27.4	No risk of corrosion resulting from contact between metal of earthing terminal and other metal		P



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Clause	Requirement Test	Result - Remark	Verdict
	Adequate resistance to corrosion of coated or uncoated parts providing earthing continuity, other than parts of a metal frame or enclosure		P
	Parts of steel providing earthing continuity provided at the essential areas with an electroplated coating, thickness at least 5 μm		P
	Adequate protection against rusting of parts of coated or uncoated steel, only intended to provide or transmit contact pressure		P
	In case of aluminium alloys precautions taken to avoid risk of corrosion		N
27.5	Low resistance of connection between earthing terminal and earthed metal parts		P
	This requirement does not apply to connections providing earthing continuity in the protective extra-low voltage circuit, provided that clearances of basic insulation are based on the rated voltage of the appliance		N
	Resistance not exceeding 0,1 Ω at the specified low-resistance test	0.082 Ω	P
27.6	The printed conductors of printed circuit boards shall not be used to provide earthing continuity in hand-held appliances.		N
	They may be used to provide earthing continuity in other appliances if at least two tracks are used with independent soldering points and the appliance complies with 27.5 for each circuit		N

28	SCREWS AND CONNECTIONS		-
28.1	Fixings, electrical connections and connections providing earthing continuity withstand mechanical stresses		N
	Screws not of soft metal liable to creep, such as zinc or aluminium	No such screws	P
	Diameter of screws of insulating material min. 3 mm		N
	Screws of insulating material not used for any electrical connection or connections providing earthing continuity		N
	Screws used for electrical connections or connections providing earthing continuity screw into metal		N
	Screws not of insulating material if their replacement by a metal screw can impair supplementary or reinforced insulation		N



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Clause	Requirement Test	Result - Remark	Verdict
	Type X attachment, screws to be removed for replacement of supply cord or for user maintenance, not of insulating material if their replacement by a metal screw can impair basic insulation		N
	For screws and nuts; test as specified	(see appended table)	P
28.2	Electrical connections and connections providing earthing continuity constructed so that contact pressure not transmitted through insulating material liable to shrink or distort, unless shrinkage or distortion compensated		P
	This requirement does not apply to electrical connections in circuits carrying a current not exceeding 0.5A		N
28.3	Space-threaded (sheet metal) screws only used for electrical connections if they clamp the parts together		N
	Thread-cutting (self-tapping) screws and thread rolling screws only used for electrical connections if they generate a full form standard machine screw thread		N
	Thread-cutting (self-tapping) screws not used if they are likely to be operated by the user or installer		N
	Thread-cutting, thread rolling and space threaded screws may be used in connections providing earthing continuity provided it is not necessary to disturb the connection:		N
	- in normal use,		N
	- during user maintenance,		N
	- when replacing a supply cord having a type X attachment, or		N
	- during installation		N
	At least two screws being used for each connection providing earthing continuity, unless		N
	the screw forms a thread having a length of at least half the diameter of the screw		N
	Thread-cutting and space-threaded screws may be used in connections providing earthing continuity, provided unnecessary to disturb the connection and at least two screws are used for each connection		N
28.4	Screws and nuts that make mechanical connection secured against loosening if they also make electrical connections or connections providing earthing continuity		N



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Clause	Requirement Test	Result - Remark	Verdict
	Rivets for electrical connections or connections providing earthing continuity secured against loosening if subjected to torsion		N
29	CLEARANCES, CREEPAGE DISTANCES AND SOLID INSULATION		-
	Clearances, creepage distances and solid insulation withstand electrical stress		P
	For coatings used on printed circuits boards to protect the microenvironment (Type 1) or to provide basic insulation (Type 2), annex J applies:		N
	The microenvironment is pollution degree 1 under Type 1 coating		N
	No clearance or creepage distance requirements under Type 2 coating		N
29.1	Clearances not less than the values specified in table 16, taking into account the rated impulse voltage for the overvoltage categories of table 15, unless	(see appended table)	P
	for basic insulation and functional insulation they comply with the impulse voltage test of clause 14		P
	However, if the construction is affected by wear, distortion, movement of the parts or during assembly, the clearances for rated impulse voltages of 1500V and above are increased by 0,5 mm and the impulse voltage test is not applicable		N
	Impulse voltage test not applicable:		-
	- when the microenvironment is pollution degree 3		N
	- for basic insulation of class 0 and class 01 appliances		N
	Appliances are in overvoltage category II		N
	Clearances less than specified in table 16 not allowed for basic insulation of class 0 and class 01 appliances,		N
	or if pollution degree 3 is applicable		N
	Compliance is checked by inspection and measurements as specified		N
29.1.1	Clearances of basic insulation withstand the overvoltages, taking into account the rated impulse voltage	(see appended table)	P
	Clearance at the terminals of tubular sheathed heating elements may be reduced to 1mm if the microenvironment is pollution degree 1		N
	Lacquered conductors of windings considered to be bare conductors		N



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Clause	Requirement Test	Result - Remark	Verdict
29.1.2	Clearances of supplementary insulation not less than those specified for basic insulation in table 16	(see appended table)	P
29.1.3	Clearances of reinforced insulation not less than those specified for basic insulation in table 16, but using the next higher step for rated impulse voltage	(see appended table)	P
29.1.4	For functional insulation, the values of table 16 are applicable, unless		P
	the appliance complies with clause 19 with the functional insulation short-circuited		N
	Lacquered conductors of windings considered to be bare conductors		N
	However, clearances at crossover points are not measured		N
	Clearance between surfaces of PTC heating elements may be reduced to 1mm		N
29.1.5	Appliances having higher working voltage than rated voltage, the voltage used for determining clearances from table 16 is the sum of the rated impulse voltage and the difference between the peak value of the working voltage and the peak value of the rated voltage		N
	If the secondary winding of a step-down transformer is earthed, or if there is an earthed screen between the primary and secondary windings, clearances of basic insulation on the secondary side not less than those specified in table 16, but using the next lower step for rated impulse voltage		N
	Circuits supplied with a voltage lower than rated voltage, clearances of functional insulation based on the working voltage used as the rated voltage in table 15		N
29.2	Creepage distances not less than those appropriate for the working voltage, taking into account the material group and the pollution degree	(see appended table)	P
	Pollution degree 2 applies, unless		P
	precautions taken to protect the insulation; pollution degree 1		N
	insulation subjected to conductive pollution; pollution degree 3		N
29.2.1	Creepage distances of basic insulation not less than specified in table 17	(see appended table)	P
	For pollution degree 1, creepage distance not less than the minimum specified for the clearance in table 16, if the clearance has been checked according to the test of clause 14		N



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Clause	Requirement Test	Result - Remark	Verdict
29.2.2	Creepage distances of supplementary insulation at least as specified for basic insulation in table 17	(see appended table)	P
29.2.3	Creepage distances of reinforced insulation at least double as specified for basic insulation in table 17	(see appended table)	P
29.2.4	Creepage distances of functional insulation not less than specified in table 18	(see appended table)	P
	Creepage distances may be reduced if the appliance complies with clause 19 with the functional insulation short-circuited		N
29.3	Supplementary and reinforced insulation having adequate thickness, or a sufficient number of layers, to withstand the electrical stresses		P
	Compliance checked by:		-
	- measurement, in accordance with 29.3.1, or		N
	- an electric strength test in accordance with 29.3.2, or		N
	- an assessment of the thermal quality of the material combined with an electric strength test, in accordance with 29.3.3		N
29.3.1	Supplementary insulation having a thickness of at least 1 mm		P
	Reinforced insulation having a thickness of at least 2 mm		P
29.3.2	Each layer of material withstand the electric strength test of 16.3 for supplementary insulation		N
	Supplementary insulation consisting of at least 2 layers		N
	Reinforced insulation consisting of at least 3 layers		N
29.3.3	The insulation is subjected to the dry heat test Bb of IEC 60068-2-2, followed by		N
	the electric strength test of 16.3		N
	If the temperature rise during the tests of Clause 19 does not exceed the value specified in Table 3, the test of IEC 60068-2-2 is not carried out		N

30	RESISTANCE TO HEAT AND FIRE		-
30.1	External parts of non-metallic material,		P
	parts supporting live parts, and		P
	thermoplastic material providing supplementary or reinforced insulation,		P
	sufficiently resistant to heat		P



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Clause	Requirement Test	Result - Remark	Verdict
	Ball-pressure test according to IEC 60695-10-2		P
	External parts: at 40 °C plus the maximum temperature rise determined during the test of clause 11, or at 75 °C, whichever is the higher; temperature (°C):	(see appended table)	P
	Parts supporting live parts: at 40°C plus the maximum temperature rise determined during the test of clause 11, or at 125°C, whichever is the higher; temperature (°C):	(see appended table)	P
	Parts of thermoplastic material providing supplementary or reinforced insulation, 25°C plus the maximum temperature rise determined during clause 19, if higher; temperature (°C):	(see appended table)	P
30.2	Parts of non-metallic material adequately resistant to ignition and spread of fire		P
	This requirement does not apply to decorative trims, knobs and other parts unlikely to be ignited or to propagate flames that originate inside the appliance		P
	Compliance checked by the test of 30.2.1. In addition:		P
	- attended appliances, 30.2.2 applies		N
	- unattended appliances, 30.2.3 applies		P
	Appliances for remote operation, 30.2.3 applies		N
	Base material of printed circuit board, 30.2.4 applies		N
	For other appliances, 30.2.2 applies		P
30.2.1	Glow-wire test of IEC 60695-2-11 at 550 °C, unless	No flame	P
	the material is classified at least HB40 according to IEC 60695-11-10		P
	Parts for which the glow-wire test cannot be carried out meet the requirements in ISO9772 for category HBF material		P
30.2.2	Appliances operated while attended, parts of non-metallic material supporting current-carrying connections, and parts of non-metallic material within a distance of 3mm of such connections, are subjected to the glow-wire test of IEC 60695-2-11.		N
	The glow-wire test is not carried out on parts of material classified as having a glow-wire flammability index according to IEC 60695-2-12 of at least:		-
	-750°C, for connections carrying a current exceeding 0,5A during normal operation		N
	-650°C, for other connections		N



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Clause	Requirement Test	Result - Remark	Verdict
	Test as specified for an interposed shielding material		N
	When the glow-wire test of IEC 60695-2-11 is carried out, the temperatures are:		-
	-750°C, for connections carrying a current exceeding 0,5A during normal operation		N
	-650°C, for other connections		N
	Test not applicable to conditions as specified		N
30.2.3	Appliances operated while unattended, tested as specified in 30.2.3.1 and 30.2.3.2		P
	Tests not applicable to conditions as specified		N
30.2.3.1	Parts of insulating material supporting connections carrying a current exceeding 0.2A during normal operation, and		P
	parts of non-metallic material within a distance of 3mm,		P
	subjected to the glow-wire test of IEC 60695-2-11 with a test severity of 850°C		P
	Glow-wire test not carried out on parts of material classified as having a glow-wire flammability index of at least 850°C according to IEC 60695-2-12		P
	Glow-wire test not carried out on small parts that comply with the needle-flame test of Annex E or on small parts of material classified as V-0 or V-1 according to IEC 60695-11-10		N
	Test as specified for an interposed shielding material		N
30.2.3.2	Parts of non-metallic material supporting current-carrying connections, and		P
	parts of non-metallic material within a distance of 3mm,		P
	subjected to glow-wire test of IEC 60695-2-11		P
	Test not carried out on material having a glow-wire ignition temperature according to IEC 60695-2-13 of at least:		N
	-775°C, for connections carrying a current exceeding 0,2A during normal operation		N
	-675°C, for other connections		N
	When the glow-wire test of IEC 60695-2-11 is carried out, the temperatures are:		N
	-750°C, for connections carrying a current exceeding 0,2A during normal operation		P
	-650°C, for other connections		P



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Clause	Requirement Test	Result - Remark	Verdict
	Parts that during the test produce a flame persisting longer than 2 s, tested as specified		N
	If a flame persists longer than 2 s during the test, parts above the connection, as specified, subjected to the needle-flame test of annex E, unless		N
	the material is classified as V-0 or V-1 according to IEC 60695-11-10		N
30.2.4	Base material of printed circuit boards subjected to needle-flame test of annex E		P
	Test not applicable to conditions as specified		N

31	RESISTANCE TO RUSTING		-
	Relevant ferrous parts adequately protected against rusting		P

32	RADIATION, TOXICITY AND SIMILAR HAZARDS		-
	Appliance shall not emit harmful radiation, present a toxic or similar hazard due to their operation in normal use		P
	Relevant tests specified in part 2, if necessary		P

