# Multi-Level Switching (MLS) Technology UPS

MEDI's MLS technology online UPS is a transformer-less UPS with front end PFC, harmonic reduction, common neutral, high efficiency three level inverter stage

Features –

1. Input front end PFC to correct the current waveform to pure sine wave, power factor will be close to unity 0.99
2. Very low harmonics < 4%
3. Three level inverter stage results in very low switching loss and requires compact magnetics.
4. Inverter stage and the PFC stage will process only the difference power which makes the efficiency very high and light weight.
5. Efficiency >98%
6. Absolute transformer-less design – no iron core transformer and no ferrite transformer used. Only light weight high frequency inductors are used. This results in very easy manufacturing.
7. No isolation transformer needed because neutral is common
8. Static bypass for uninterruptable bypass during hazard condition
9. 4-level battery charging. Charging current up to 15A
10. Suitable for all kinds of batteries – Lithium, lead acid etc
11. 4-line LCD and graphic display
12. Wifi connectivity with Android
13. Temperature sensor and fan control
14. Suitable for 110V
15. Suitable for frequency converters – 50Hz input 60Hz / 400Hz output, 60Hz input 50Hz /400Hz output, 400Hz input 50Hz /60Hz output

**TECHNICAL SPECIFICATION**

| | |
|---|---|
| Capacity | 1KVA, 2KVA, 3KVA, 4KVA, 5KVA<br>single phase input, single phase output |
| Nominal AC input | 230V / 110V |
| AC input range | 170V to 270V / 80V to 130V |
| Input frequency | 50Hz / 60Hz |
| Input power factor | >0.98 (full load) |
| Input current harmonics | < 4% (full load) |
| Current crest factor ratio | 3:1 max |
| Nominal output voltage | 230V / 110V |
| Output frequency | 50Hz / 60Hz |
| Output voltage regulation | < +/-1% |
| Output waveform | Pure sinewave |
| Output voltage harmonic distortion (THD) | < 2% |
| Transfer time in UPS mode | Mains to battery – 0ms |

| | |
|---|---|
| | Battery to mains – 0ms |
| Automatic bypass | Static bypass using SCR |
| Static bypass transfer time | Inverter to mains bypass – 0ms<br>Mains to inverter bypass – 0ms |
| Topology | True online with double conversion with high efficiency three level inverter and APFC.<br>Neutral common, no isolation transformer required |
| Efficiency | >98% |
| Input power factor | 0.99 |
| Input current total harmonic distortion (THD) | <4% |
| Battery voltage | 1KVA 96V to 240V<br>2KVA 96V to 240V<br>3KVA 192V to 240V<br>4KVA 192V to 240V<br>5KVA 192V to 300V |
| Number of battery banks | Single battery bank system |
| Battery type | Lithium / lead acid batteries |
| Charging current | 1 to 15A settable |
| Charger type | CCCV + float cum boost + trickle charging.<br>4-level and 2-level settable |
| Interface and connectivity | Wifi with Android and net connectivity |
| Protection | Overload, surge load, short circuit, battery low, mains low voltage, mains high voltage, high temperature |

There is no DC component presence in the sine wave output of the MLS online UPS because in this topology, the positive half and the negative half of the sinewave are made from two different DC voltages. Unlike some transformer-less UPS where the positive and negative halves are made from a single DC voltage where the DC component can be present in the sinewave output.

In a traditional transformer type online UPS, there is an iron core transformer which will eliminate any DC component presence.

In a conventional transformer-less UPS, there is no transformer to eliminate the presence of any DC component. When a half wave load or non-linear load is connected, the positive or negative might get loaded unevenly. Because of the absence of any transformer to rectify this, this unevenness will then be carried forward to the final sinewave output.
In MLS online UPS, the positive half is made from one DC voltage and the negative half is made from a different DC voltage. The DSP will monitor the sinewave output and independently vary the two DC voltages to make sure the positive half and negative half are both equal.

Even in a transformer type online UPS, if the load imbalance between positive and negative is above a certain limit, the sinewave output will have DC component.

Under the same conditions, our MLS online UPS will have lesser DC component compared to the transformer type online UPS.

PFC stage : This is a DSP based PFC stage which is developed with MEDI's own protocol. Because of the unique algorithm, we are able to achieve very low current harmonics and very high power factor. In this method, we are not using the traditional method of bridge rectifier to convert AC to DC which will result in no neutral at the DC output. Moreover, there will be a further voltage drop in the diodes used causing heat dissipation.

