

Mains Protection Unit (MPU)

Product Description

MPU is designed as an advanced “Mains Protection Unit” device, mainly dedicated for household appliance protection. The product is designed for domestic use mainly but not limited to this field only. Device functions are designed for “Effective Protection of the Load”, which protects the load against most common disturbances from the mains power feed line.



The device provides high degree of reliable protection for general household appliances in domestic applications. Device is equipped with some special features, which increases the level of protection;

- Voltage and frequency range protection
- Phase polarity swap
- Earth connection loss
- Burst and surge suppression from mains side
- Brown-out time delay
- Power-on time delay
- High temperature protection on plug pin connection
- Time reset button
- Multicolor status and alarms indicator

The device is designed as a wall-mount protection unit, which plugs into standard wall type socket in domestic buildings. It is designed with standard earthed socket, where live and neutral polarity is also continuously monitored.

For applications, where there is not enough room at the back of the appliance and the wall socket, another model is also produced with a short cable, which allows the customer to extend the device without using additional extension cables, which may reduce the degree of protection under working conditions.

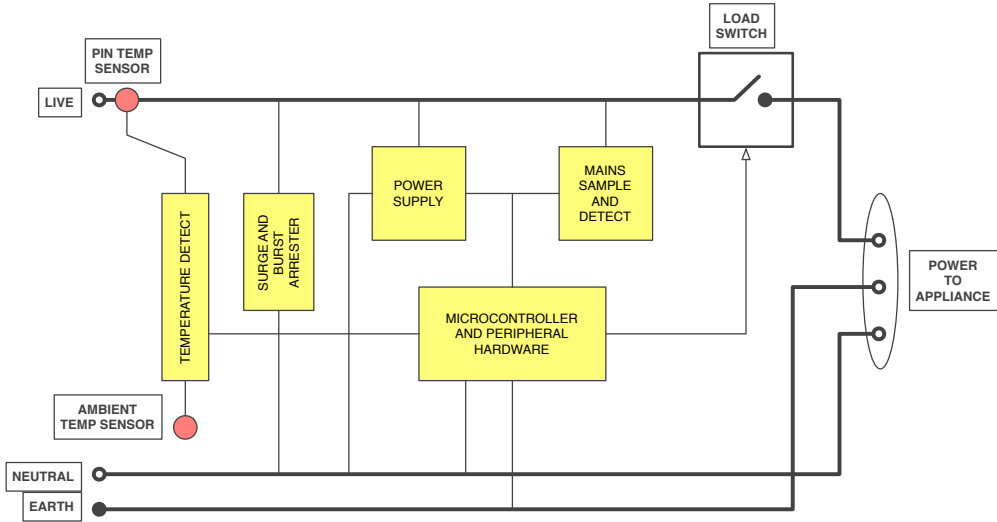
MPU also provides effective protection for all office equipment commonly used in today's offices. Since the device also provides a degree of protection against atmospheric discharge and lightning protection, this is particularly beneficiary for all office equipment, including PC and communication equipment. Effective transient protection functions of the device can provide safe operation of office equipment under all conditions.

Device EMC compliance is designed to meet "Light Industry" emissions standards therefore; device can safely be used with communication equipment without causing any disturbance, which reduces the quality of use of such equipment.

Circuit design concept:

Protection device electronic design concept is based on latest generation microcontroller applications, where instruction execution speed is very high. This allows the device, to execute more sophisticated software algorithms, in order to capture narrow transients and at the same time, make more accurate measurements on the mains voltage waveform to even calculate the harmonics of the supply feed to appliance load.

Components used in the design are specially chosen for this particular application, where reliability is kept at its highest level, even at extreme conditions. Device specifications are kept very wide and high design tolerances are accepted in order to allow reliable operation at device limits. Also, average operating temperature gradient of stressed components are kept as low as possible so that, device MTBF is maximized.



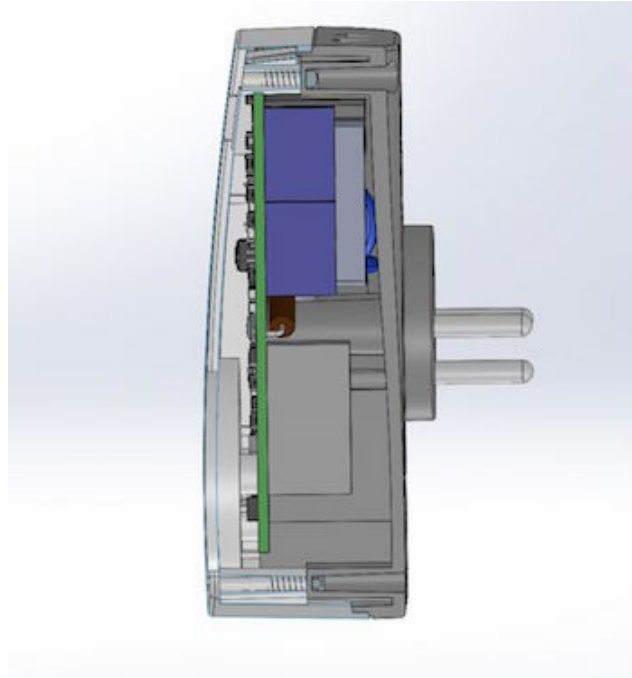
MPU block diagram

Design limits of the device is based on “Electrical Safety Regulations for household appliances” and protection limits are set according to these standards. The device does not intend to guarantee “time critical” protection on mains voltage rise and dip but ensures load disconnection in less than 300mS (under worst case conditions).