A	ANNEX A (INFORMATIVE) ROUTINE TESTS		-
	Description of routine tests to be carried out by the manufacturer		P
B	ANNEX B (NORMATIVE) APPLIANCES POWERED BY RECHARGEABLE BATTERIES		-
	The following modifications to this standard are applicable for appliances powered by batteries that are recharged in the appliance		N
	This annex does not apply to battery chargers		N
3.1.9	Appliance operated under the following conditions:		-
	-the appliance, supplied by its fully charged battery, operated as specified in relevant part 2		N
	-the battery is charged, the battery being initially discharged to such an extent that the appliance cannot operate		N
	-if possible, the appliance is supplied from the supply mains through its battery charger, the battery being initially discharged to such an extent that the appliance cannot operate. The appliance is operated as specified in relevant part 2		N



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Clause	Requirement Test	Result - Remark	Verdict
	If the appliance incorporates inductive coupling between two parts that are detachable from each other, the appliance is supplied from the supply mains with the detachable part removed		N
3.6.2	Part to be removed in order to discard the battery is not considered to be detachable		N
5.101	Appliances supplied from the supply mains tested as specified for motor-operated appliances		N
7.1	Battery compartment for batteries intended to be replaced by the user, marked with battery voltage and polarity of the terminals		N
7.12	The instructions for appliances incorporating batteries intended to be replaced by the user includes required information		N
	Details about how to remove batteries containing materials hazardous to the environment given		N
7.15	Markings placed on the part of the appliance connected to the supply mains		N
8.2	Appliances having batteries that according to the instruction may be replaced by the user need only have basic insulation between live parts and the inner surface of the battery compartment		N
	If the appliance can be operated without batteries, double or reinforced insulation required		N
11.7	The battery is charged for the period described		N
19.1	Appliances subjected to tests of 19.101, 19.102 and 19.103		N
19.101	Appliances supplied at rated voltage for 168 h, the battery being continually charged		N
19.102	Short-circuiting of the terminals of the battery, being fully charged, for appliances having batteries that can be removed without the aid of a tool		N
19.103	Appliances having batteries replaceable by the user supplied at rated voltage under normal operation with the battery removed or in any position allowed by the construction		N
21.101	Appliances having pins for insertion into socket-outlets have adequate mechanical strength, checked according to procedure 2 of IEC 68-2-32		N
	Part of the appliance incorporating the pins subjected to the free fall test, procedure 2, of IEC 60068-2-32, the number of falls being:		N
	- 100, the mass of part does not exceed 250 g		N
	- 50, the mass of part exceeds 250 g		N
	After the test, the requirements of 8.1, 15.1.1, 16.3 and clause 29 are met		N



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Clause	Requirement Test	Result - Remark	Verdict
22.3	Appliances having pins for insertion into socket-outlets tested as fully assembled as possible		N
25.13	An additional lining or bushing not required for interconnection cords operating at safety extra-low voltage		N
30.2	For parts of the appliance connected to the supply mains during the charging period, 30.2.3 applies		N
	For other parts, 30.2.2 applies		N
C	ANNEX C (NORMATIVE) AGEING TEST ON MOTORS		-
	Tests, as described, carried out when doubt with regard to the temperature classification of the insulation of a motor winding		N
	The value of p in Table C.1 is 2000 (IEC 60335-2-15)		N
D	ANNEX D (NORMATIVE) THERMAL MOTOR PROTECTORS		-
	Applicable to appliances having motors that incorporate thermal motor protectors		N
E	ANNEX E (NORMATIVE) NEEDLE-FLAME TEST		-
	Needle-flame test carried out in accordance with IEC 60695- 11-5, with the following modifications:		P
7	Severities		P
	The duration of application of the test flame is 30 s $\pm$ 1 s		P
9	Test procedure		P
9.1	The specimen so arranged that the flame can be applied to a vertical or horizontal edge as shown in the examples of figure 1		P
9.2	The first paragraph does not apply		P
	If possible, the flame is applied at least 10 mm from a corner		P
9.3	The test is carried out on one specimen		P
	If the specimen does not withstand the test, the test may be repeated on two additional specimens, both withstanding the test		N
11	Evaluation of test results		P
	The duration of burning not exceeding 30 s		N
	However, for printed circuit boards, the duration of burning not exceeding 15 s		P



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Clause	Requirement Test	Result - Remark	Verdict
F	ANNEX F (NORMATIVE) CAPACITORS		-
	Capacitors likely to be permanently subjected to the supply voltage, and used for radio interference suppression or voltage dividing, comply with the following clauses of IEC 60384-14, with the following modifications:		N
1.5	Terminology		N
1.5.3	Class X capacitors tested according to subclass X2		N
1.5.4	This subclause is applicable		N
1.6	Marking		N
	Items a) and b) are applicable		N
3.4	Approval testing		N
3.4.3.2	Table II is applicable as described		N
4.1	Visual examination and check of dimensions		N
	This subclause is applicable		N
4.2	Electrical tests		N
4.2.1	This subclause is applicable		N
4.2.5	This subclause is applicable		N
4.2.5.2	Only table IX is applicable		N
	Values for test A apply		N
	However, for capacitors in heating appliances the values for test B or C apply		N
4.12	Damp heat, steady state		N
	This subclause is applicable		N
	Only insulation resistance and voltage proof are checked		N
4.13	Impulse voltage		N
	This subclause is applicable		N
4.14	Endurance		N
	Subclauses 4.14.1, 4.14.3, 4.14.4 and 4.14.7 applicable		N
4.14.7	Only insulation resistance and voltage proof are checked		N
	Visual examination, no visible damage		N
4.17	Passive flammability test		N



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Clause	Requirement Test	Result - Remark	Verdict
	This subclause is applicable		N
4.18	Active flammability test		N
	This subclause is applicable		N
G	ANNEX G (NORMATIVE) SAFETY ISOLATING TRANSFORMERS		-
	The following modifications to this standard are applicable for safety isolating transformers:		N
7	Marking and instructions		N
7.1	Transformers for specific use marked with:		N
	-name, trademark or identification mark of the manufacturer or responsible vendor		N
	-model or type reference		N
17	Overload protection of transformers and associated circuits		N
	Fail-safe transformers comply with subclause 15.5 of IEC 61558-1		N
22	Construction		N
	Subclauses 19.1 and 19.1.2 of IEC 61558-2-6 are applicable		N
29	Clearances, creepage distances and solid insulation		N
29.1, 29.2 and 29.3	The distances specified in items 2a, 2c and 3 in table 13 of IEC 61558-1 apply		N
H	ANNEX H (NORMATIVE) SWITCHES		-
	Switches comply with the following clauses of IEC 61058-1, as modified:		N
	-The tests of IEC 61058-1 carried out under the conditions occurring in the appliance		N
	-Before being tested, switches are operated 20 times without load		N
8	Marking and documentation		N
	Switches are not required to be marked		N
	However, switches that can be tested separately from the appliance marked with the manufacturer's name or trade mark and the type reference		N
13	Mechanism		N
	The tests may be carried out on a separate sample		N
15	Insulation resistance and dielectric strength		N
15.1	Not applicable		N



EN 60335-1			
Clause	Requirement Test	Result - Remark	Verdict
15.2	Not applicable		N
15.3	Applicable for full disconnection and micro-disconnection		N
17	Endurance		N
	Compliance is checked on three separate appliances or switches		N
	For 17.2.4.4, the number of cycles is 10 000, unless otherwise specified in 24.1.3 of the relevant part 2 of IEC 60335		N
	Switches for operation under no load and which can be operated only by a tool and switches operated by hand that are interlocked so that they cannot be operated under load, are not subjected to the tests		N
	Subclauses 17.2.2 and 17.2.5.2 not applicable		N
	The ambient temperature during the test is that occurring in the appliance during the test of Clause 11 in IEC 60335-1		N
	Temperature rise of the terminals not more than 30 K above the temperature rise measured in clause 11 of IEC 60335-1		N
20	Clearances, creepage distances, solid insulation and coatings of rigid printed board assemblies		N
	This clause is applicable to clearances and creepage distances for functional insulation, across full disconnection and micro-disconnection, as stated in table 24		N
I	ANNEX I (NORMATIVE) MOTORS HAVING BASIC INSULATION THAT IS INADEQUATE FOR THE RATED VOLTAGE OF THE APPLIANCE		-
	The following modifications to this standard are applicable for motors having basic insulation that is inadequate for the rated voltage of the appliance:		N
8	Protection against access to live parts		N
8.1	Metal parts of the motor are considered to be bare live parts		N
11	Heating		N
11.3	Temperature rise of the body of the motor is determined instead of the temperature rise of the windings		N
11.8	Temperature rise of the body of the motor, where in contact with insulating material, not exceeding values in table 3 for the relevant insulating material		N
16	Leakage current and electric strength		N



EN 60335-1			
Clause	Requirement Test	Result - Remark	Verdict
16.3	Insulation between live parts of the motor and its other metal parts not subjected to the test		N
19	Abnormal operation		N
19.1	The tests of 19.7 to 19.9 not carried out		N
19.101	Appliance operated at rated voltage with each of the following fault conditions:		N
	- short circuit of the terminals of the motor, including any capacitor incorporated in the motor circuit		N
	- short circuit of each diode of the rectifier		N
	- open circuit of the supply to the motor		N
	- open circuit of any parallel resistor, the motor being in operation		N
	Only one fault simulated at a time, the tests carried out consecutively		N
22	Construction		N
22.101	For class I appliances incorporating a motor supplied by a rectifier circuit, the d.c. circuit being insulated from accessible parts of the appliance by double or reinforced insulation		N
	Compliance checked by the tests specified for double and reinforced insulation		N
J	ANNEX J (NORMATIVE) COATED PRINTED CIRCUIT BOARDS		-
	Testing of protective coatings of printed circuit boards carried out in accordance with IEC 60664-3 with the following modifications:		N
5.7	Conditioning of the test specimens		N
	When production samples are used, three samples of the printed circuit board are tested		N
5.7.1	Cold		N
	The test is carried out at -25°C		N
5.7.3	Rapid change of temperature		N
	Severity 1 is specified		N
5.9	Additional tests		N
	This subclause is not applicable		N
K	ANNEX K (NORMATIVE) OVERVOLTAGE CATEGORIES		-
	The information on overvoltage categories is extracted from IEC 60664-1		P



EN 60335-1			
Clause	Requirement Test	Result - Remark	Verdict
	Overvoltage category is a numeral defining a transient overvoltage condition		P
	Equipment of overvoltage category IV is for use at the origin of the installation		N
	Equipment of overvoltage category III is equipment in fixed installations and for cases where the reliability and the availability of the equipment is subject to special requirements		N
	Equipment of overvoltage category II is energy consuming equipment to be supplied from the fixed installation		P
	If such equipment is subjected to special requirements with regard to reliability and availability, overvoltage category III applies		N
	Equipment of overvoltage category I is equipment for connection to circuits in which measures are taken to limit transient overvoltages to an appropriate low level		N
L	ANNEX L (INFORMATIVE) GUIDANCE FOR THE MEASUREMENT OF CLEARANCES AND CREEPAGE DISTANCES		-
	Sequences for the determination of clearances and creepage distances		P
M	ANNEX M (NORMATIVE) POLLUTION DEGREE		-
	The information on pollution degrees is extracted from IEC 60664-1		P
	Pollution		-
	The microenvironment determines the effect of pollution on the insulation, taking into account the microenvironment		P
	Means may be provided to reduce pollution at the insulation by effective enclosures or similar		P
	Minimum clearances specified where pollution may be present in the microenvironment		P
	Degrees of pollution in the microenvironment		-
	For evaluating creepage distances, the following degrees of pollution in the microenvironment are established:		P
	- pollution degree 1: no pollution or only dry, non-conductive pollution occurs. The pollution has no influence		N
	- pollution degree 2: only non-conductive pollution occurs, except that occasionally a temporary conductivity caused by condensation is to be expected		N



EN 60335-1			
Clause	Requirement Test	Result - Remark	Verdict
	- pollution degree 3: conductive pollution occurs or dry non-conductive pollution occurs that becomes conductive due to condensation that is to be expected		P
	- pollution degree 4: the pollution generates persistent conductivity caused by conductive dust or by rain or snow		N
N	ANNEX N (NORMATIVE) PROOF TRACKING TEST		-
	The proof tracking test is carried out in accordance with IEC 60112 with the following modifications:		N
7	Test apparatus		-
7.3	Test solutions		-
	Test solution A is used		N
10	Determination of proof tracking index (PTI)		N
10.1	Procedure		-
	The proof voltage is 100V, 175V, 400V or 600V:		N
	The last paragraph of Clause 3 applies		N
	The test is carried out on five specimens		N
	In case of doubt, additional test with proof voltage reduced by 25V, the number of drops increased to 100		N
10.2	Report		-
	The report stating if the PTI value was based on a test using 100 drops with a test voltage of (PTI-25) V		N
O	ANNEX O (INFORMATIVE) SELECTION AND SEQUENCE OF THE TESTS OF CLAUSE 30		-
	Description of tests for determination of resistance to heat and fire		P
P	ANNEX P (INFORMATIVE) GUIDANCE FOR THE APPLICATION OF THIS STANDARD TO APPLIANCES USED IN WARM DAMP EQUABLE CLIMATES		-
	Modifications applicable for class 0 and 01 appliances having a rated voltage exceeding 150V, intended to be used in countries having a warm damp equable climate and that are marked		N
	Modifications may also be applied to class 1 appliances having a rated voltage exceeding 150V, intended to be used in countries having a warm damp equable climate and that are marked , if liable to be connected to a supply mains that excludes the protective earthing conductor		N
5	General conditions for the tests		N