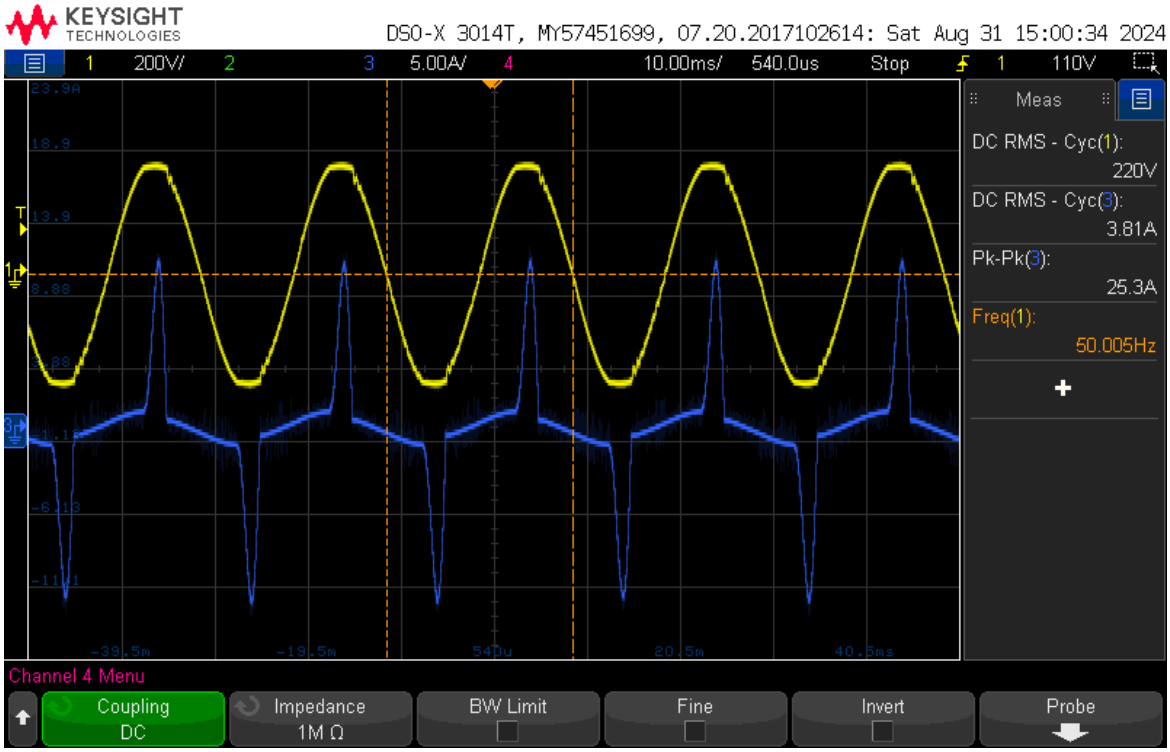



**Figure 1 - Waveform of computer load without PF (Yellow Voltage, Blue Current)**

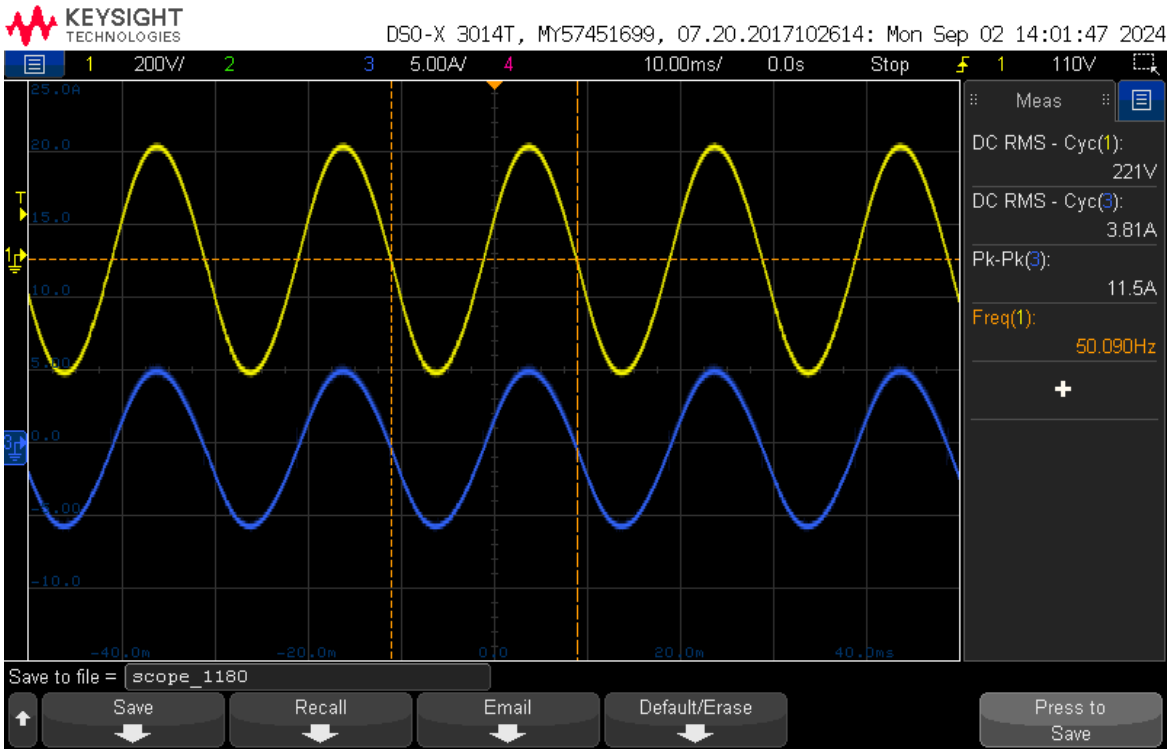



**Figure 2 - Waveform of computer load with power factor correction through MEDI's MLS online UPS**

In our design, we are not using any bridge rectifier at the AC input. The AC is directly fed to the IGBTs. This eliminates the diode losses and also gives the benefit of neutral at the output. The advantage of having neutral at the output will eliminate the need for bulky isolation transformer. Moreover, the incoming neutral failure will not make the output voltage high.

All the different stages – inverter, PFC and battery stage are all in a single PCB making it easy to assemble and eliminates any complicated wiring. The BOM is drastically low while the performance and efficiency are not compromised.

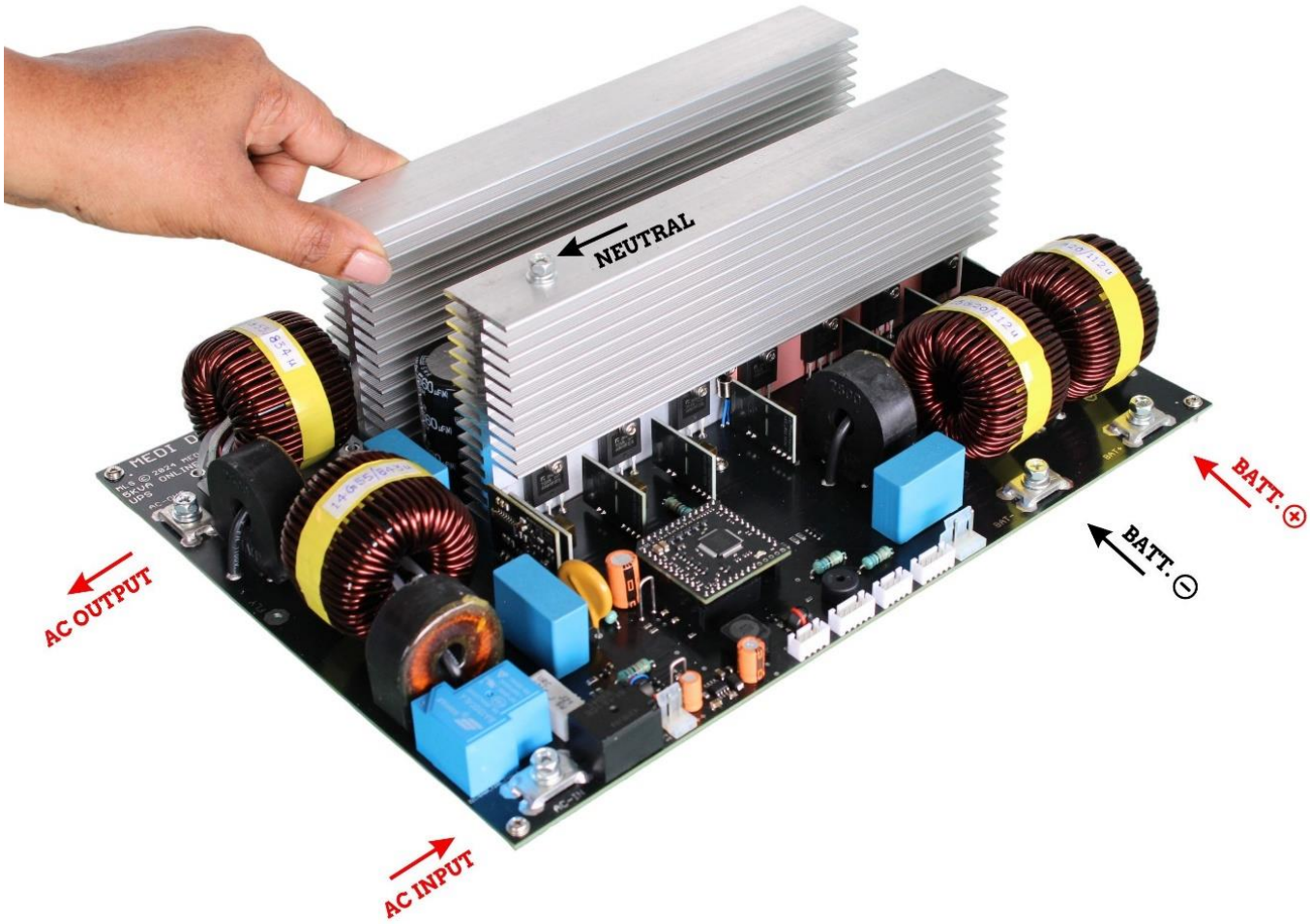



**Figure 3 – fully assembled MEDI's MLS online UPS**

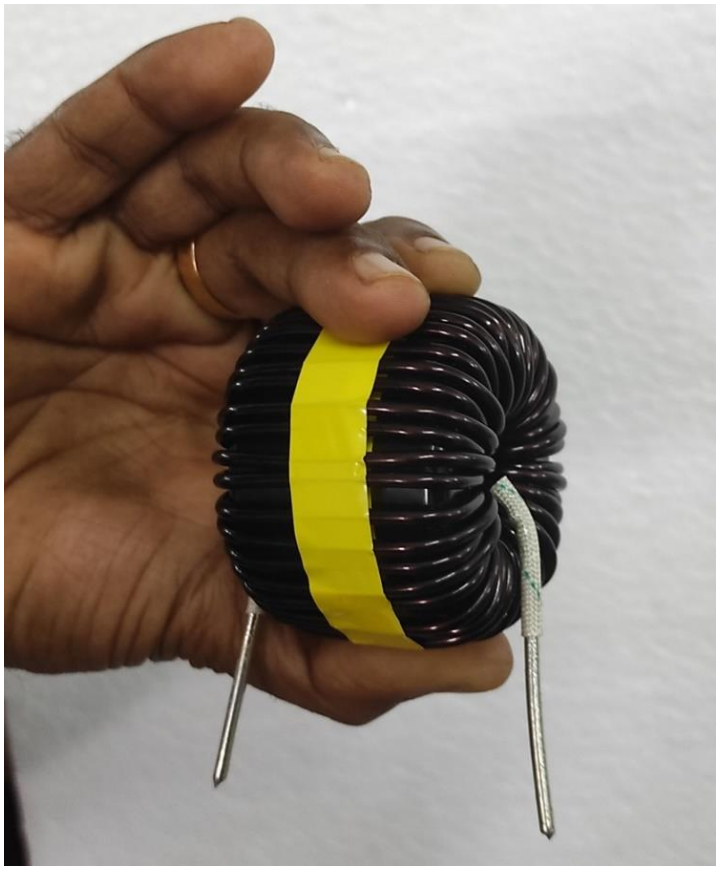



**Figure 4 - 5KVA Inductor**

There is no iron core transformer used and there is no ferrite core transformer used.