MPU device monitors all voltages which the load is subject to and ensures that; if any one of these voltage values are above critical limits, the load is disconnected and will not connect back to the supply, unless the mains supply voltage stays within safe limits for a certain minimum amount of time.

The circuit assembly does not use any power cables within the device and this ensures safe and cool operation of the device under maximum load conditions. Power connections are made by fast-

on connections, without any solder joints. This also ensures low contact resistance and safer operating conditions.



Because bad contacts cause danger in the house, MPU device is equipped with sensitive temperature measuring hardware and special software algorithms in order to be able to monitor and detect such failures. Device is equipped with dual temperature sensing inputs, which also measures remote wall socket temperature in the cables extended version.

Device functions:

Device is equipped with a series of protection functions, which ensures high degree of protection for household appliances, up to 15Aac load current with AC1 class switching and 7Aac with AC2 class switching.

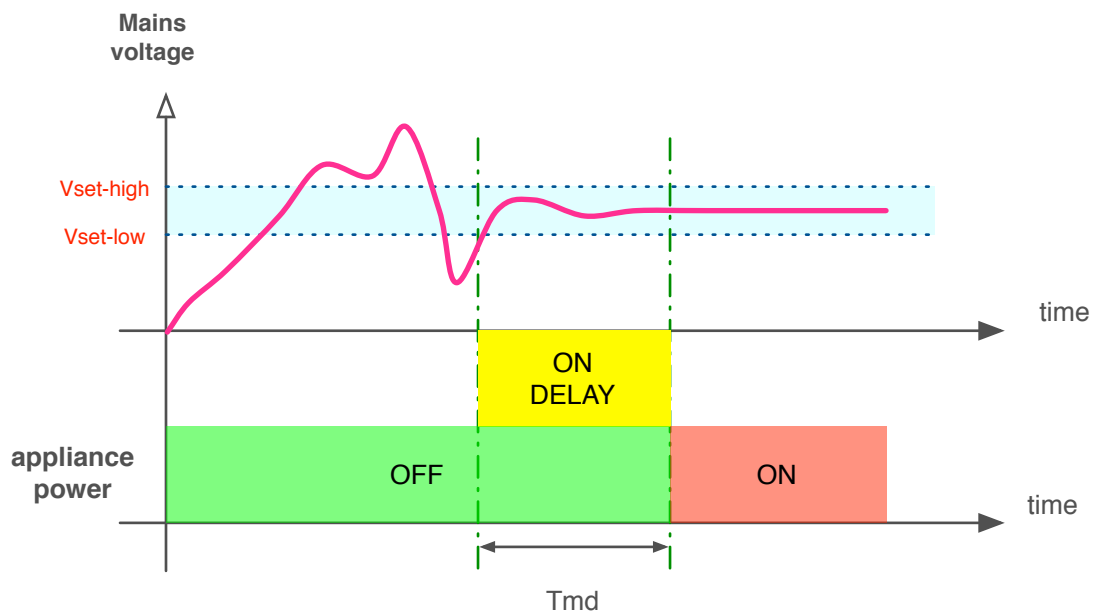
Device functions are described below for technical reference only. Accurate technical specifications can be found in the “Technical Specifications” section of this document.

“POWER-ON” DELAY PROTECTION:

MPU is normally an “open circuit” device, where the power relay is normally at “de-energized” state (contacts are open). The device remembers this state when it is plugged into the wall socket.