EN 60335-1			
Clause	Requirement Test	Result - Remark	Verdict
5.7	The ambient temperature for the tests of Clauses 11 and 13 is 40 +3/0		N
7	Marking and instructions		N
7.1	The appliance marked with the letters		N
7.12	The instructions state that the appliance is to be supplied through a RCD having a rated residual operating current not exceeding 30 mA		N
	The instructions state that the appliance is considered to be suitable for use in countries having a warm damp equable climate, but may also be used in other countries		N
11	Heating		-
11.8	The values of Table 3 are reduced by 15 K		N
13	Leakage current and electric strength at operating temperature		N
13.2	The leakage current for class I appliances not exceeding 0,5 mA		N
15	Moisture resistance		-
15.3	The value of t is 37 °C		N
16	Leakage current and electric strength		N
16.2	The leakage current for class I appliances not exceeding 0,5 mA		N
19	Abnormal operation		N
19.13	The leakage current test of 16.2 is applied in addition to the electric strength test of 16.3		N
Q	ANNEX Q (INFORMATIVE) SEQUENCE OF TESTS FOR THE EVALUATION OF ELECTRONIC CIRCUITS		-
	Description of tests for appliances incorporating electronic circuits		P
R	ANNEX R (NORMATIVE) SOFTWARE EVALUATION		-
	Software evaluated in accordance with the following clauses of Annex H of IEC 60730-1, as modified		-
H.2	Definitions		-
	Only definitions H.2.16 to H.2.20 applicable		N
H.7	Information		-
	Only footnotes 12) to 18) of Table 7.2, as modified, applicable		N
H.11.12	Controls using software		-
H.11.12.7	Delete text		N



EN 60335-1			
Clause	Requirement Test	Result - Remark	Verdict
H.11.12.7.1	For appliances using software class C having a single channel with self-test and monitoring structure, the manufacturer provides the measures necessary to address the fault/errors in safety related segments and data		N
H.11.12.8	Software fault/error detection occurs before compliance with 19.13 of IEC 60335-1 is impaired		N
H.11.12.8.1	Replace text		N
H.11.12.13	Software and safety related hardware under its control initializes and terminates before compliance with 19.13 of IEC 60335-1 is impaired		N

ZA	ANNEX ZA(NORMATIVE) SPECIAL NATIONAL CONDITION		N
	National characteristic or practice that cannot be changed even over a long period, e.g. climatic conditions, electrical earthing conditions. If it affects harmonization, it forms part of the European Standard or Harmonization Document.		N
ZB	ANNEX ZB(INFORMATIVE) A-DEVIATION		N
	National deviation due to regulations, the alteration of which is for the time being outside the competence of the CEN/CENELEC member.		N
ZC	ANNEX ZC(NORMATIVE) NORMATIVE REFERENCE TO INTERNATIONAL PUBLICATIONS WITH THEIR CORRESPONDING EUROPEAN PUBLICATIONS		N
	IEC standards and EN standards used		N
ZD	ANNEX Z(INFORMATIVE) IEC AND CENELEC CODE DESIGNATIONS FOR FLEXIBLE CORDS		N
	IEC and CENELEC code designations for flexible cords		N



10.1	TABLE: Power input deviation					P
Input deviation of/at:		P rated (W)	P measured (W)	dP	Required dP	Remark
90V/60		6	5.5	-8.3%	+15%	--
250V/60		6	5.5	-8.3%	+15%	--

10.2	TABLE : Current deviation					N
Current deviation of/at:		I rated (A)	I measured (A)	Di	Required Di	Remark
--		--	--	--	--	--

11.8	TABLE: Heating test, thermocouples			P
	Test voltage (V)..... :	254.4V		—
	Ambient (°C)..... :	25.0		—
Thermocouple locations		Dt (K)	Max. Dt (K)	
Plug		5	60	
PCB		10	105	
Internal wire		6	85	
Plastic enclosure		5	60	
Test corner		3	65	

13.2	TABLE: Leakage current					P
Heating appliances: 1.15 x rated input.....				-	—	
Motor-operated and combined appliances: 1.06 x rated voltage.....				254.4V	—	
Leakage current between				I (mA)	Max. allowed I (mA)	
L/N of the supply to plastic part				0,07	0,35 mA peak	
L/N of the supply to metal part				0.22	3,5 mA peak	

13.3	TABLE: Electric strength					P
Test voltage applied between:				Voltage (V)	Breakdown (Yes/No)	
L/N of the supply to plastic part				3000	No	
L/N of the supply to metal part				1750	No	

16.2	TABLE: Leakage current					P
Single phase appliances: 1.06 x rated voltage.....				254.4V	—	



	Three phase appliances 1.06 x rated voltage divided by $\sqrt{3}$:..... :	-	—
Leakage current between		I (mA)	Max. allowed I (mA)
L/N of the supply to plastic part		0,05	0,25 mA
L/N of the supply to metal part		0.18	3,5 mA peak

16.3	TABLE: Electric strength		P
Test voltage applied between:		Voltage (V)	Breakdown (Yes/No)
L/N of the supply to plastic part		3000	No
L/N of the supply to metal part		1750	No

24.1	TABLE: Components				P
object part No.	manufacturer / trademark	type/model	technical data	standard	mark(s) of conformity
Plug	Various	Various	250V~,16A	UL 1681	UL/ETI
Plastic enclosure	Shenzhen Fuheng New Material CO LTD	ABS-R600	94V-0 130°C	UL 60335-1	UL E234833 Test with appliance
PCB	GOLDENMAX INTERNATIONAL TECHNOLOGY (HANGZHOU) LTD	DL-C3	Min. thickness 1.5mm, V-0, 130°C	UL 60335-1	UL E134893 Test with appliance
Internal wire	ZHONGSHAN HE YI ELECTRICAL APPLIANCES FACTORY	1015	18AWG, 600V, 105°C	UL 60335-1	UL E313976 Test with appliance



29.1	TABLE: Clearances					P
	Overvoltage category					—
		Type of insulation:				
Rated impulse voltage (V):	Min. cl (mm)	Basic	Functional	Supplementary	Reinforced	Verdict / Remark
330	0,5*					N
500	0,5*					N
800	0,5*					N
1500	0,5*/**					N
2500	1,5**	P		P		P
4000	3,0**				P	P
6000	5,5**					N
8000	8,0**					N
10000	11,0**					N
*) The value is increased to 0,8mm for pollution degree 3						
*) If the construction is affected by wear, distortion, movement of the parts or during assembly, the value is increased by 0,5 mm						



29.2	TABLE: Creepage distances, basic, supplementary and reinforced insulation										P
Working voltage (V)	Creepage distance (mm)										
	Pollution degree										
	1	2			3			Type of insulation			
		Material group			Material group						
		I	II	IIIa/IIIb	I	II	IIIa/IIIb*)	B**)	S**)	R**)	Verdict
≤50	0,18	0,6	0,85	1,2	1,5	1,7	1,9		—	—	N/A
≤50	0,18	0,6	0,85	1,2	1,5	1,7	1,9	—		—	N/A
≤50	0,36	1,2	1,7	2,4	3,0	3,4	3,8	—	—		N/A
125	0,28	0,75	1,05	1,5	1,9	2,1	2,4		—	—	N/A
125	0,28	0,75	1,05	1,5	1,9	2,1	2,4	—		—	N/A
125	0,56	1,5	2,1	3,0	3,8	4,2	4,8	—	—		N/A
250	0,56	1,25	1,8	2,5	3,2	3,6	4,0	P	—	—	P
250	0,56	1,25	1,8	2,5	3,2	3,6	4,0	—	P	—	P
250	1,12	2,5	3,6	5,0	6,4	7,2	8,0	—	—	P	P
400	1,0	2,0	2,8	4,0	5,0	5,6	6,3		—	—	N/A
400	1,0	2,0	2,8	4,0	5,0	5,6	6,3	—		—	N/A
400	2,0	4,0	5,6	8,0	10,0	11,2	12,6	—	—		N/A
500	1,3	2,5	3,6	5,0	6,3	7,1	8,0		—	—	N/A
500	1,3	2,5	3,6	5,0	6,3	7,1	8,0	—		—	N/A
500	2,6	5,0	7,2	10,0	12,6	14,2	16,0	—	—		N/A
>630 and ≤800	1,8	3,2	4,5	6,3	8,0	9,0	10,0		—	—	N/A
>630 and ≤800	1,8	3,2	4,5	6,3	8,0	9,0	10,0	—		—	N/A
>630 and ≤800	3,6	6,4	9,0	12,6	16,0	18,0	20,0	—	—		N/A
>800 and ≤1000	2,4	4,0	5,6	8,0	10,0	11,0	12,5		—	—	N/A
>800 and ≤1000	2,4	4,0	5,6	8,0	10,0	11,0	12,5	—		—	N/A
>800 and ≤1000	4,8	8,0	11,2	16,0	20,0	22,0	25,0	—	—		N/A
>1000 and ≤1250	3,2	5,0	7,1	10,0	12,5	14,0	16,0		—	—	N/A
>1000 and ≤1250	3,2	5,0	7,1	10,0	12,5	14,0	16,0	—		—	N/A
>1000 and ≤1250	6,4	10,0	14,2	20,0	25,0	28,0	32,0	—	—		N/A
>1250 and ≤1600	4,2	6,3	9,0	12,5	16,0	18,0	20,0		—	—	N/A
>1250 and ≤1600	4,2	6,3	9,0	12,5	16,0	18,0	20,0	—		—	N/A
>1250 and ≤1600	8,4	12,6	18,0	25,0	32,0	36,0	40,0	—	—		N/A
>1600 and ≤2000	5,6	8,0	11,0	16,0	20,0	22,0	25,0		—	—	N/A
>1600 and ≤2000	5,6	8,0	11,0	16,0	20,0	22,0	25,0	—		—	N/A
>1600 and ≤2000	11,2	16,0	22,0	32,0	40,0	44,0	50,0	—	—		N/A
>2000 and ≤2500	7,5	10,0	14,0	20,0	25,0	28,0	32,0		—	—	N/A
>2000 and ≤2500	7,5	10,0	14,0	20,0	25,0	28,0	32,0	—		—	N/A
>2000 and ≤2500	15,0	20,0	28,0	40,0	50,0	56,0	64,0	—	—		N/A
>2500 and ≤3200	10,0	12,5	18,0	25,0	32,0	36,0	40,0		—	—	N/A
>2500 and ≤3200	10,0	12,5	18,0	25,0	32,0	36,0	40,0	—		—	N/A
>2500 and ≤3200	20,0	25,0	36,0	50,0	64,0	72,0	80,0	—	—		N/A
>3200 and ≤4000	12,5	16,0	22,0	32,0	40,0	45,0	50,0		—	—	N/A
>3200 and ≤4000	12,5	16,0	22,0	32,0	40,0	45,0	50,0	—		—	N/A
>3200 and ≤4000	25,0	32,0	44,0	64,0	80,0	90,0	100,0	—	—		N/A
>4000 and ≤5000	16,0	20,0	28,0	40,0	50,0	56,0	63,0		—	—	N/A
>4000 and ≤5000	16,0	20,0	28,0	40,0	50,0	56,0	63,0	—		—	N/A
>4000 and ≤5000	32,0	40,0	56,0	80,0	100,0	112,0	126,0	—	—		N/A
>5000 and ≤6300	20,0	25,0	36,0	50,0	63,0	71,0	80,0		—	—	N/A
>5000 and ≤6300	20,0	25,0	36,0	50,0	63,0	71,0	80,0	—		—	N/A
>5000 and ≤6300	40,0	50,0	72,0	100,0	126,0	142,0	160,0	—	—		N/A



>6300 and ≤8000	25,0	32,0	45,0	63,0	80,0	90,0	100,0		—	—	N/A
>6300 and ≤8000	25,0	32,0	45,0	63,0	80,0	90,0	100,0	—		—	N/A
>6300 and ≤8000	50,0	64,0	90,0	126,0	160,0	180,0	200,0	—	—		N/A
>8000 and ≤10000	32,0	40,0	56,0	80,0	100,0	110,0	125,0		—	—	N/A
>8000 and ≤10000	32,0	40,0	56,0	80,0	100,0	110,0	125,0	—		—	N/A
>8000 and ≤10000	64,0	80,0	112,0	160,0	200,0	220,0	250,0	—	—		N/A
>10000 and ≤12500	40,0	50,0	71,0	100,0	125,0	140,0	160,0		—	—	N/A
>10000 and ≤12500	40,0	50,0	71,0	100,0	125,0	140,0	160,0	—		—	N/A
>10000 and ≤12500	80,0	100,0	142,0	200,0	250,0	280,0	320,0	—	—		N/A