Only light weight high frequency inductors are used.

The front-end PFC side uses one inductor, UPS output side uses one inductor, battery buck-boost converter uses two inductors. The total system works with only four light weight inductors.

In a traditional method of 5KVA high frequency transformer-less UPS, there will be a full rated power ferrite transformer with primary and secondary windings which is complex to wind and the size is bigger than our 5KVA inductor. Our inductor has a single wire winding which is easy to wind, and the size is very small because the full power is not processed, only the difference power is processed because of Multi Level Switching (MLS) topology.

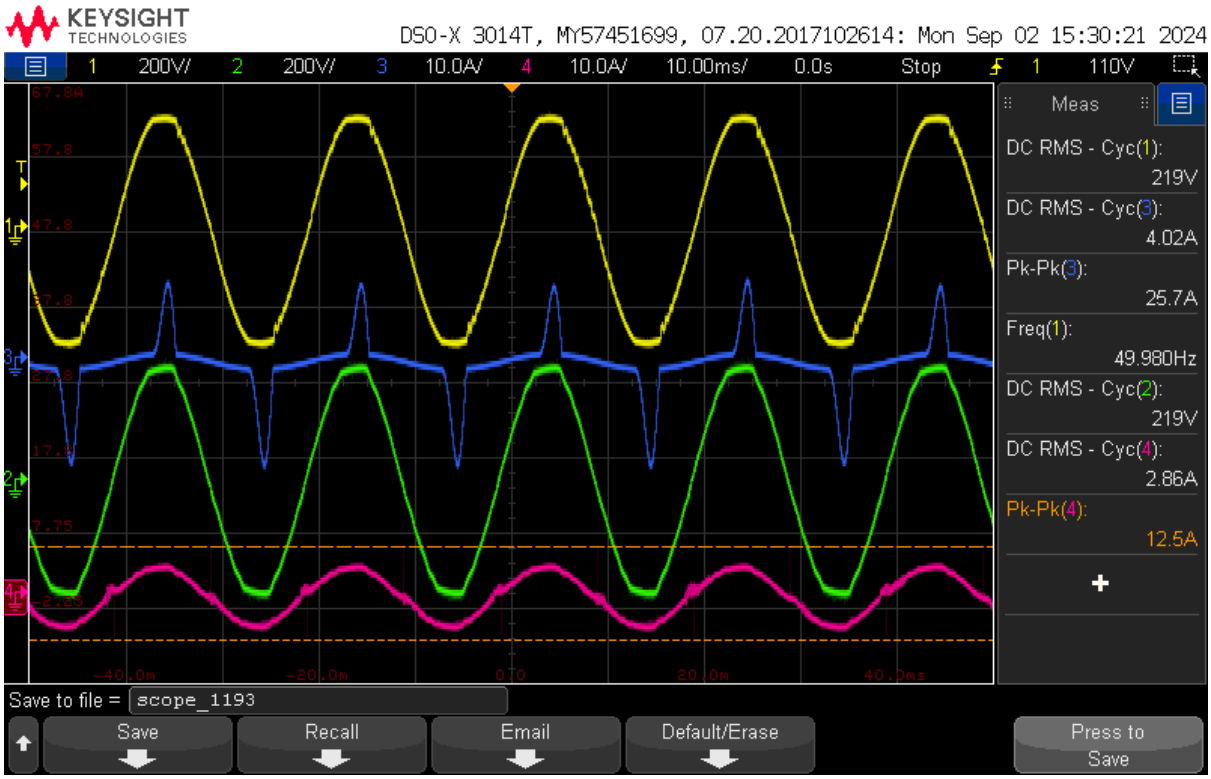



**Figure 5 - Computer load without PFC is connected through MLS online UPS**

Yellow is the output voltage.
Blue is the nonlinear current taken by the computer.
Green is the input voltage.
Red is the power factor corrected input current by the MLS online UPS.

From the waveform above, the UPS output voltage is 219V, output current is 4.02A. So the output VA is 880VA.
The UPS input voltage from mains is 219V, input current is 2.86A. So the input VA is only 626VA.

If this computer load is connected directly from the mains it will take 880VA. If the same computer load is connected through MEDI's MLS online UPS, it will take only 626VA which is nearly 30% lesser VA.

Moreover, the peak to peak current taken by the computer load is 25.7A when connected directly from the mains. But when connected through MEDI's MLS online UPS, the peak to peak current is dropped to 12.5A which is nearly 50% lesser current peak.
This kind of nonlinear load has very high current harmonics and high current crest factor which will pollute the power quality in the distribution system resulting in overheating of circuit and devices, overheating of transformers / transformer burn, extreme high current in the neutral causing neutral float / neutral burn etc. The generators, distribution transformers and transmission line should all be overrated to compensate for this non-linear load and low power factor loads.