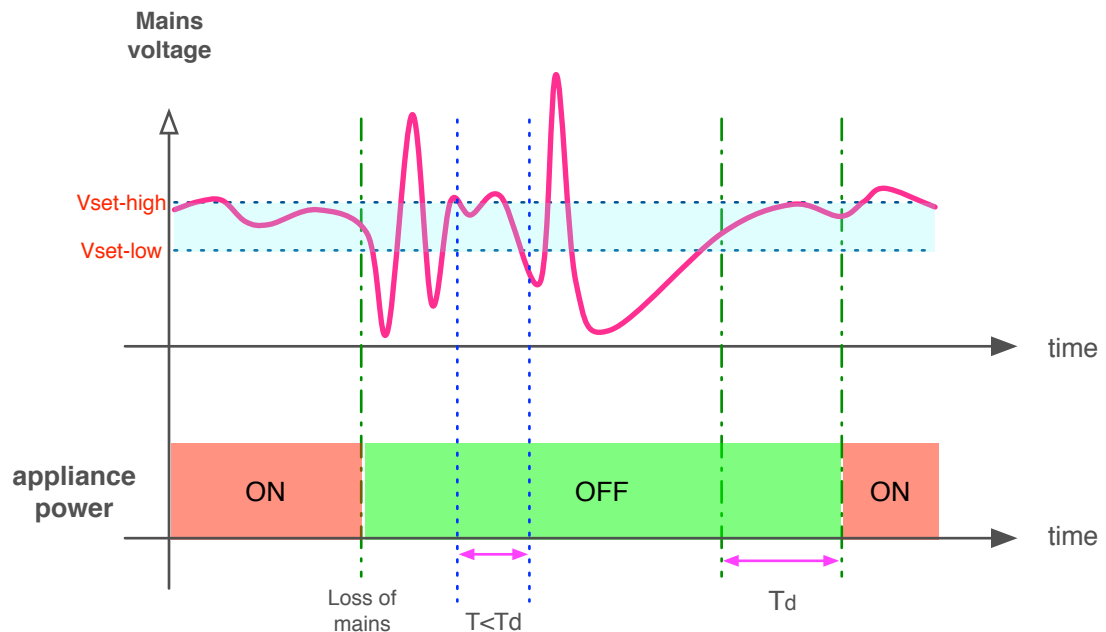
Therefore; when the device is connected to the wall socket, load does not connect to mains supply immediately. After device detects stable mains supply stable conditions, load is connected to the supply, after T_{md} delay time period. During this time period, if mains supply falls out of set limits, T_{md} is reset and same delay is timed again.

The function description is shown in the following graphics;



VOLTAGE PROTECTION:

MPU device has a built-in voltage monitoring hardware and related software for precisely measuring the mains supply volts to the load.



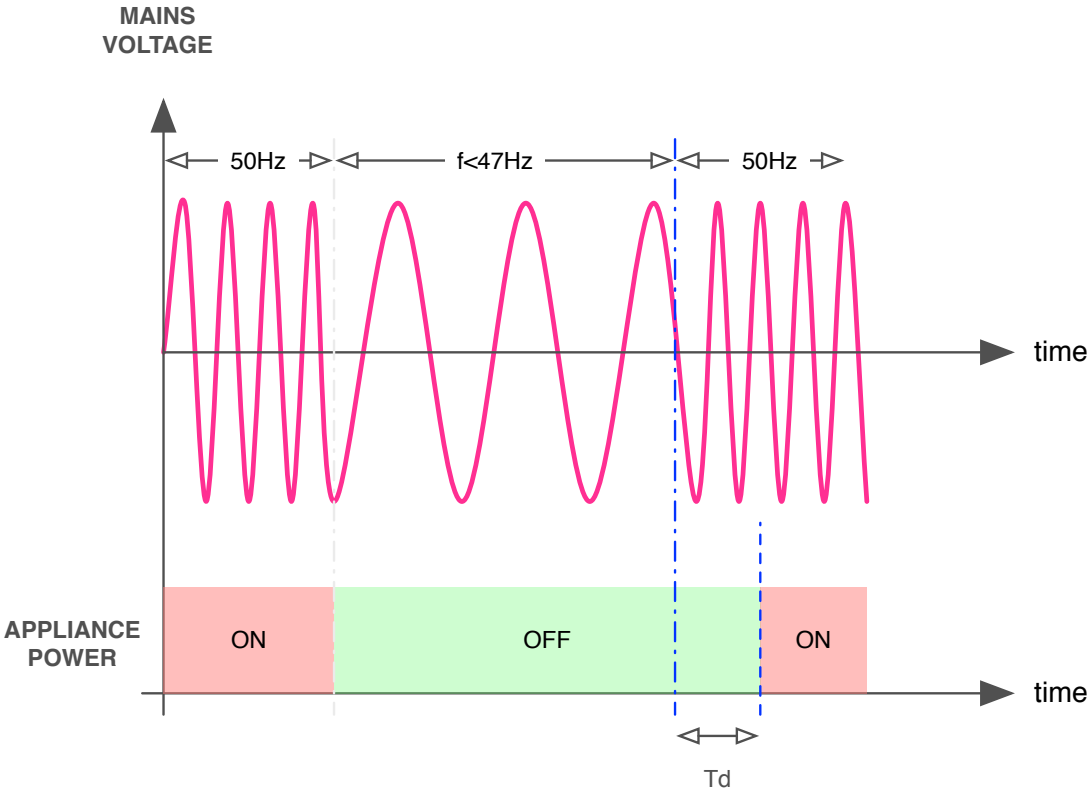
As shown in the above graphical representation of mains supply voltage behavior, appliance power is disconnected as soon as supply voltage falls outside the set limits and will not be connected back, before the voltage settles within the set limits for a time delay of T_d seconds. This ensures that; dangerous transient voltages cannot reach the load during “unstable” duration of mains supply line.