Supplementary information:

*) Material group IIIb is allowed if the working voltage does not exceed 50 V

**) B = Basic insulation, S = Supplementary insulation, R = Reinforced insulation

30.1	TABLE: Ball pressure				P
Part	Test temperature (°C)		Impression diameter (mm)	Allowed impression diameter (mm)	
Plug	125		1.1	2	
PCB	125		0.8	2	

30.1	TABLE: RESISTANCE TO HEAT, FIRE AND TRACKING (appended table)									P
Component	Manufacturer	Type	Tracking test [CTI/ PTI]	Glow wire test					Needle flame test	Verdict
				GWT 550°C	GWT 650°C	GWT 750°C	GWT 850°C	GWIT		
Plug	See table 24.1	See table 24.1	--	No flame	--	No flame	No flame	--	--	P
PCB	See table 24.1	See table 24.1	--	--	--	--	--	--	No flame	P

1) Flame persisting longer than 2 s

2) Surrounding parts are subjected to the needle-flame test of annex E

3) These parts subjected to the needle-flame test of annex E

4) Adjacent parts subjected to the needle-flame test of annex E

5) Parts of material classified as V-0 or V-1

6) Base material classified as V-0

supplementary information:



ANNEX A: Photo-documentation

EUT Photo 1

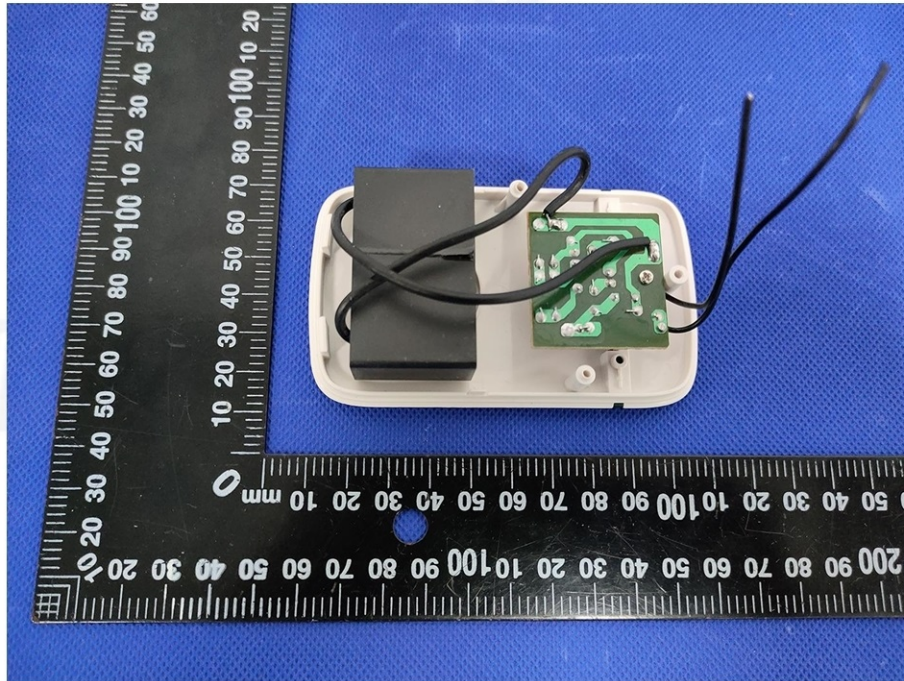


EUT Photo 2

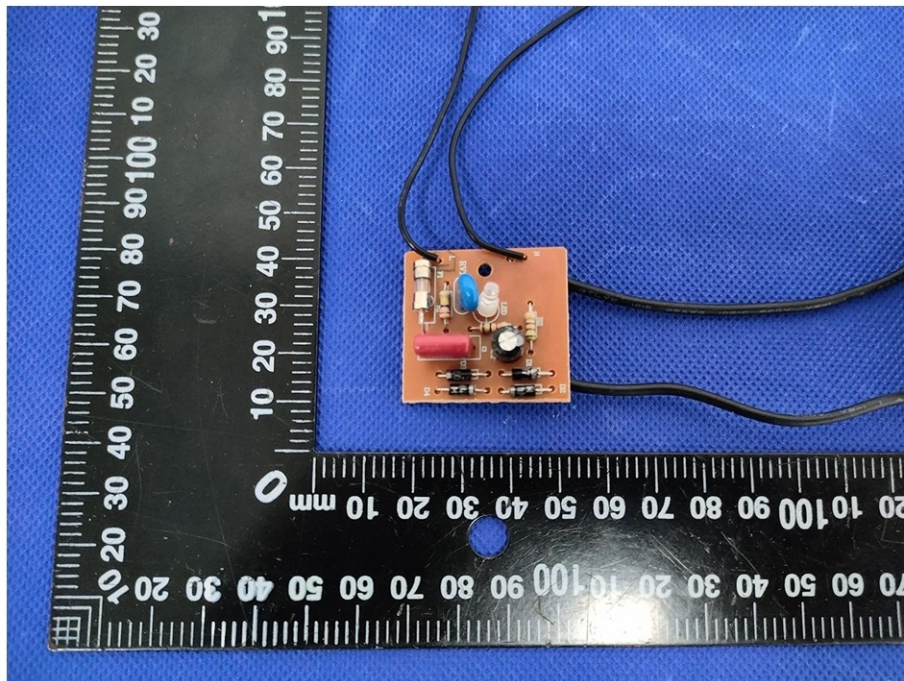




EUT Photo 3



EUT Photo 4



***** END OF REPORT *****

Shenzhen ZKT Technology Co., Ltd.

1/F, No. 101, Building B, No. 6, Tangwei Community Industrial Avenue,
Fuhai Street, Bao'an District, Shenzhen, China



SUPPLIER'S DECLARATION OF CONFORMITY

Certificate Number: ZKT-2305243785C

Certificate's Holder : Dongguan Wednesday Technology Co.,Ltd.
Room 301,Building 2,No.142,Middle Sili Road,Tangxia Town,
Dongguan City, Guangdong Province

Manufacturer : Dongguan Wednesday Technology Co.,Ltd.
Room 301,Building 2,No.142,Middle Sili Road,Tangxia Town,
Dongguan City, Guangdong Province

Trade Mark : N/A

Product : Power saver

Model(s) : SD008
SD001, SD002, SD003, SD004, SD005, SD006, SD007, SD009,
SD010

Test Standard : FCC Part 15 B,
ANSI C63.4:2014

This Attestation of Compliance is issued on a voluntary basis for electrical equipment below the voltage limits of FCC standard. The essential requirement are fulfilled accordingly based on the technical specifications applicable at the time of issuance. See also notes overleaf. It is only valid in connection with the test report number: ZKT-2305243785E.



This Certificate of Conformity is based on single evaluation of the submitted sample(s) of the above mentioned product. It does not imply an assessment of the whole product and relevant Directives to be observed.



FCC TEST REPORT

FCC Part 15 B

Report Number..... : ZKT-2305243785E

Date of Test..... May. 24, 2023 to May. 30, 2023

Date of issue..... : May. 30, 2023

Total number of pages..... 17

Test Result : PASS

Testing Laboratory..... : Shenzhen ZKT Technology Co., Ltd.

Address : 1/F, No. 101, Building B, No. 6, Tangwei Community Industrial Avenue, Fuhai Street, Bao'an District, Shenzhen, China

Applicant's name : Dongguan Wednesday Technology Co.,Ltd.

Address : Room 301,Building 2,No.142,Middle Sili Road,Tangxia Town, Dongguan City, Guangdong Province

Manufacturer's name : Dongguan Wednesday Technology Co.,Ltd.

Address : Room 301,Building 2,No.142,Middle Sili Road,Tangxia Town, Dongguan City, Guangdong Province

Test specification:

Standard..... : FCC Part 15 B, ANSI C63.4:2014

Test procedure..... : /

Non-standard test method : N/A

Test Report Form No..... : TRF-EL-117_V0

Test Report Form(s) Originator..... : ZKT Testing

Master TRF : Dated: 2020-01-06

This device described above has been tested by ZKT, and the test results show that the equipment under test (EUT) is in compliance with the FCC requirements. And it is applicable only to the tested sample identified in the report.

This report shall not be reproduced except in full, without the written approval of ZKT, this document may be altered or revised by ZKT, personal only, and shall be noted in the revision of the document.

Product name..... : Power saver

Trademark : N/A

Model/Type reference..... : SD008

SD001, SD002, SD003, SD004, SD005, SD006, SD007, SD009, SD010

Rated voltage: 90-250V~

Rated frequency: 50/60Hz

Ratings..... : Rated Power: 6W

Useful load: 30KW



Testing procedure and testing location:

Testing Laboratory.....: **Shenzhen ZKT Technology Co., Ltd.**

Address.....: 1/F, No. 101, Building B, No. 6, Tangwei Community
Industrial Avenue, Fuhai Street, Bao'an District,
Shenzhen, China

Tested by (name + signature).....: Jim Liu

Jim Liu

Reviewer (name + signature).....: Jackson Fang

Jackson Fang

Approved (name + signature).....: Lake Xie





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1.VERSION

Report No.	Version	Description	Approved
ZKT-2305243785E	Rev.01	Initial issue of report	May. 30, 2023



2.GENERAL INFORMATION

2.1 Description of Device (EUT)

EUT	Power saver
Trademark	N/A
Model Number	SD008 SD001, SD002, SD003, SD004, SD005, SD006, SD007, SD009, SD010
Model Difference	Only for different model name
Power Supply	Rated voltage: 90-250V~ Rated frequency: 50/60Hz Rated Power: 6W Useful load: 30KW

2.2 Tested System Details

None.

2.3 Test Facility

Site Description

Name of Firm : Shenzhen ZKT Technology Co., Ltd.

Site Location : 1/F, No. 101, Building B, No. 6, Tangwei Community Industrial Avenue, Fuhai Street, Bao'an District, Shenzhen, China

FCC Test Firm Registration Number: 692225
Designation Number: CN1299
IC Registered No.: 27033

2.4 MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the Product as specified in CISPR 16-4-2. This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2.

Test item	Value (dB)
Conducted Emission (150K-30MHZ)	3.20
Radiated disturbance30MHz-1000MHz	4.80



2.5 Test Instrument Used

Conducted emissions Test

Item	Kind of Equipment	Manufacturer	Type No.	Serial No.	Firmware Version	Last calibration	Calibrated until
1	LISN	R&S	ENV216	101471	N/A	Oct. 21, 2022	Oct. 20, 2023
2	LISN	CYBERTEK	EM5040A	E1850400149	N/A	Oct. 21, 2022	Oct. 20, 2023
3	Test Cable	N/A	C-01	N/A	N/A	Oct. 21, 2022	Oct. 20, 2023
4	Test Cable	N/A	C-02	N/A	N/A	Oct. 21, 2022	Oct. 20, 2023
5	Test Cable	N/A	C-03	N/A	N/A	Oct. 21, 2022	Oct. 20, 2023
6	EMI Test Receiver	R&S	ESCI3	101393	4.42 SP3	Oct. 28, 2022	Oct. 27, 2023
7	Triple-Loop Antenna	N/A	RF300	N/A	N/A	Oct. 28, 2022	Oct. 27, 2023
8	Absorbing Clamp	DZ	ZN23201	15034	N/A	Oct. 31, 2022	Oct. 30, 2023
9	EMC Software	Frad	EZ-EMC	Ver.EMC-CO N 3A1.1	N/A	\	\

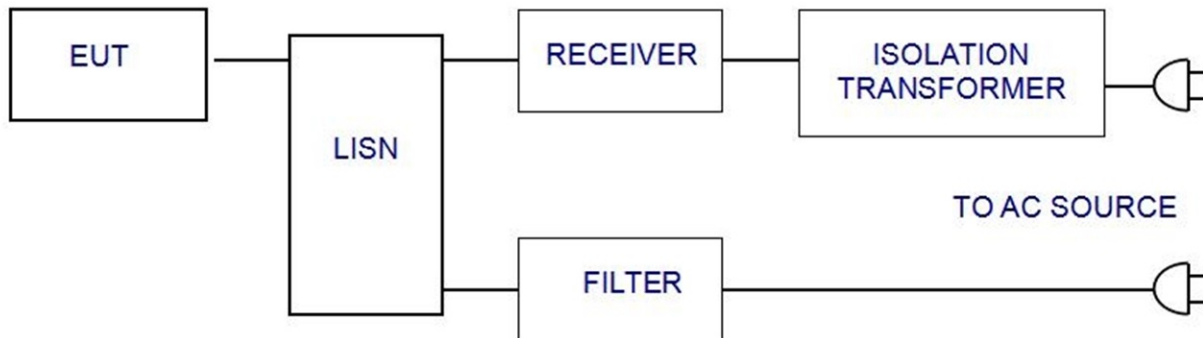
Radiation emissions& Radio Test equipment