**EFFICIENCY TEST**

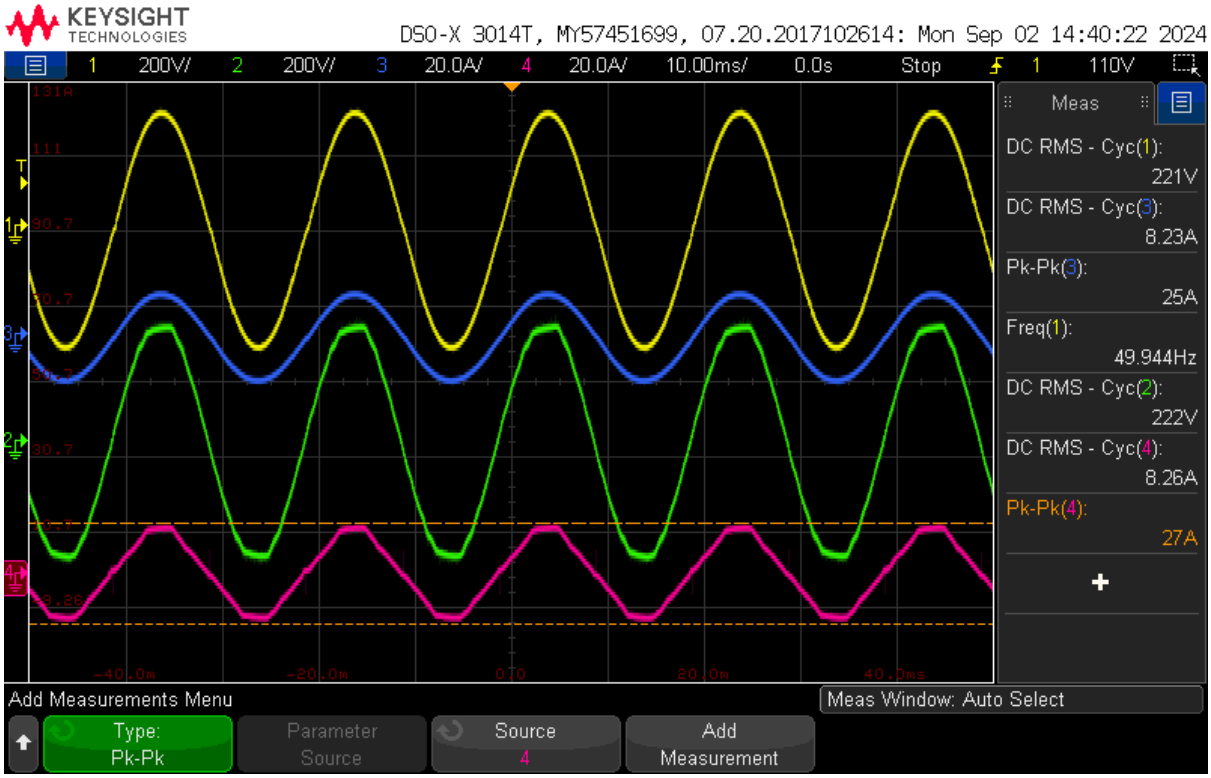



**Figure 6 - Yellow output voltage, blue output current, green input voltage, red input current**

Output voltage is 221V, output current is 8.23A.
So the output VA is 1818.83VA
Input voltage is 222V, input current is 8.26A.
So the input VA is 1833.72VA

Efficiency = (output / input) x 100% which is (1818.83 / 1833.72) x 100%
Efficiency = 99.18%

The Multi Level Switching (MLS) topology uses only the difference power processing method unlike the traditional transformer-less UPS which will process the full rated power. This makes it possible to achieve such high efficiency in MLS online UPS.

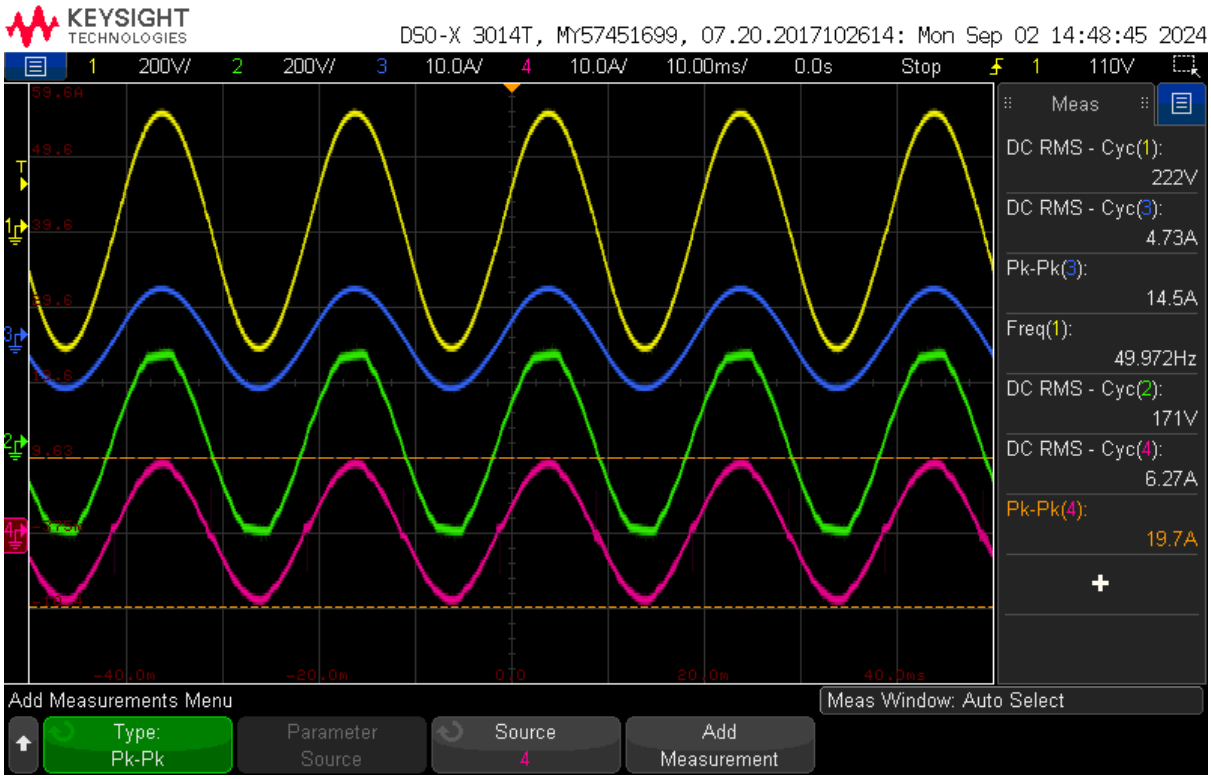



**Figure 7 – Yellow output voltage, blue output current, green input voltage, red input current**

Output voltage is 222V, output current is 4.73A.
So the output VA is 1050.06VA
Input voltage is 171V, input current is 6.27A.
So the input VA is 1072.17VA

Efficiency = (output / input) x 100% which is (1050.06/ 1072.17) x 100%
Efficiency = 97.93%

Efficiency at low input voltage of 171V is also 97.93%.

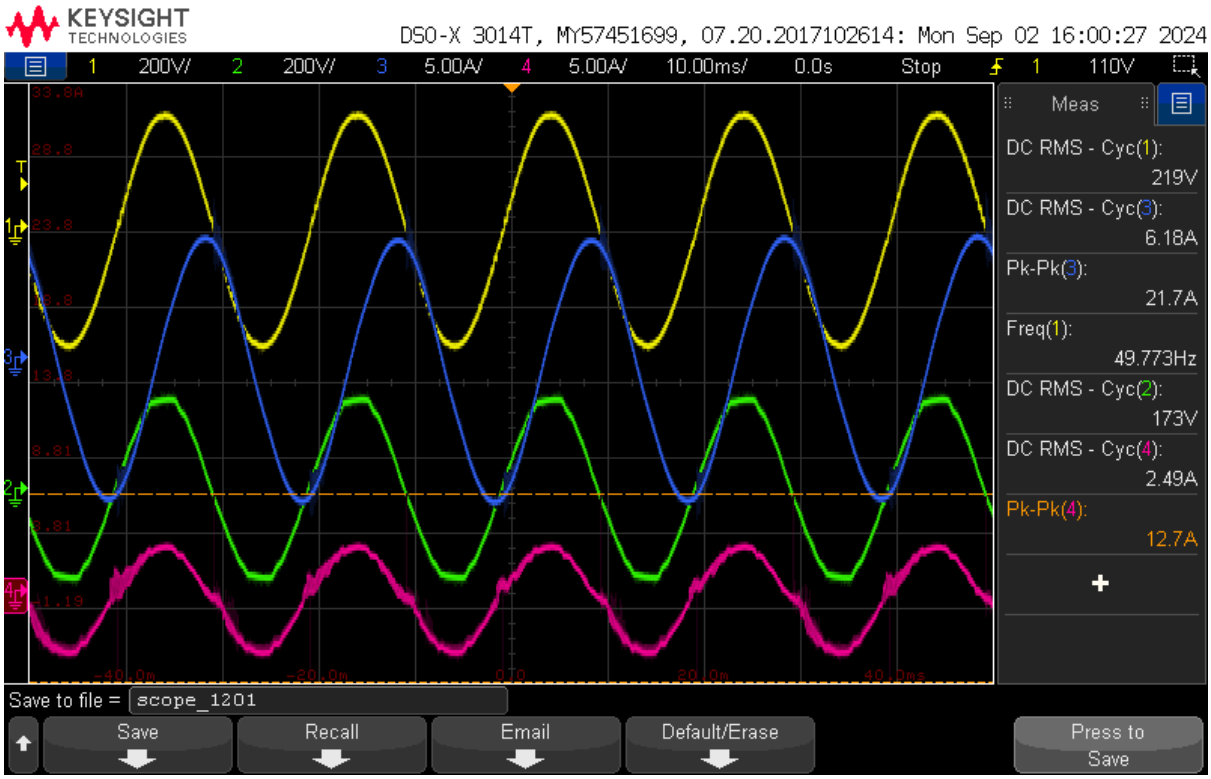



**Figure 8 – Connected to a low power factor load**

Yellow is the output voltage.
Blue is the low power factor load current.
Green is the input voltage.
Red is the power factor corrected input current by the MLS online UPS.