Voltage sensing inputs of the device can operate and control up to 500Vac rms between phase and neutral lines. In order to avoid multiple disconnections of the load from supply, device will allow a 2 second delay before the load is disconnected from the supply line. This delay is only active within set “Low” and “High” voltage limits of device, if supply voltage limits go beyond these limits, device will disconnect the load in less than 200mS. (this is not shown in the above diagram for clarity)

FREQUENCY PROTECTION:

The device is also equipped with a “Supply Frequency Monitoring” function, which disconnects the load from Mains Supply line, if the supply frequency abnormally changes. Sudden change in supply frequency cannot happen under normal operating conditions. If the load is being fed from a diesel generator, the supply frequency can vary suddenly and this will mean an engine malfunction. Eventually, such a disturbance will also cause bad effects on the supply voltage, which can damage the load, if not disconnected from its supply line.

Therefore; frequency protection also becomes a “critical” protection function for household appliances. The function is graphically shown below for a reduced frequency, which is usually the case for supply feed;



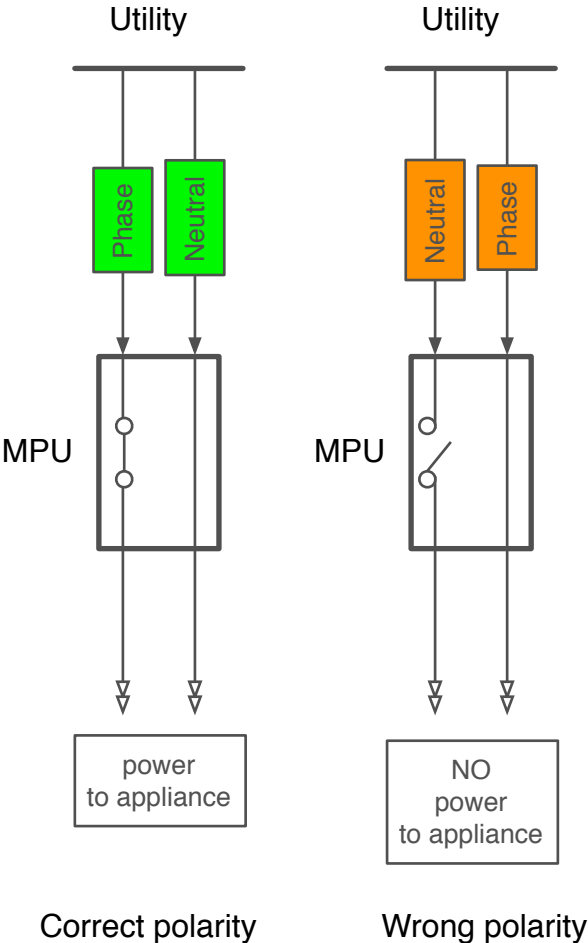
Frequency protection function also has a built-in time delay, which prevents the load to be connected to supply, even if the supply frequency falls within the set limits. This time delay is factory set and cannot be changed.

MAINS POLARITY DETECTION AND PROTECTION:

Usually, most appliances are not sensitive to live and neutral polarity of the mains supply. This is because; many appliances have an internal power supply, which also compensates for the wrong connection.

But some appliances use the live connection for its internal distributed systems and sometimes this may cause problem because they are polarity sensitive. For such appliances, connecting phase and neutral lines may cause danger to the appliance and also to humans.

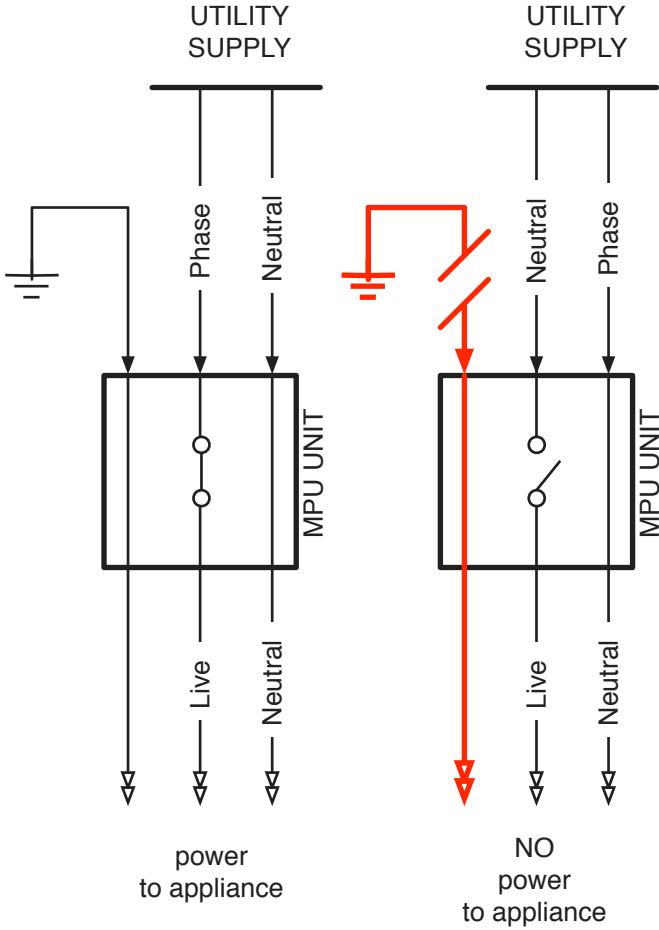
For safe application, wall socket live and neutral line connections should never change place and this should be common practice for all household installations. MPU device is equipped with necessary hardware and software to detect connection polarity on the wall outlet and will not allow the load to be connected, if the polarity is changed or wrong. The function is shown in the below representation:



EARTH FAULT PROTECITON:

Earth connection is one of the most common faults that can be seen on household power installation. Failing to provide a healthy “Earth” connection to the load can sometime cause severe damage to the user or pets in the houses and around the office environment.

Due to this serious risk; MPU protection device employs a special algorithm to securely monitor and control the earth line connection on the wall socket. If the earth line is somehow disconnected from supply side or earth connection quality is reduced (bad earth connection), then this conditions is immediately detected and load is securely disconnected from the supply line.

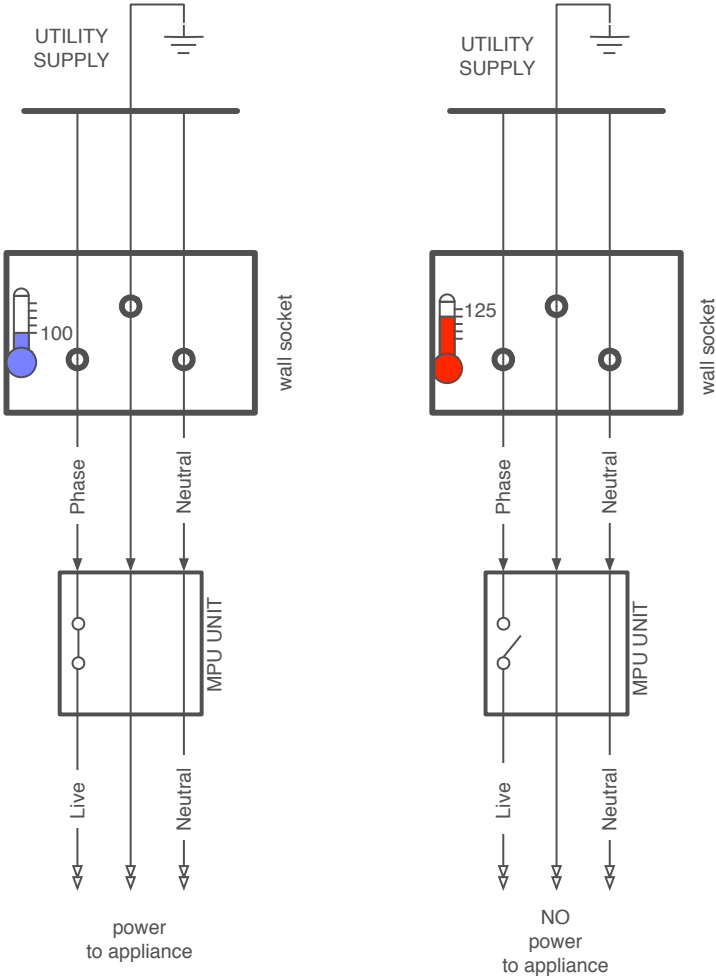


Since the device also continuously monitors and controls mains polarity, disconnecting live terminal is safe to remove the risk of having electric shock at the load side. Load will not be connected to supply line until earth fault condition is removed from the wall socket.

HIGH TEMPERATURE PROTECTION:

One of the most common causes of fire in the house is because the wall socket terminals are diminished and bad terminal surface quality causes high insertion losses, which in turn causes arcing and contact temperatures can go up so high that; installation can catch fire.

MPU protection device takes this condition very seriously and brings a very reliable and effective protection against sudden rise of pin contact temperature.



Pin contact temperature in the wall socket is monitored in the MPU device precisely. Rate of rise of temperature is monitored as well as maximum pin temperature and of these values reach beyond set limits, MPU immediately disconnects the load from mains supply and will not switch back on, until the device is “reset” externally.

This behavior of MPU ensures that; user attends the protection device and controls the wall socket before being able to connect the load back to mains supply. If this condition insists, MPU will repeat the above sequence indefinitely.

TEMPERATURE MEASUREMENT WITH CABLE AND PLUG:

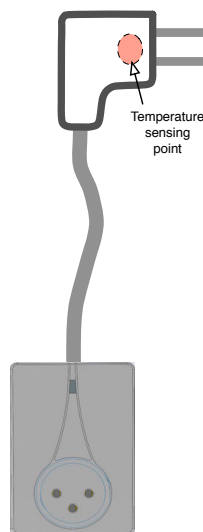
MPU is designed as two models;

- 1- “Direct plug-in” to fit into the wall socket
- 2- “Cable extended” model (30cm in length) for narrow space use

Both models have the same specifications; only difference between the two is the extension cable at power input side of the MPU device.