Item	Equipment	Manufacturer	Type No.	Serial No.	Firmware Version	Last calibration	Calibrated until
1	Spectrum Analyzer (9kHz-26.5GHz)	KEYSIGHT	9020A	MY55370835	A.17.05	Oct. 28, 2022	Oct. 27, 2023
2	Spectrum Analyzer (10kHz-39.9GHz)	R&S	FSV40-N	100363	1.71 SP2	Oct. 28, 2022	Oct. 27, 2023
3	EMI Test Receiver (9kHz-7GHz)	R&S	ESCI7	101169	4.32	Oct. 28, 2022	Oct. 27, 2023
4	Bilog Antenna (30MHz-1500MHz)	Schwarzbeck	VULB9168	N/A	N/A	Nov. 02, 2022	Nov. 01, 2023
5	Horn Antenna (1GHz-18GHz)	Agilent	AH-118	071145	N/A	Nov. 01, 2022	Oct. 31, 2023
6	Horn Antenna (15GHz-40GHz)	A.H.System	SAS-574	588	N/A	Oct. 28, 2022	Oct. 27, 2023
7	Loop Antenna	TESEQ	HLA6121	58357	N/A	Nov. 01, 2022	Oct. 31, 2023
8	Amplifier (30-1000MHz)	EM Electronics	EM330 Amplifier	060747	N/A	Nov. 15, 2022	Nov. 14, 2023
9	Amplifier (1GHz-26.5GHz)	Agilent	8449B	3008A00315	N/A	Oct. 28, 2022	Oct. 27, 2023
10	Amplifier (500MHz-40GHz)	全聚达	DLE-161	097	N/A	Oct. 28, 2022	Oct. 27, 2023
11	Test Cable	N/A	R-01	N/A	N/A	Oct. 28, 2022	Oct. 27, 2023
12	Test Cable	N/A	R-02	N/A	N/A	Oct. 28, 2022	Oct. 27, 2023
13	Test Cable	N/A	R-03	N/A	N/A	Oct. 28, 2022	Oct. 27, 2023
14	Test Cable	N/A	RF-01	N/A	N/A	Oct. 28, 2022	Oct. 27, 2023
15	Test Cable	N/A	RF-02	N/A	N/A	Oct. 28, 2022	Oct. 27, 2023
16	Test Cable	N/A	RF-03	N/A	N/A	Oct. 28, 2022	Oct. 27, 2023
17	D.C. Power Supply	LongWei	TPR-6405D	N/A	N/A	\	\
18	EMC Software	Frad	EZ-EMC	Ver.EMC-CO N 3A1.1	N/A	\	\
19	Turntable	MF	MF-7802BS	N/A	N/A	\	\
20	Antenna tower	MF	MF-7802BS	N/A	N/A	\	\



3.CONDUCTED EMISSION AT THE MAINS TERMINALS TEST

3.1 Block Diagram Of Test Setup



3.2 Test Standard

FCC PART 15 B

3.3 Power Line Conducted Emission Limit

Frequency MHz	Limits dB(μV)	
	Quasi-peak Level	Average Level
0.15 ~ 0.50	66 ~ 56*	56 ~ 46*
0.50 ~ 5.00	56	46
5.00 ~ 30.00	60	50

Notes: 1. *Decreasing linearly with logarithm of frequency.
2. The lower limit shall apply at the transition frequencies.

3.4 EUT Configuration on Test

The following equipments are installed on conducted emission test to meet FCC PART 15 B requirement and operating in a manner which tends to maximize its emission characteristics in a normal application.

3.5 Operating Condition of EUT

- 3.5.1 Setup the EUT and simulators as shown in Section 3.1.
- 3.5.2 Turn on the power of all equipments.
- 3.5.3 Let the EUT work in test modes and test it.

3.6 Test Procedure

The EUT is put on the ground and connected to the AC mains through a Artificial Mains Network (AMN). This provided a 50ohm coupling impedance for the tested equipments. Both sides of AC line are checked to find out the maximum conducted emission levels according to the **FCC PART 15 B** regulations during conducted emission test.

The bandwidth of the test receiver (R&S Test Receiver ESCI) is set at 10KHz.

The frequency range from 150 KHz to 30 MHz is investigated.

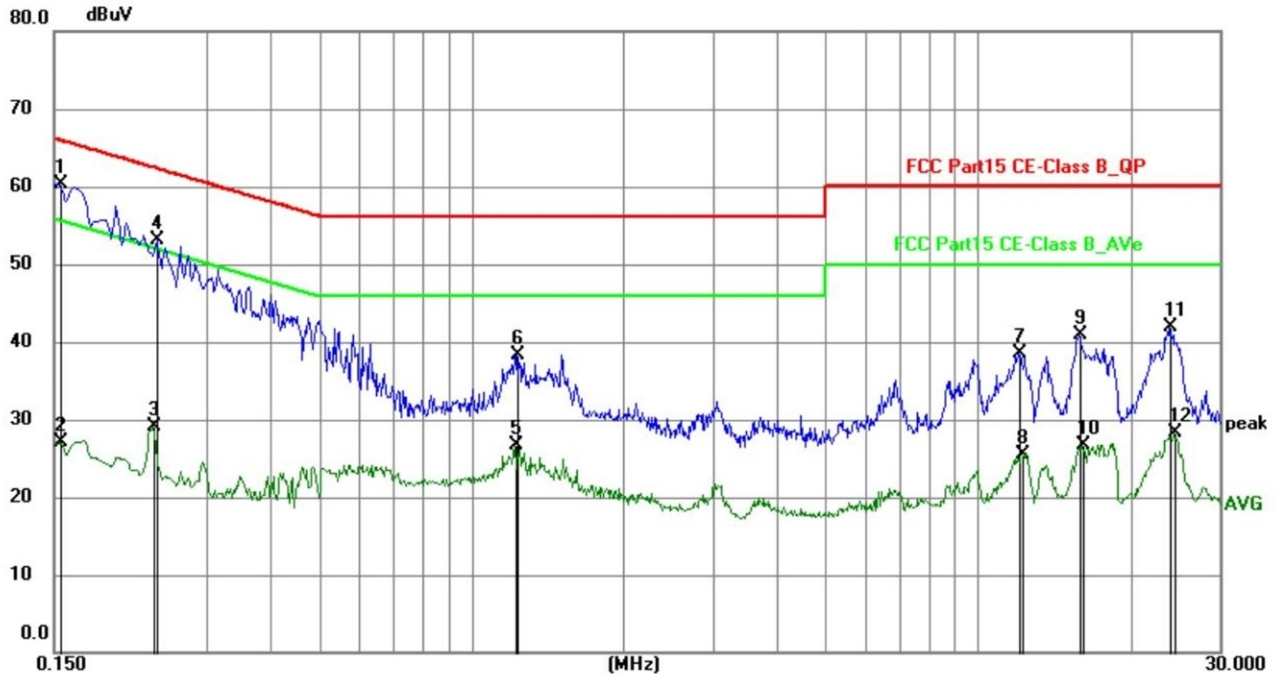
3.7 Test Result

PASS

Please refer to the following page.



Conducted Emission At The Mains Terminals Test Data			
Temperature:	24.5 °C	Relative Humidity:	54%
Pressure:	1009hPa	Phase :	Line
Test Voltage :	AC 120V/60Hz	Test Mode:	Working

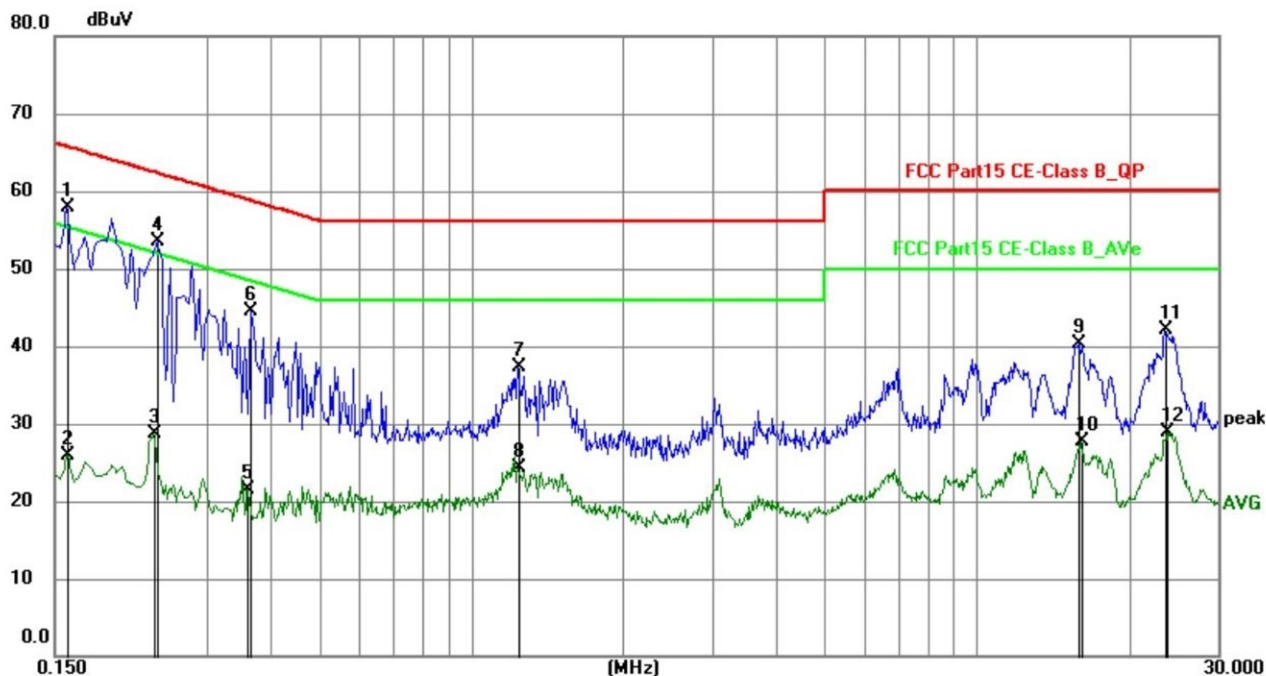


No.	Frequency (MHz)	Reading (dBuV)	Factor (dB)	Level (dBuV)	Limit (dBuV)	Margin (dB)	Detector	P/F	Remark
1	0.1544	39.80	20.50	60.30	65.76	-5.46	QP	P	
2	0.1544	6.55	20.50	27.05	55.76	-28.71	AVG	P	
3	0.2354	8.49	20.67	29.16	52.26	-23.10	AVG	P	
4	0.2400	32.44	20.67	53.11	62.10	-8.99	QP	P	
5	1.2163	5.94	20.77	26.71	46.00	-19.29	AVG	P	
6	1.2300	17.57	20.77	38.34	56.00	-17.66	QP	P	
7	12.0165	16.98	21.59	38.57	60.00	-21.43	QP	P	
8	12.2279	3.84	21.59	25.43	50.00	-24.57	AVG	P	
9	15.8505	19.22	21.61	40.83	60.00	-19.17	QP	P	
10	16.0800	5.03	21.61	26.64	50.00	-23.36	AVG	P	
11	23.9370	20.01	21.80	41.81	60.00	-18.19	QP	P	
12	24.4454	6.49	21.81	28.30	50.00	-21.70	AVG	P	



Conducted Emission At The Mains Terminals Test Data

Temperature:	24.5 °C	Relative Humidity:	54%
Pressure:	1009hPa	Phase :	Neutral
Test Voltage :	AC 120V/60Hz	Test Mode:	Working