From the waveform above, the UPS output voltage is 219V, output current is 6.18A.
So the output VA is 1353VA.

The UPS input voltage from mains is 173V, input current is 2.49A.
So the input VA is only 430VA.

If this low power factor load is connected directly from the mains it will take 1353VA. If the same load is connected through MEDI's MLS online UPS, it will take only 430VA which is nearly 70% lesser VA.

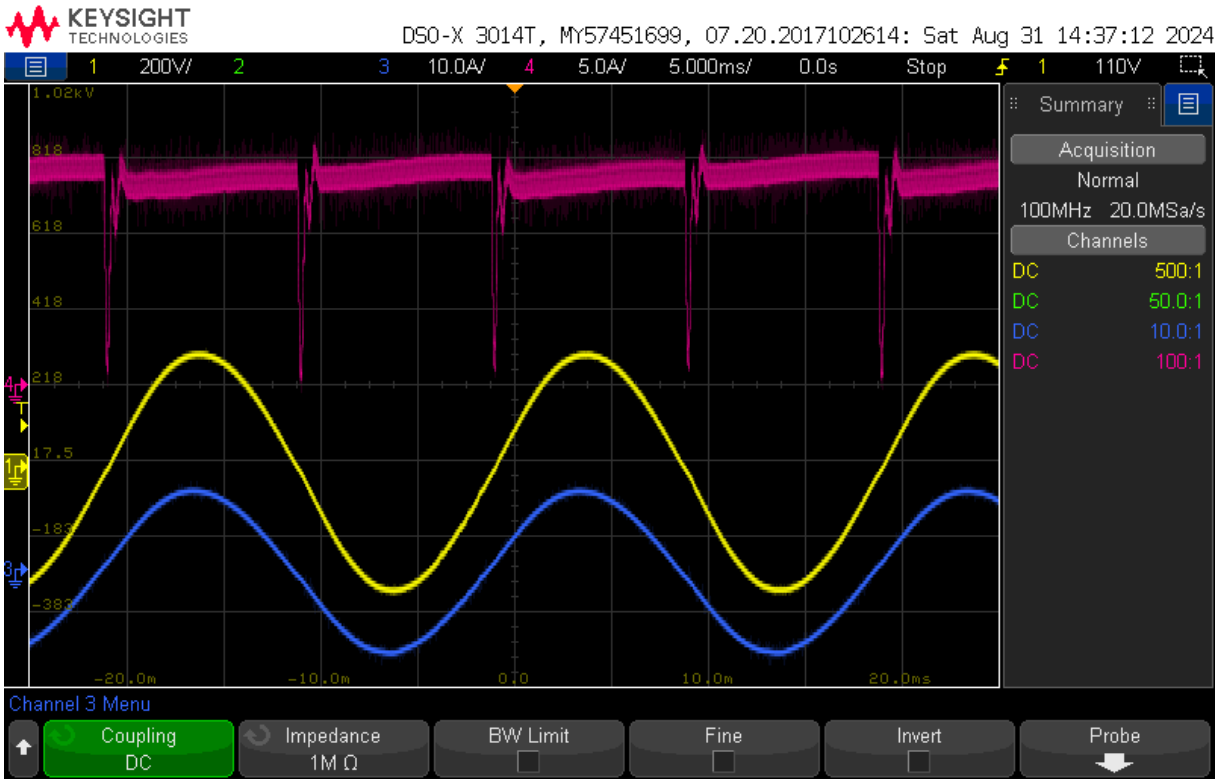



**Figure 9 - Red battery current without ripple, yellow UPS output voltage, blue output current in MLS online UPS**

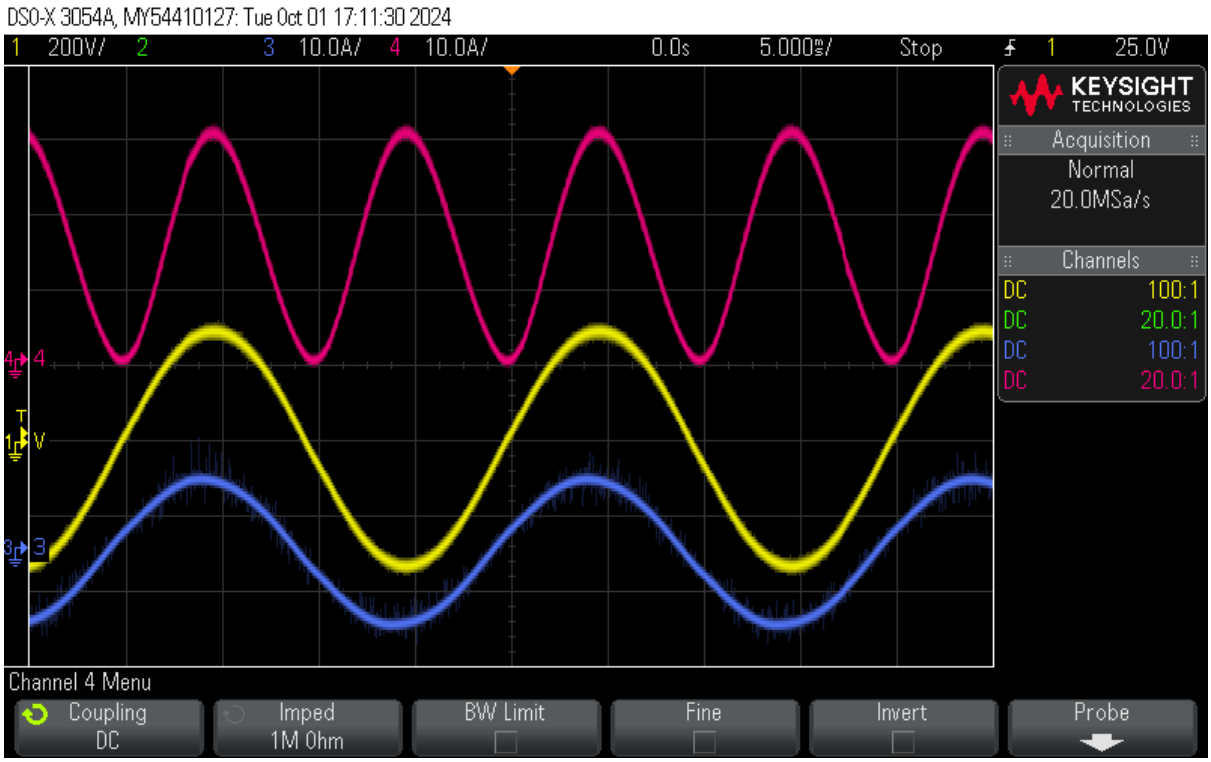



**Figure 10 - Red battery current with ripple, yellow UPS output voltage, blue output current in normal online UPS**

Generally, in online UPS, the inverter stage is working from the battery giving an AC sinewave output. The load is connected to this sinewave output so the load current will be in the shape of sinewave or non-linear pulsating current. So, battery current will have this high ripple.

In MLS online UPS, due to the topology this naturally eliminates the high ripple in the battery current. The waveform you see above shows red which is the battery current without any ripple. To achieve this in a conventional online UPS, you should use infinite uF capacitors across the battery terminals.