Both models carry the same features and protection functions, but cable version has an additional feature, which is unique to this kind of “Mains Protection Devices” and this innovation is documented and WIPO patent application is initiated.

Since MPU device has an integrated extension cable, measuring wall socket terminal temperature becomes an important feature of the device, which requires a special plug to be designed. The device measures its own internal temperature, as well as the temperature of the wall socket contacts to ensure safe operation of the appliance and protect its environment. This feature requires an additional temperature input, where both entities are monitored independently. Schematic representation is shown in below graphics;



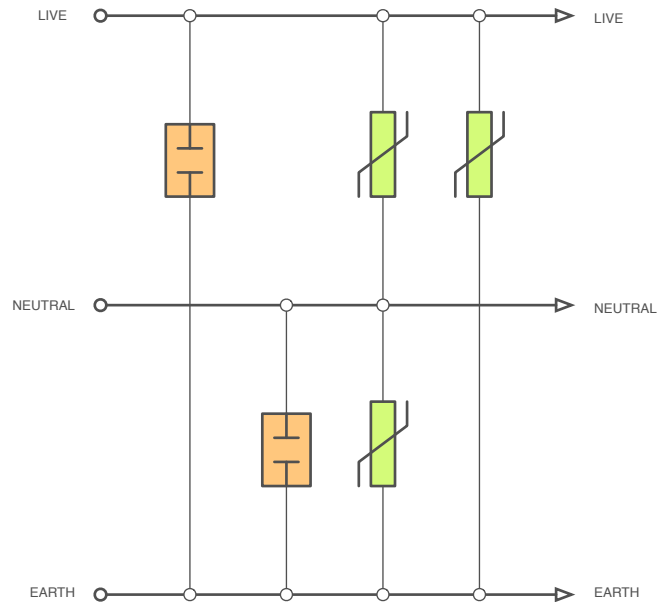
MPU device measures plug temperature in the wall socket as well as measuring its own internal temperature rise. From this data, MPU calculates the risk of a “bad contact” and disconnects the load immediately. Front panel indication shows the nature of failure and user needs to “reset” the MPU device by unplugging and plugging it back to the power outlet socket on the wall.

The plug is specially designed with an injection inserted temperature sensor (thermistor) close to the power pins. The data from the sensor is sent to the microcontroller for further processing. Power extension cable is also custom produced for the MPU and it is a “Halogen-free” production complying to H05VV-F standard with 5 conductors within the power chord.

TRANSIENT AND SURGE PROTECTION:

MPU protection unit is also equipped with a transient and surge protection circuit, which intends to limit the peak transient pulse that reaches the load, which can be generated by various disturbances on the mains supply line.

The block diagram of MPU protection circuit is shown in the diagram below:



Both phase and neutral supply lines are protected against transient disturbances and also, both supply lines are fitted with surge arresters for protection against sudden electrostatic discharges onto the supply lines.

This mode of protection is limited with the suppression capacity of the protection devices used in MPU device. Disconnect circuit is not effective in this mode of operation and load safety totally depends on the surge suppression capacity of the components mounted inside the device.

Since there are no power cables used inside the device, the protection components are mounted very close to the input supply pins and this ensures maximum yield from the protection components used in the MPU device.

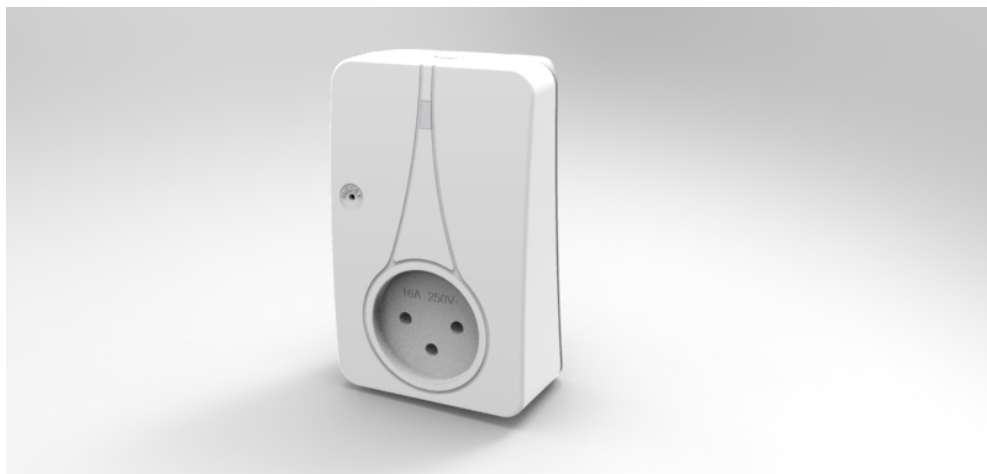
ENCLOSURE DESIGN AND INDICATION:

MPU enclosure and board artwork is specially designed for high efficiency and reliability. MPU plastic enclosure size and shape is optimized for device internal heat rise and safety for access to live parts in the device.