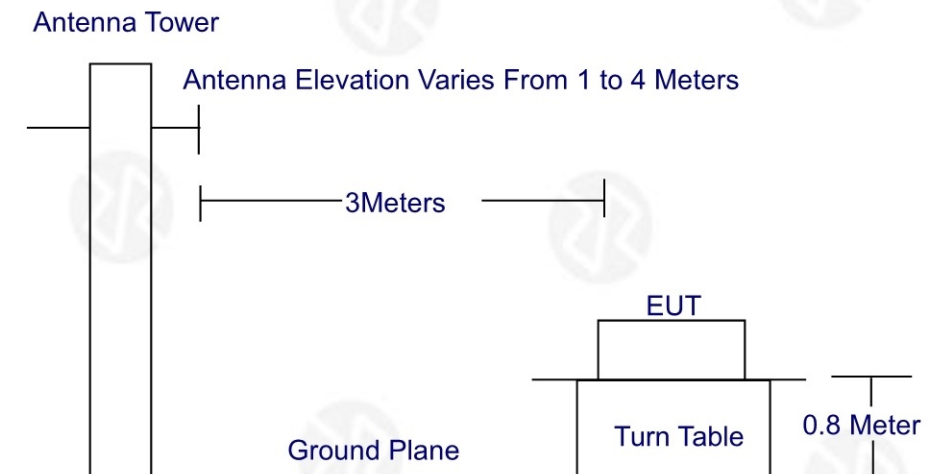


No.	Frequency (MHz)	Reading (dBuV)	Factor (dB)	Level (dBuV)	Limit (dBuV)	Margin (dB)	Detector	P/F	Remark
1	0.1590	37.23	20.62	57.85	65.52	-7.67	QP	P	
2	0.1590	5.21	20.62	25.83	55.52	-29.69	AVG	P	
3	0.2354	7.98	20.78	28.76	52.26	-23.50	AVG	P	
4	0.2400	32.78	20.78	53.56	62.10	-8.54	QP	P	
5	0.3614	0.84	20.74	21.58	48.70	-27.12	AVG	P	
6	0.3659	23.80	20.74	44.54	58.59	-14.05	QP	P	
7	1.2388	16.50	20.81	37.31	56.00	-18.69	QP	P	
8	1.2388	3.57	20.81	24.38	46.00	-21.62	AVG	P	
9	15.9224	18.76	21.53	40.29	60.00	-19.71	QP	P	
10	16.0620	6.08	21.53	27.61	50.00	-22.39	AVG	P	
11	23.5949	20.43	21.72	42.15	60.00	-17.85	QP	P	
12	23.8335	7.20	21.73	28.93	50.00	-21.07	AVG	P	



4.RADIATION EMISSION TEST

4.1 Block Diagram of Test Setup



4.2 Test Standard

FCC PART 15 B

4.3 Radiation Limit

FREQUENCY (MHz)	DISTANCE (Meters)	FIELD STRENGTHS LIMITS (dB μ V/m)
30 ~ 88	3	40.0
88 ~ 216	3	43.5
216 ~ 960	3	46.0
960 ~ 1000	3	54.0

4.4 EUT Configuration on Test

The FCC PART 15 B regulations test method must be used to find the maximum emission during radiated emission test. The configuration of EUT is the same as used in conducted emission test. Please refer to Section 2.2.

4.5 Operating Condition of EUT

Same as conducted emission test, which is listed in Section 2.2 except the test set up replaced as Section 4.1.

4.6 Test Procedure

The EUT and its simulators are placed on a turned table that is 0.8 meter above the ground. The turned table can rotate 360 degrees to determine the position of the maximum emission level. The EUT is set 3 meters away from the receiving antenna that is mounted on the antenna tower. The antenna can move up and down between 1 meter and 4 meters to find out the maximum emission level. Broadband antenna (calibrated biconical and log periodical antenna) is used as receiving antenna. Both horizontal and vertical polarization of the antenna is set on test. In order to find the maximum emission levels, the interface cable must be manipulated according to FCC PART 15 B on radiated emission test.

The bandwidth setting on the field strength meter (R&S Test Receiver ESCI) is set at 120KHz below 1GHz, set at 1MHz above 1GHz. The frequency range from 30MHz to 1000MHz is checked. The highest frequency of the internal sources of the EUT was below 108MHz, so the measurement was only made up to 1GHz.



4.7 Test Result

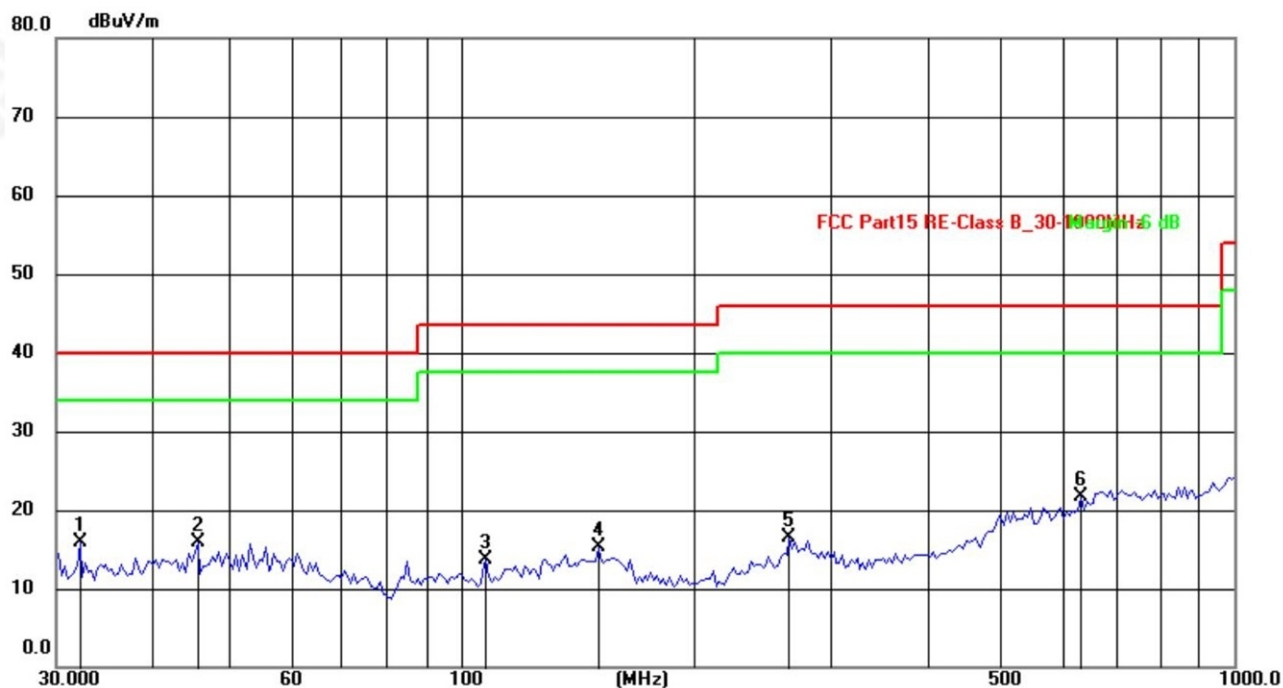
PASS

Please refer to the following page.



Radiation Emission Test Data

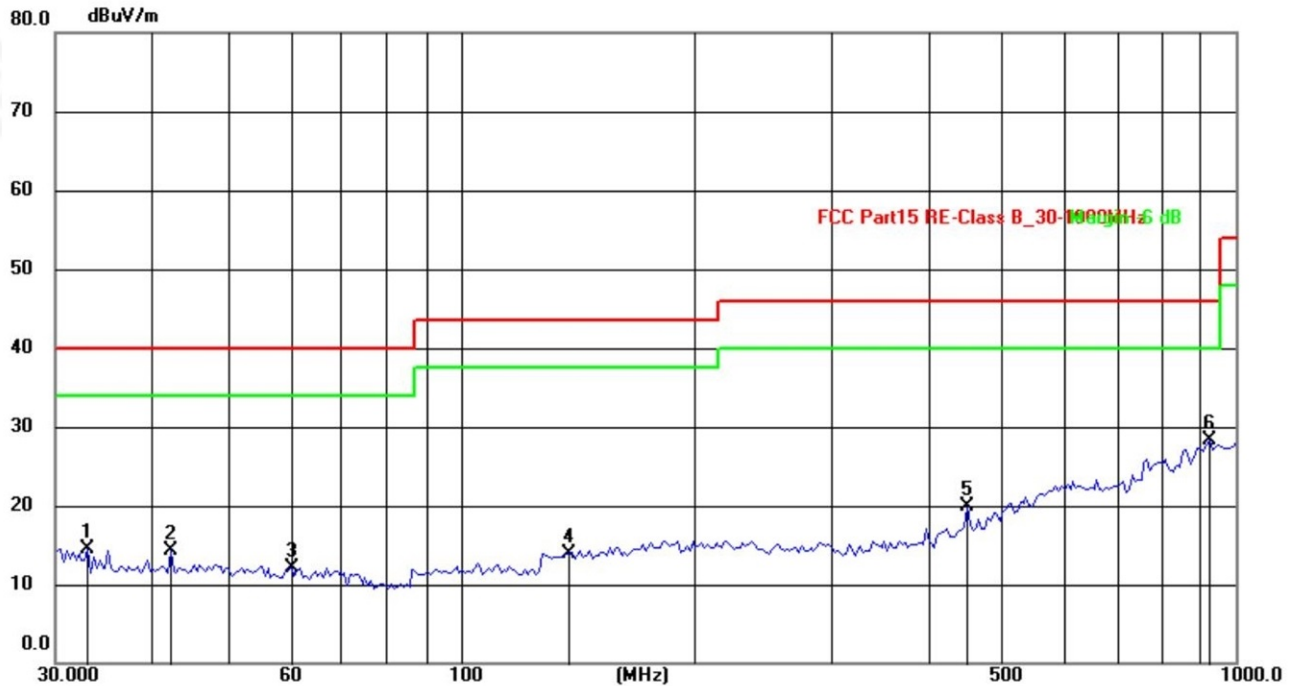
Temperature:	26°C	Relative Humidity:	54%
Pressure:	1009hPa	Phase :	Horizontal
Test Voltage :	AC 120V/60Hz	Test Mode:	Working



No.	Frequency (MHz)	Reading (dBuV)	Factor (dB/m)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Height (cm)	Azimuth (deg.)	P/F	Remark
1	32.1794	30.50	-14.58	15.92	40.00	-24.08	QP				
2	45.6946	30.00	-14.08	15.92	40.00	-24.08	QP				
3	107.8876	33.07	-19.33	13.74	43.50	-29.76	QP				
4	150.5377	31.93	-16.54	15.39	43.50	-28.11	QP				
5	266.1419	31.59	-15.18	16.41	46.00	-29.59	QP				
6	633.9071	29.76	-8.10	21.66	46.00	-24.34	QP				



Radiation Emission Test Data			
Temperature:	26℃	Relative Humidity:	54%
Pressure:	1009hPa	Phase :	Vertical
Test Voltage :	AC 120V/60Hz	Test Mode:	Working

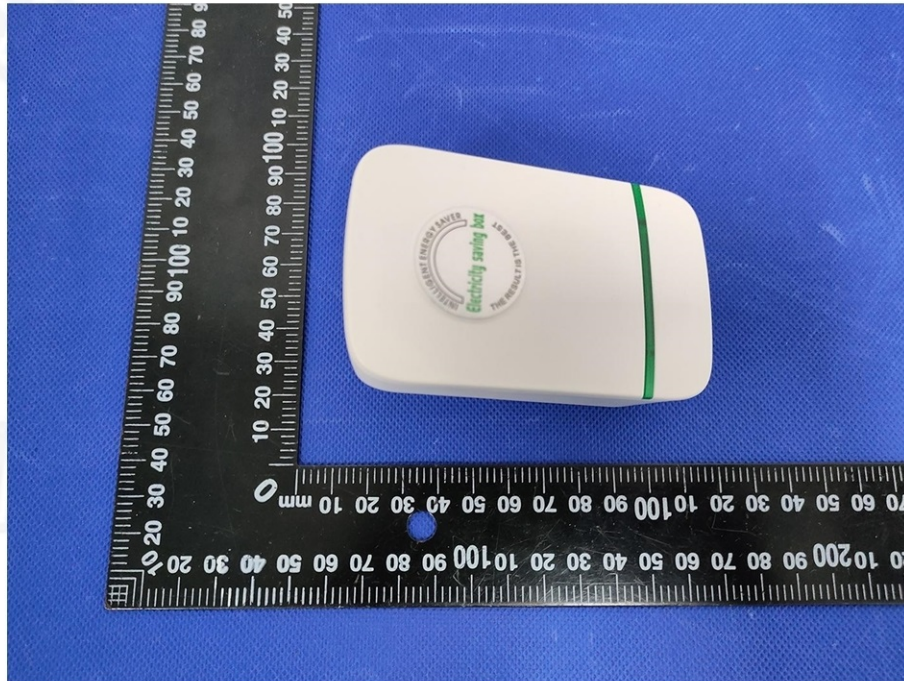


No.	Frequency (MHz)	Reading (dBuV)	Factor (dB/m)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Height (cm)	Azimuth (deg.)	P/F	Remark
1	33.0369	32.37	-17.93	14.44	40.00	-25.56	QP				
2	42.2280	31.22	-16.96	14.26	40.00	-25.74	QP				
3	60.4917	30.45	-18.36	12.09	40.00	-27.91	QP				
4	137.9028	34.92	-20.97	13.95	43.50	-29.55	QP				
5	450.3446	33.28	-13.30	19.98	46.00	-26.02	QP				
6	924.1345	28.96	-0.61	28.35	46.00	-17.65	QP				