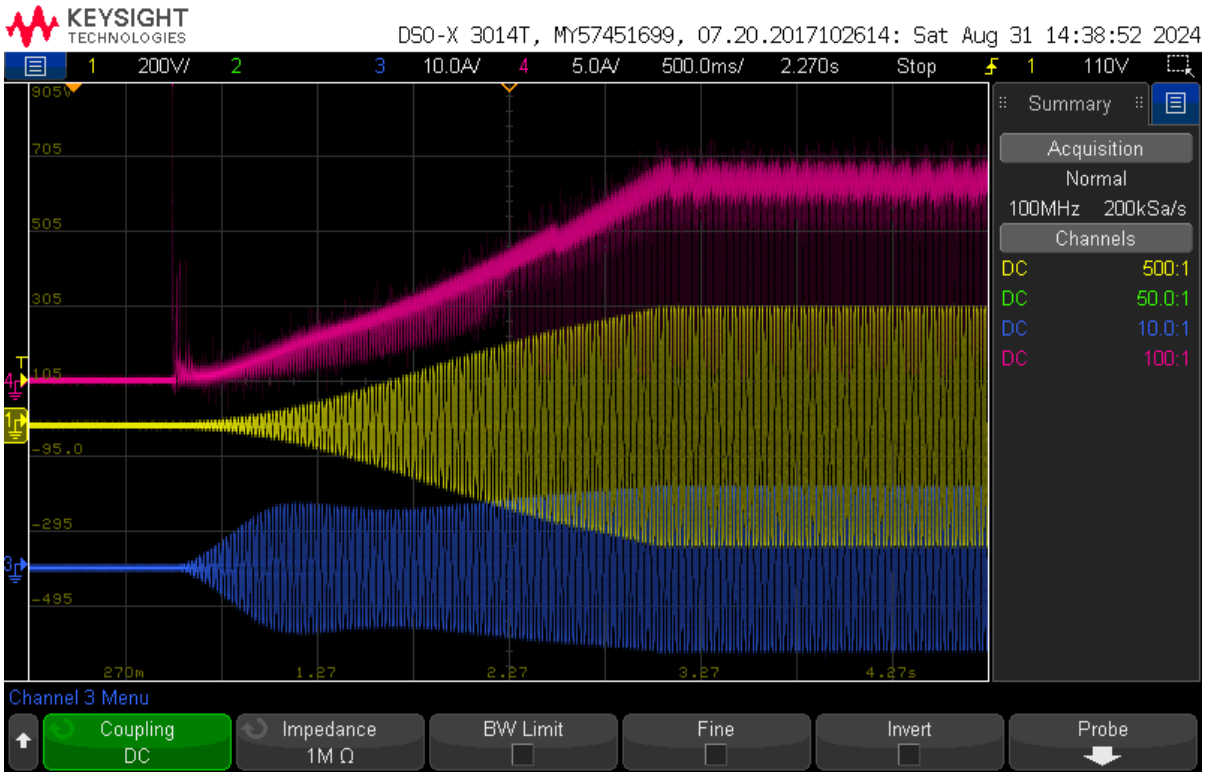



**Figure 11 - Soft start no battery inrush current**
Red battery current, yellow output voltage, blue output current

Ordinarily, when battery / mains is connected to the UPS there is a huge inrush current from the battery / mains due to the charging of capacitor bank.

As you can see in figure 9 and 11, in MLS online UPS, there is no inrush current because the capacitor bank is charging smoothly.

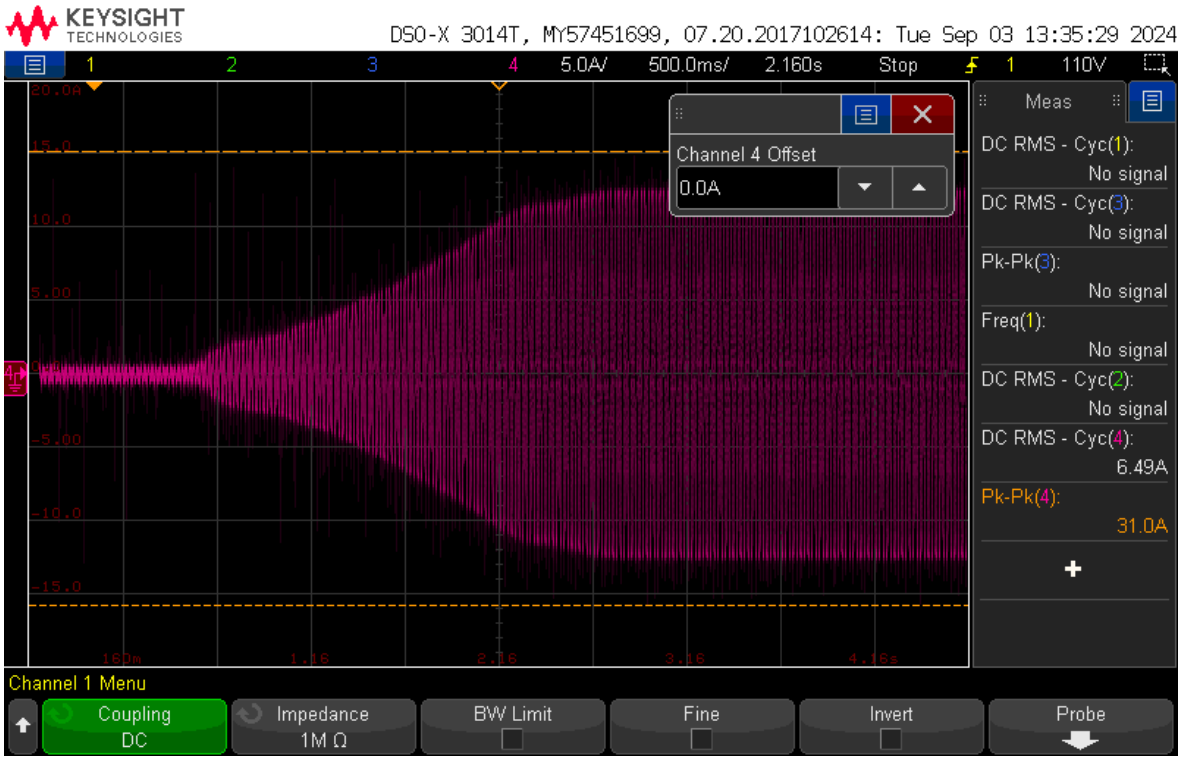



**Figure 12 - Mains inrush current limiting, No mains inrush current**

Mains inrush current limiting: When mains is switched on or mains returns after power failure, usually the UPS will take high inrush current to charge the high value DC bus capacitors. In our circuit there will not be any inrush current because when the mains return the capacitors will be charged through a current limiting circuit. The DSP will sense when the capacitors are fully charged, then it will directly connect the mains to the capacitors.

Similarly, when you connect the battery bank to the UPS there will not be any inrush current from the battery. Because the DSP will smoothly increase the PWM to limit the inrush current and charge the DC bus capacitors from the battery.
Without the inrush current limiting protection, the components will degrade or fail over repeated inrush current during turn on of mains / battery.
The inrush current limiting protection in our design will increase the life of all the associated components like IGBTs, diodes, capacitors etc.

Static bypass : During the operation of the UPS if there is any fault condition like high surge current, overload, high temperature etc, the UPS will need to shut down immediately. During this time there will be an uninterrupted static bypass, so the output of the UPS remains unaffected. The static bypass is done through SCR so the computer will not reboot.