High current carrying parts are specially designed to reduce contact impedance, hence keeping temperature rise to its minimum. Control board copper thickness is 70 microns and this ensures cool operation of the board.

No cables are used inside the unit for current carrying conductors. Using wires means extra heat source within the box and this is avoided by state-of-the-art design. All current carrying contacts use screw type fasteners, which also avoids any solder joints.

The circuit board design complies with IPC standards. This ensures safe operation of the device under transient conditions and also when subject to high voltage. Since the operating upper limit of the device is set to 500Vac, all clearances are kept at this voltage level. The board used SMD technology and all components are reflow soldered for high reliability operation and long operating lifetime.



The board is also chemically treated for humidity and better potential insulation. Since the board surface is not exposed to atmosphere, no solder corrosion is possible and also it provides better insulation between the adjacent tracks.

LED indicator on the front surface has dual colour operation and indication also uses “pulse patterns” in order to indicate different alarms and failure status. The operation of the LED is explained in more detail in the “Error Conditions” section of this document. LED light is completely isolated from the front panel by a light diffusor.

The device also allows the user to reset the long time delays during testing of the protector. The “Time Reset” button is accessible from the front panel and reaching to any live parts within the device is completely eliminated from the reset opening. Access to the internal parts through the reset hole is physically eliminated.

APPLICABLE STANDARDS:

The “Mains Protection Device” is completely designed according to household appliance standards. The applicable standards are given in the list below.

Compliance with the standards are arranged according to the following table:

- 1- EN norms Electromagnetic Interference and Immunity tests
- 2- Electromagnetic immunity tests
- 3- Environmental tests
- 4- Vibration tests
- 5- Voltage performance tests
- 6- Safety performance tests

Applicable standards and related limiting conditions are given in the list below:

- 1- Electromagnetic interference and immunity tests:
 - a. EN55014-1
 - b. EN55014-2
 - c. EN61000-3-2
 - d. EN61000-3-3
- 2- Electromagnetic Immunity tests:
 - a. 61000-4-2
 - b. 61000-4-4
 - c. 61000-4-5
 - d. 61000-4-6
- 3- Environmental tests:
 - a. IEC60068-2-1
 - b. IEC60068-2-2
- 4- Vibration tests:
 - a. IEC60068-2-64
 - b. IEC60068-2-27
- 5- Voltage performance tests:
 - a. High voltage test; $V_{app}= 470V_{ac}$
 - b. Low voltage test; $V_{app}=150V_{ac}$
 - c. Ramp test; 14V/60ms
 - d. Step voltage and Brown out; 0 to 470Vac in 10 steps
 - e. Harmonic immunity;
 - f. Frequency variation;
- 6- Safety performance tests:
 - a. IEC335-1

Technical Specifications:

Technical specifications for the MPU device is given in the table below. These specifications are subject to change without any notice in order to improve the device performance and at the same time, complying to with the standards given in this document.

MPU GENERAL TECHNICAL SPECIFICATIONS				
	Description	Specification	Conditions	Comments
OPERATING SPECIFICATIONS	Voltage input (at power outlet wall socket pins)	170Vac ~ 265Vac	Phase – Neutral voltage	Continuous
		190Vac ~ 243Vac	Phase – Neutral voltage	Hysteresis (restart after voltage error trip)
		150Vac ~ 440Vac	Phase – Neutral voltage	Max limits
		0V ~ 25Vac	Neutral – Earth voltage	Continuous
		265Vac	Phase – Earth voltage	Continuous
	Standby input current	45mA (max)	At 230Vac input (50Hz)	Capacitive PF
	Load current capacity	15A (max)	At 250Vac input (AC1)	Continuous
		7A (max)	250Vac @ PF=0,4 (AC2)	Continuous
	Load switch	Power relay	16A @ 250Vac (phase pin switching only)	Normally de-energized relay contact (NO)
	Operating frequency	47Hz ~ 53Hz		Continuous operation
		48Hz ~ 52Hz	Hysteresis function	Restart after frequency error trip
	Operating temperature range	-25°C to +55°C	Maximum specified load ratings	Continuous operating ambient temperature
	Storage temperature range	-30°C to +85°C	Ambient temperature	Continuous
	Operating humidity range	30%Rh to 95%Rh	At specified load	Non-condensing, continuous operation
Storage humidity range	20%Rh to 98%Rh	Non-condensing	Continuous	
DETECTION	Voltage detection	Phase and Neutral potential	Check safe operation voltage limits	Continuous monitoring (load disconnect and warning)
	Phase polarity detection	Phase pin position detection	Over full operating range (load disconnect + warning indication)	
	Neutral polarity detection	Neutral pin position detection	Over full operating range (load disconnect + warning indication)	
	Earth connection	Measure of earth potential	Earth connection detection with respect to Neutral line (load disconnect and warning indication)	
	Relay contact detection	Contact potential difference detection	Voltage control across relay contacts	Continuous monitoring (load disconnect and indication)
	Temperature detection	Internal temperature monitoring (dT/dt)		Monitor pin temperature and internal environment temperature (load disconnect and warning)
Remote temperature detection			Monitor remote plug pin temperature (load disconnect and warning)	
PROTECTION	Over-voltage protection	265Vac<Vac<300Vac	Delay of 2 seconds	Load disconnection and warning indication
		Vac>300Vac	Delay of 0,2 seconds	
	Under-voltage protection	150Vac<Vac<170Vac	Delay of 2 seconds	
		Vac<150Vac	Delay of 0,2 seconds	
	Over-frequency detection	Frequency>53Hz	Delay of 2 seconds	Load disconnection and warning indication
Under-frequency detection	Frequency<47Hz	Delay of 2 seconds		