5.EUT PHOTOGRAPHS

EUT photo 1

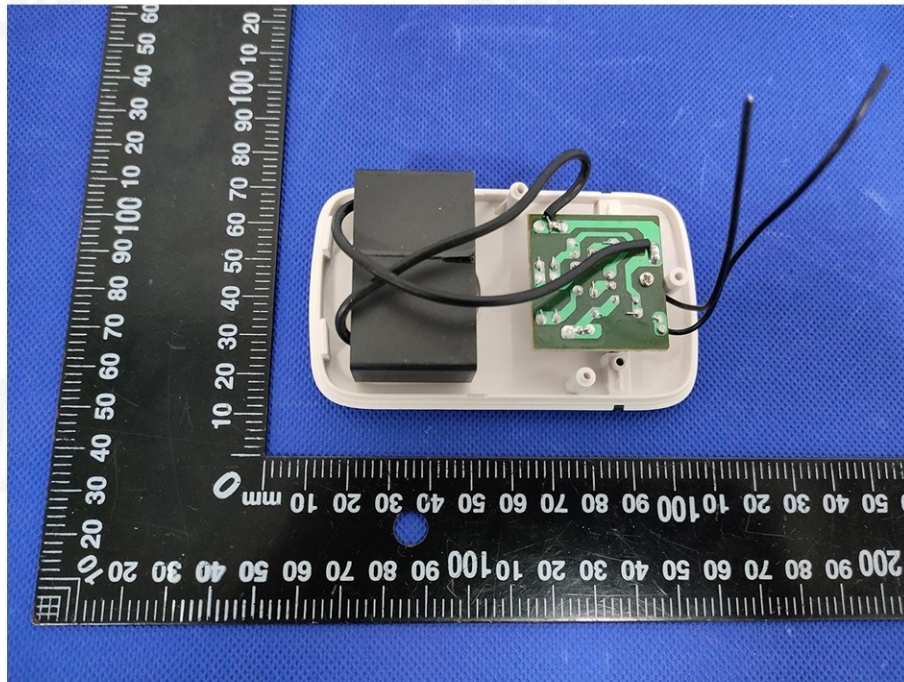


EUT photo 2

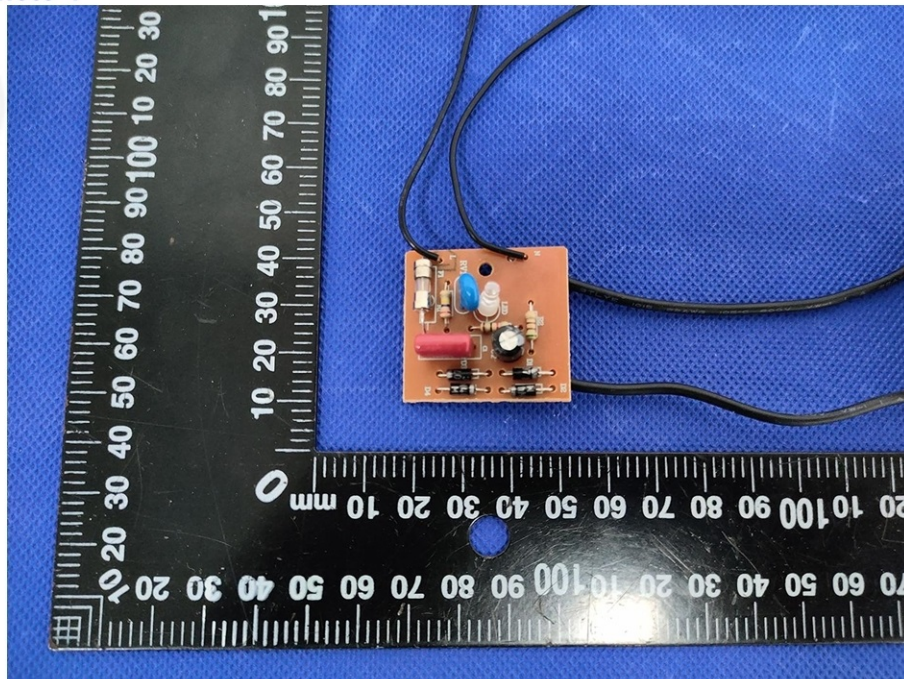




EUT Photo 3

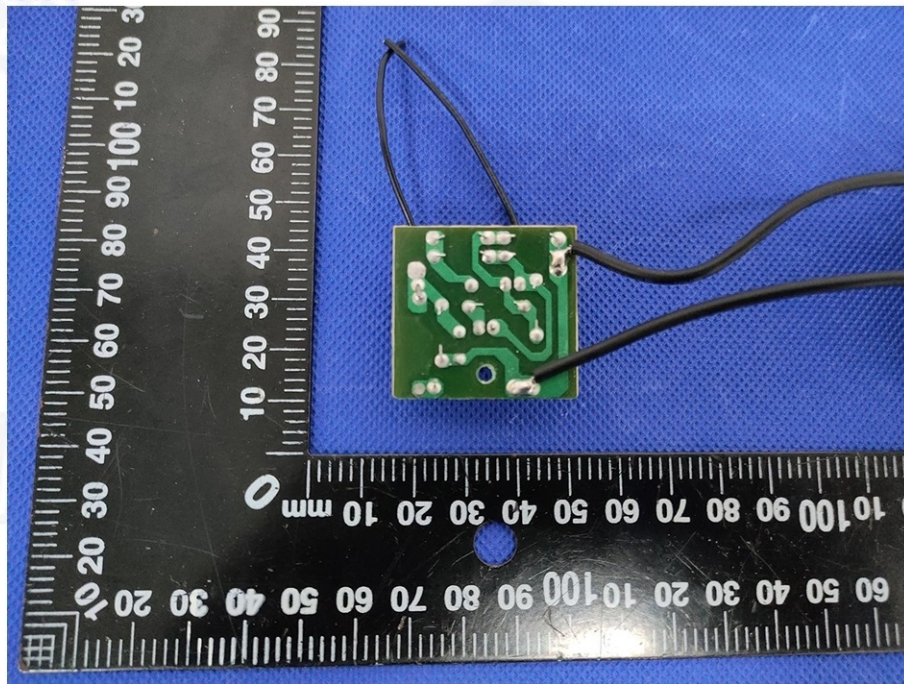


EUT Photo 4





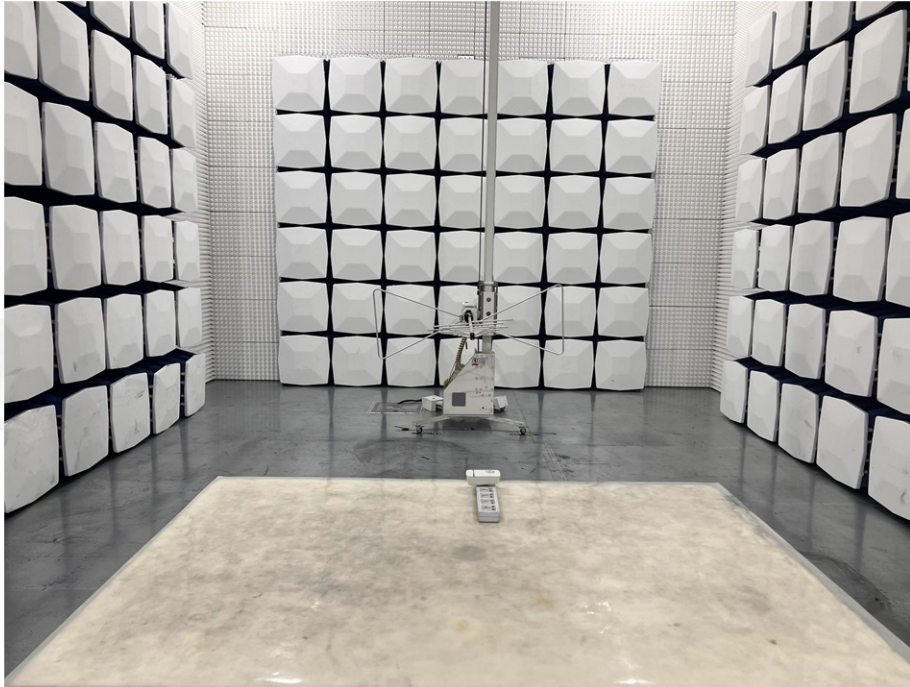
EUT Photo 5





6.EUT TEST PHOTOGRAPHS

RE



CE



***** END OF REPORT *****

Shenzhen ZKT Technology Co., Ltd.

1/F, No. 101, Building B, No. 6, Tangwei Community Industrial Avenue,
Fuhai Street, Bao'an District, Shenzhen, China



Certificate of Compliance

Certificate Number: ZKT-2305243786C

Certificate's Holder : Dongguan Wednesday Technology Co.,Ltd.
Room 301,Building 2,No.142,Middle Sili Road,Tangxia
Town, Dongguan City, Guangdong Province

Manufacturer : Dongguan Wednesday Technology Co.,Ltd.
Room 301,Building 2,No.142,Middle Sili Road,Tangxia
Town, Dongguan City, Guangdong Province

Trade Mark : N/A

Product : Power saver

Model(s) : SD008
SD001,SD002,SD003,SD004,SD005,SD006,SD007,SD009,
SD010

Test Method : IEC 62321-5:2013& IEC 62321-4:2013+A1:2017&
IEC 62321-7-2:2017& IEC 62321-6:2015& IEC 62321-8:2017
&IEC 62321-3-1:2013 & IEC 62321-7-1:2015

The following products have been tested by us and found in conformity with the (RoHS) Directive 2011/65/EU Annex II amending Annex (EU)2015/863 and amending Annex (EU)2017/2102. It is possible to use CE Marking to demonstrate the conformity with this Directive.It is only valid in connection with the test report number: ZKT-2305243786R.

RoHS



This Certificate of Conformity is based on single evaluation of the submitted sample(s) of the above mentioned product. It does not imply an assessment of the whole product and relevant Directives to be observed.



ROHS TEST REPORT

Report Reference No......: **ZKT-2305243786R**

Date of issue.....: May. 30, 2023

Total number of pages..... 11

Testing Laboratory.....: **Shenzhen ZKT Technology Co., Ltd.**

Address.....: 1/F, No. 101, Building B, No. 6, Tangwei Community Industrial Avenue, Fuhai Street, Bao'an District, Shenzhen, China

Applicant's name.....: **Dongguan Wednesday Technology Co.,Ltd.**

Address.....: Room 301,Building 2,No.142,Middle Sili Road,Tangxia Town, Dongguan City, Guangdong Province

Manufacturer's name: **Dongguan Wednesday Technology Co.,Ltd.**

Address: Room 301,Building 2,No.142,Middle Sili Road,Tangxia Town, Dongguan City, Guangdong Province

Test Requested:

Conclusion

- (1) RoHS Directive 2011/65/EU Annex II amending Annex (EU)2015/863 and amending Annex (EU)2017/2102
—Lead, Cadmium, Mercury, Hexavalent Chromium, PBBs and PBDEs Content
—Di-(2-ethylhexyl) phthalate(DEHP), Benzylbutyl phthalate(BBP), Dibutyl phthalate (DBP), Diisobutyl phthalate(DIBP) Content

PASS

Test Report Form No.....: --

Test Report Form(s) Originator.....: ZKT Testing

Master TRF.....: Dated: 2017-06

This test report is specially limited to the above client company and product model only. It may not be duplicated without prior written consent of ZKT Test.

Test item description.....: **Power saver**

Trade Mark : N/A

SD008

Model/Type reference.....: SD001,SD002,SD003,SD004,SD005,SD006,SD007,SD009, SD010

**Testing procedure and testing location:****Testing Laboratory.....: Shenzhen ZKT Technology Co., Ltd.****Address.....: 1/F, No. 101, Building B, No. 6, Tangwei Community
Industrial Avenue, Fuhai Street, Bao'an District,
Shenzhen, China**
-----**Date of Test.....: May. 24, 2023- May. 30, 2023**
-----**Tested by (name + signature).....: Doris Zhan**
-----**Reviewer (name + signature).....: Simon Gong**
-----**Approved (name + signature).....: Awen He**
-----



2. Test Item Description And Photo List

Sample No.	Description
001	Black plastic
002	WHITE PLASTIC
003	PCB
004	IC
005	TIN
006	SMD DIODE
007	METALLIZED FILM CAPACITOR
008	black wire
009	FUSE
010	ALUMINUM ELECTROLYTIC CAPACITORS
011	Color ring inductance
012	y capacitOR
013	Screw



3. Test Results

3.1 Screening test for the specified hazardous substances of RoHS for the selected materials of the submitted sample:

- Heavy Metal (Cadmium, Chromium, Mercury, Lead) Content Test
- Bromine Content Test

According to IEC 62321-3-1:2013, and Quantification analyzed with Energy Dispersive X-ray Fluorescence Spectrometers.