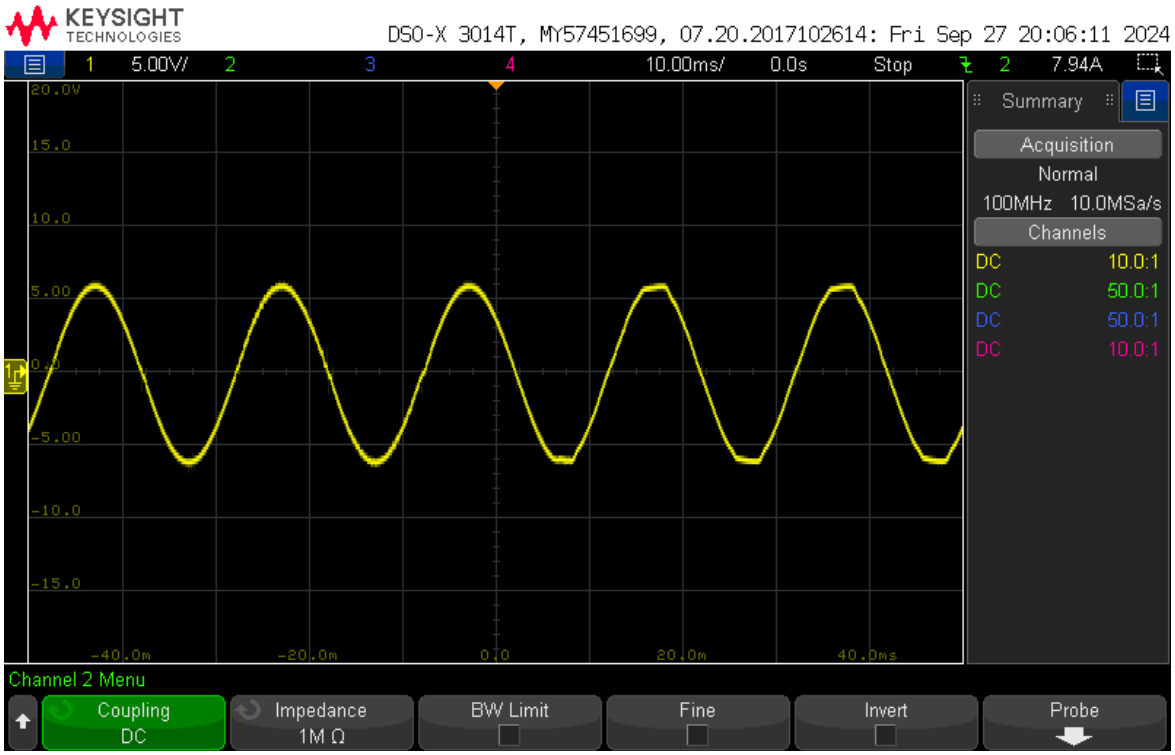



**Figure 13 - Static bypass Inverter to Mains when mains voltage is close to inverter output voltage 220V**

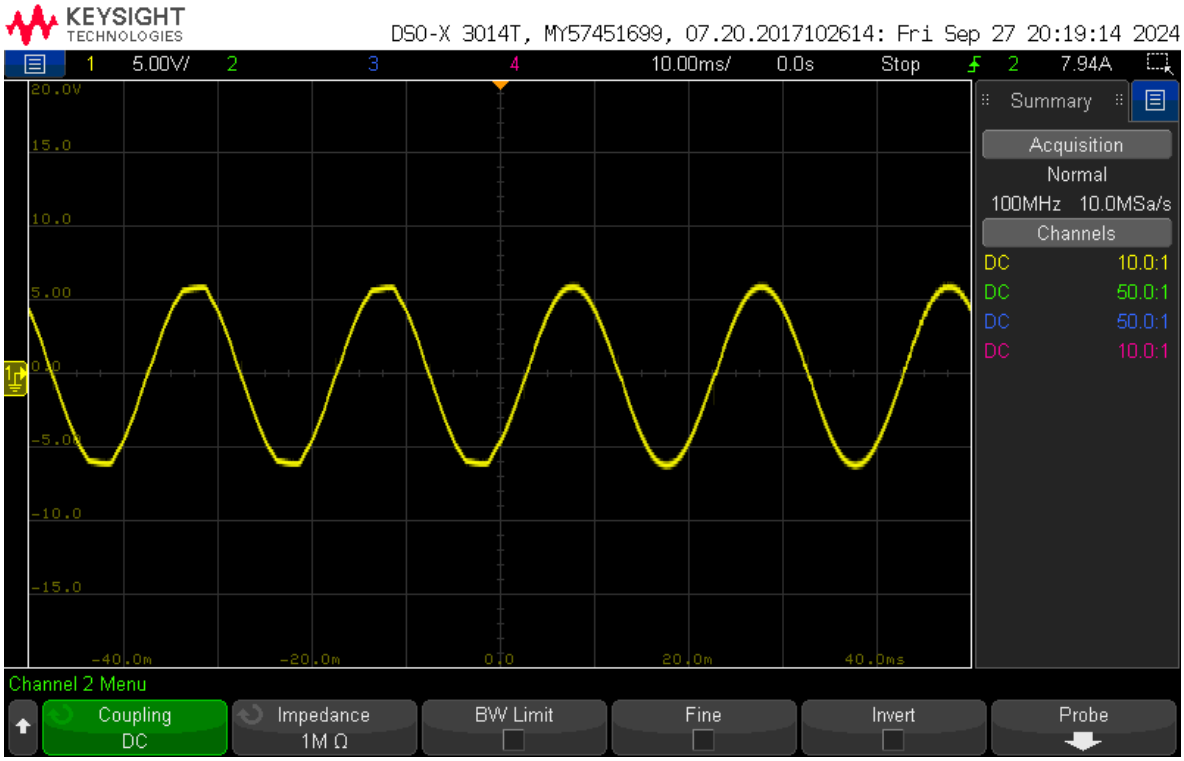



**Figure 14 - Static bypass Mains to Inverter when mains voltage is close to inverter output voltage 220V**

You can see in both Fig 13 and 14, the waveform is uninterrupted and there is no change-over time.