	Internal Temperature detection	Tb>105°C	Pin temp > 130°C	Load disconnect and device locking (needs external reset)	
	Remote temperature detection	Tp>120°C	Pin temp > 130°C	Load disconnect and device locking (needs external reset)	
	Transient voltage clamping	Vt > 375Vac	Clamp voltage at 375V (Varistor protection across phase, neutral and earth)	No disconnect and no warning	
	Surge arrestor	<10KA @ 1uS pulses (10 surges)	Gas Discharge Tube protection across Phase and neutral to earth)	No disconnect and no warning	
	Noise filtering	Capacitive filtering	Phase-Neutral Phase-Earth Neutral-Earth	Suppression above 30MHz (comply with light industry standards)	
	Mains recovery protection delay	300 seconds (factory set on-delay time)	Load is disconnected for Td seconds after recovering from mains failure status		
	Mains healthy protection delay	60 seconds (factory set delay time)	Load energize delay time after "Mains Healthy" detection		
INDICATION & LAYOUT	Delay time over-ride button	Push button on front panel	Connects load without time delay for testing purposes		
	Front panel alarm indicator	Dual color LED indication	1- RED color for "Alarm" 2- GREEN color for "Power OK" 3- Blinking operation for delay and alarm indication (for alarm functions, check LED indication table)		
	Mechanical design	Wall-socket mounting type	MPU device is plugged directly into the power outlet socket on the wall		
		Cable extended version	MPU has an extension cable with plug, halogen-free chord H05VV-F 5-conductors (30cm)		
	Load connection	Standard plug connection with earth terminals	15A@AC1 7A@AC2	Continuous	
	MPU configuration	Factory set	Not user configurable		
SAFETY	EMC & EMI protection	EN standards for household appliances	EN55014-1 EN55014-2 EN61000-3-2 EN61000-3-3 EN61000-4-2, 4-4, 4-5 and 4-6 IEC60068-2-1 IEC60068-2-2 IEC60068-2-27 IEC60068-2-64 IEC335-1		
	Plastic enclosure	Top cover	Polycarbonate	Non-flammable	
		Bottom part	PBT	Non-flammable	
	Labeling	Label on bottom plastic part	Metallized label with transfer printing	Specifications and approvals	
	User manual	English booklet	Insert in each device package		

LINE PROTECTOR INDICATION TABLE

Conditions	GREEN LED	RED LED	RELAY	Error Delay Time	Recovery Delay Time	High Level Error	High Level Recovery	Low Level Error	Low Level Recovery	tolerance	TEST
Running Condition	ON	OFF	ON	-	-	-	-	-	-	-	
Wait Delay	Fixed Flashing	OFF	OFF	-	-	-	-	-	-	-	
High/Low Voltage Error	OFF	1 Blink	OFF	2s	300s	265 VAC	243 VAC	170 VAC	190VAC	+1%	
High/Low Frequency Error	OFF	2 Blink	OFF	2s	300s	52,5 Hz	51,5 Hz	47,5 Hz	48,5 Hz	+1%	
Polarity Error	OFF	3 Blink	OFF	200ms	must be restarted	-	-	-	-	-	
Earth Connection Error	OFF	4 Blink	OFF	200ms	300s	25 VAC	22 VAC	-	-	+5%	
Temperature Error	OFF	5 Blink	OFF	2s	must be restarted	120 °C	95 °C	-	-	+5 °C	
NTC Sensor Error	ON	6 Blink	ON	200ms	300s	Short Circuit	-	Open Circuit	-	-	
Relay Short Circuit Error	OFF	ON	Short circuit	1s	must be called technical service	-	-	-	-	-	
Relay Open Circuit Error	OFF	ON	Open circuit	1s	must be called technical service	-	-	-	-	-	
Multiple Error	OFF	10 Blink	OFF	200ms	300s	-	-	-	-	-	