Sample No.	Total Cadmium	Total Lead	Total Mercury	Total Chromium	Total Bromine
Sample 001	BL	BL	BL	BL	BL
Sample 002	BL	BL	BL	BL	BL
Sample 003	BL	BL	BL	BL	BL
Sample 004	BL	BL	BL	BL	BL
Sample 005	BL	BL	BL	BL	N.A.
Sample 006	BL	BL	BL	BL	BL
Sample 007	BL	BL	BL	BL	BL
Sample 008	BL	BL	BL	BL	BL
Sample 009	BL	BL	BL	BL	BL
Sample 010	BL	BL	BL	BL	BL
Sample 011	BL	BL	BL	BL	BL
Sample 012	BL	BL	BL	BL	BL
Sample 013	BL	BL	BL	BL	N.A.

Note:

All Concentrations express in “mg/kg” (milligram per kilogram), mg/kg ~ ppm

“OL” denotes “over limit”

“BL” denotes “below limit”

“N.A.” denotes “Not Applicable”

“Inconclusive” denotes result is intermediate between “OL” and “BL”

“A” denotes the screening result was inconclusive(X) or over limit (OL), thus further confirmation test was conducted, results are listed in 3.2 and 3.3.



XRF screening limits for different materials:

Materials	Concentration (mg/kg)				
	Cd	Cr	Pb	Hg	Br
Metal	$BL \leq (70-3\sigma) < X < (130+3\sigma) \leq OL$	$BL \leq (700-3\sigma) < X$	$BL \leq (700-3\sigma) < X < (1300+3\sigma) \leq OL$	$BL \leq (700-3\sigma) < X < (1300+3\sigma) \leq OL$	N.A.
Polymers	$BL \leq (70-3\sigma) < X < (130+3\sigma) \leq OL$	$BL \leq (700-3\sigma) < X$	$BL \leq (700-3\sigma) < X < (1300+3\sigma) \leq OL$	$BL \leq (700-3\sigma) < X < (1300+3\sigma) \leq OL$	$BL \leq (300-3\sigma) < X$
Composite material	$BL \leq (50-3\sigma) < X < (150+3\sigma) \leq OL$	$BL \leq (500-3\sigma) < X$	$BL \leq (500-3\sigma) < X < (1500+3\sigma) \leq OL$	$BL \leq (500-3\sigma) < X < (1500+3\sigma) \leq OL$	$BL \leq (250-3\sigma) < X$



3. 2 Test for Heavy Metals

Lead, Cadmium, Hexavalent Chromium and Mercury Tests according to IEC 62321-4:2013+A1:2017 & IEC 62321-5:2013 & IEC 62321-7-1:2015 & IEC 62321-7-2:2017, Analysis was conducted by ICP-OES, UV-VIS.

Element	Total Cadmium [mg/kg]	Total Lead [mg/kg]	Total Mercury [mg/kg]	Hexavalent Chromium [µg/cm ²]	Hexavalent Chromium [mg/kg]
Detection Limit	5	5	5	0.10	5
Limit	100	1000	1000	0.10	1000

Note:

1. All Concentrations express in “mg/kg”(milligram per kilogram), mg/kg ~ ppm.

2. “N.D.” = “Not Detected”.

3. Boiling-water-extraction:

Negative = Absence of Cr(VI) coating / surface layer: the detected concentration in boiling-water-extraction solution is less than 0.10µg with 1cm² sample surface area. Positive = Presence of Cr(VI) coating / surface layer: the detected concentration in boiling-water-extraction solution is greater than 0.13µg with 1cm² sample surface area.

Inconclusive = the detected concentration in boiling-water-extraction solution is greater than 0.10µg and less than 0.13µg with 1cm² sample surface area.

4. Positive = result be regarded as not comply with RoHS requirement

Negative = result be regarded as comply with RoHS requirement

5. “-” = Not regulated



3. 3 Test for Flame retardants

Test Method: With reference to IEC 62321-6:2015, extracted by toluene and analyzed by Gas Chromatography and Mass Spectrometry (GC-MS). [Reporting Limit: 5mg/kg]

Test Item		Result [mg/kg]	RoHS Requirement [mg/kg]
		Sample 003	
PBBs	Monobromobiphenyl	< 5	Sum of PBBs < 1000
	Dibromobiphenyl	< 5	
	Tribromobiphenyl	< 5	
	Tetrabromobiphenyl	< 5	
	Pentabromobiphenyl	< 5	
	Hexabromobiphenyl	< 5	
	Heptabromobiphenyl	< 5	
	Octabromobiphenyl	< 5	
	Nonabromobiphenyl	< 5	
	Decabromobiphenyl	< 5	
	Sum of PBBs	< 5	
PBDEs	Monobromodiphenyl Ether	< 5	Sum of PBDEs < 1000
	Dibromodiphenyl Ether	< 5	
	Tribromodiphenyl Ether	< 5	
	Tetrabromodiphenyl Ether	< 5	
	Pentabromodiphenyl Ether	< 5	
	Hexabromodiphenyl Ether	< 5	
	Heptabromodiphenyl Ether	< 5	
	Octabromodiphenyl Ether	< 5	
	Nonabromodiphenyl Ether	< 5	
	Decabromodiphenyl Ether	< 5	
	Sum of PBDEs	< 5	

Note:

1. All Concentrations express in "mg/kg" (milligram per kilogram), mg/kg ~ ppm.
2. "<" denotes less than



3.4 Di-(2-ethylhexyl) phthalate(DEHP), Benzylbutyl phthalate(BBP), Dibutyl phthalate (DBP), Diisobutyl phthalate (DIBP) Content—RoHS Directive 2011/65/EU Annex II amending Annex (EU)2017/2102

Test method: With reference to IEC 62321-8:2017; Analysis was conducted by GC-MS.

Element	Di-(2-ethylhexyl) phthalate (DEHP) [mg/kg]	Benzylbutyl phthalate (BBP) [mg/kg]	Dibutyl phthalate (DBP) [mg/kg]	Diisobutyl phthalate(DIBP) [mg/kg]
Detection Limit	50	50	50	50
Limit	1000	1000	1000	1000
Sample 001	N.D.	N.D.	N.D.	N.D.
Sample 002	N.D.	N.D.	N.D.	N.D.
Sample 003	N.D.	N.D.	N.D.	N.D.
Sample 004	N.D.	N.D.	N.D.	N.D.
Sample 006	N.D.	N.D.	N.D.	N.D.
Sample 007	N.D.	N.D.	N.D.	N.D.
Sample 008	N.D.	N.D.	N.D.	N.D.
Sample 009	N.D.	N.D.	N.D.	N.D.
Sample 010	N.D.	N.D.	N.D.	N.D.
Sample 011	N.D.	N.D.	N.D.	N.D.
Sample 012	N.D.	N.D.	N.D.	N.D.

Note:

All Concentrations express in “mg/kg”(milligram per kilogram), mg/kg ~ ppm.

“N.D.” = “Not Detected”.



ANNEX A: Photo-documentation

EUT photo 1

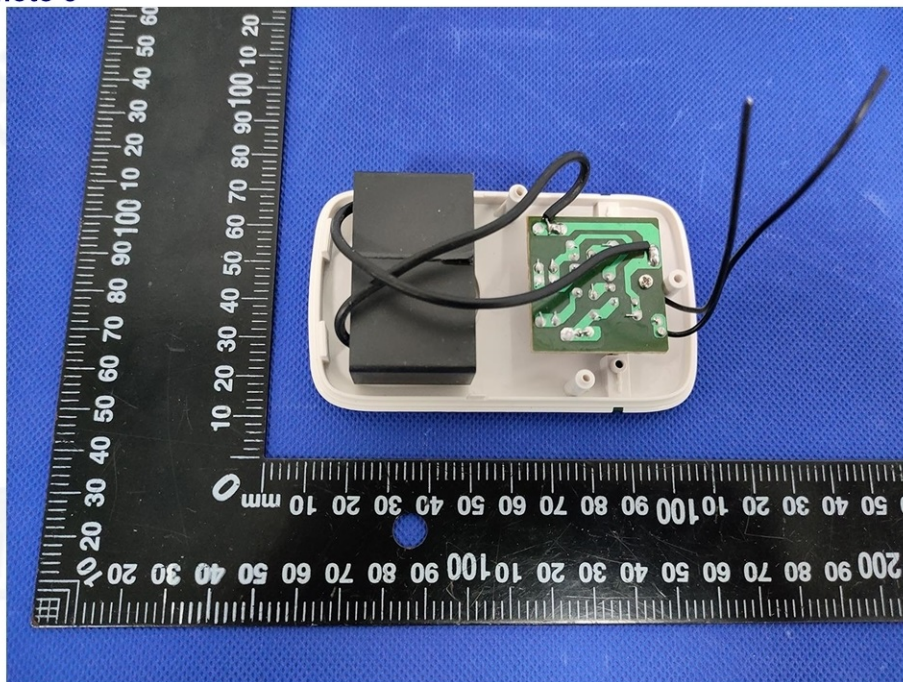


EUT photo 2

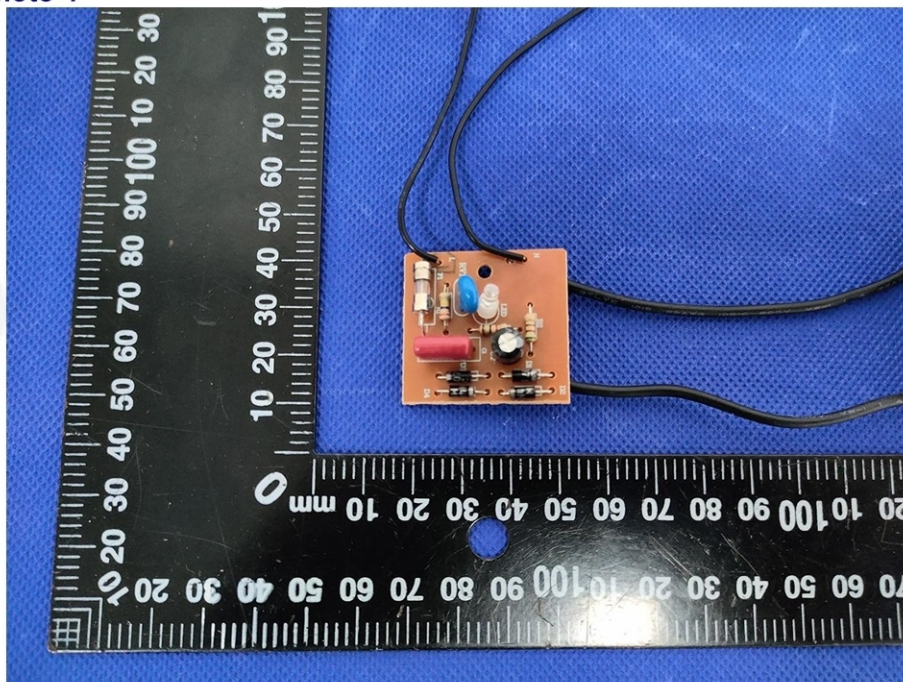




EUT Photo 3

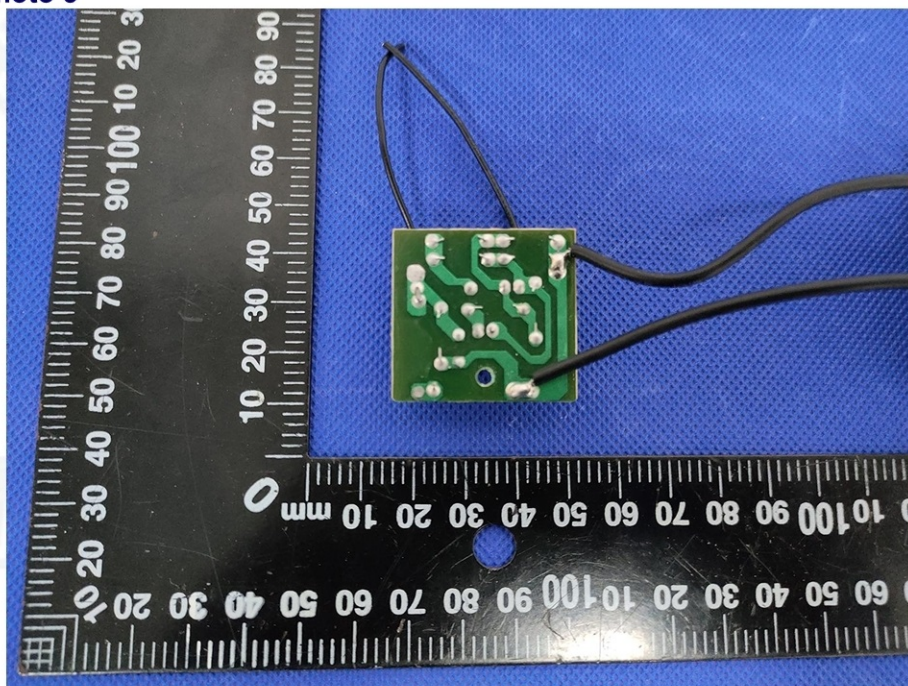


EUT Photo 4





EUT Photo 5



***** END OF REPORT*****