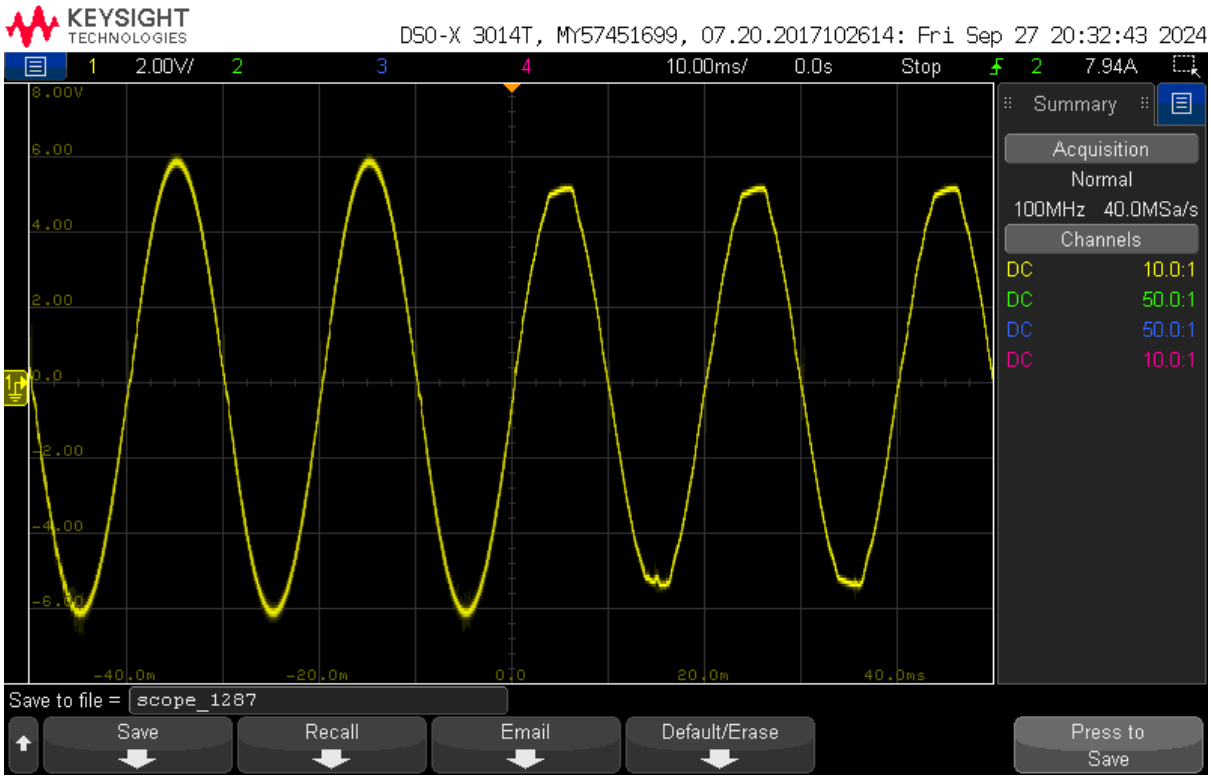



**Figure 15 - Static bypass Inverter to Mains when mains voltage is 190V and inverter output voltage is 220V**

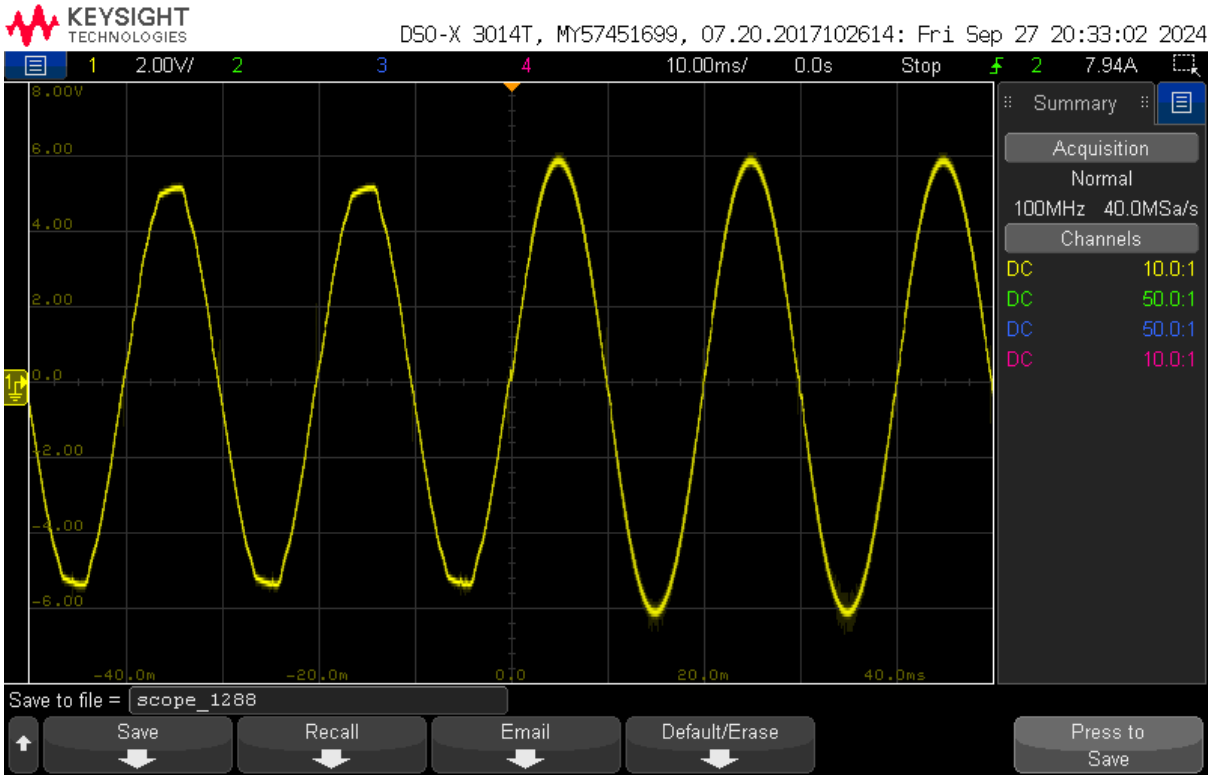



**Figure 16 - Static bypass Mains when mains voltage is 190V and inverter output voltage is 220V**

You can see in both Fig 15 and 16, the waveform is uninterrupted and there is no change-over time. You can see the voltage difference between mains and inverter output.

Total Harmonic Distortion (THD) < 4%
The use of SMPS in computers, LED and CFL in lighting etc. contributes to high non-linear load. This produces high current harmonics which makes the THD high. When the THD is high, this is a hindrance on the electrical equipment to work at its full rated capacity. High harmonics will also cause heating and breakdown of the electrical wiring, MCB etc.

When you use three conventional UPS in R, Y, B, the neutral current will become three times per UPS current.
In our design, the neutral current will be brought down to nearly zero when three UPS are working in three phases.

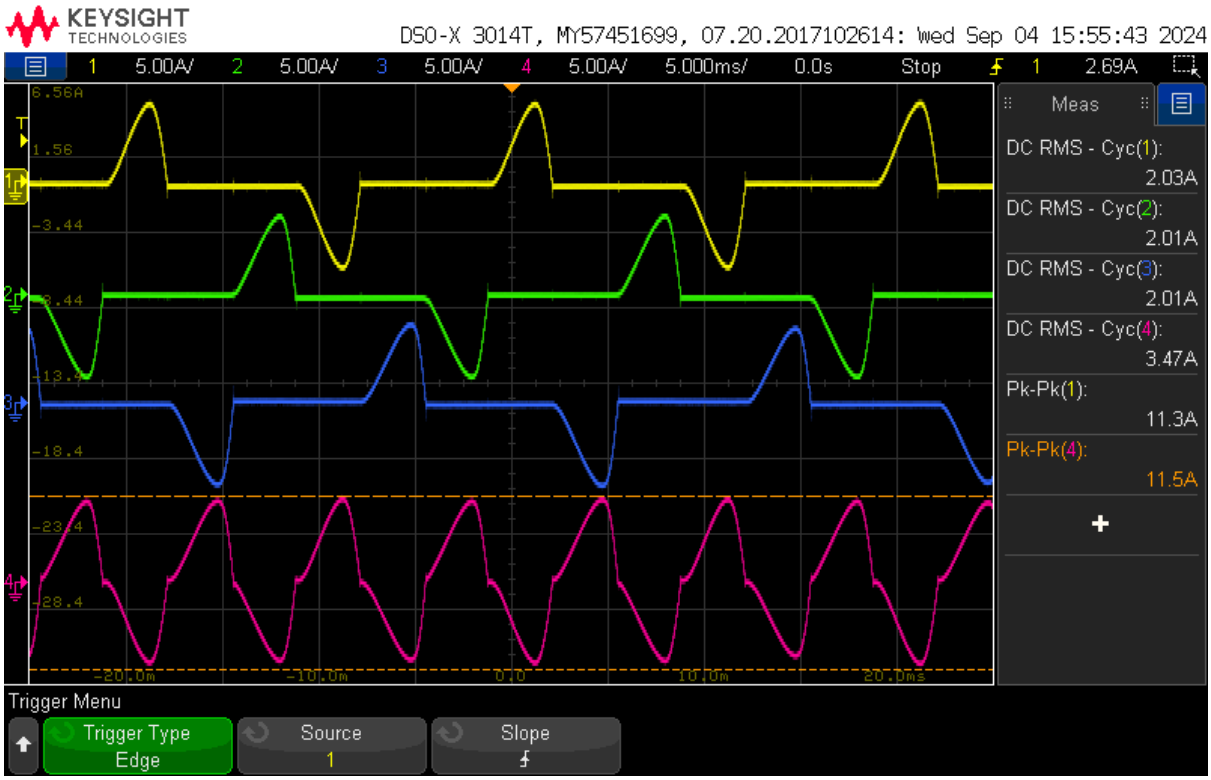



**Figure 17 – Conventional UPS without PFC. Current in each phase & neutral**

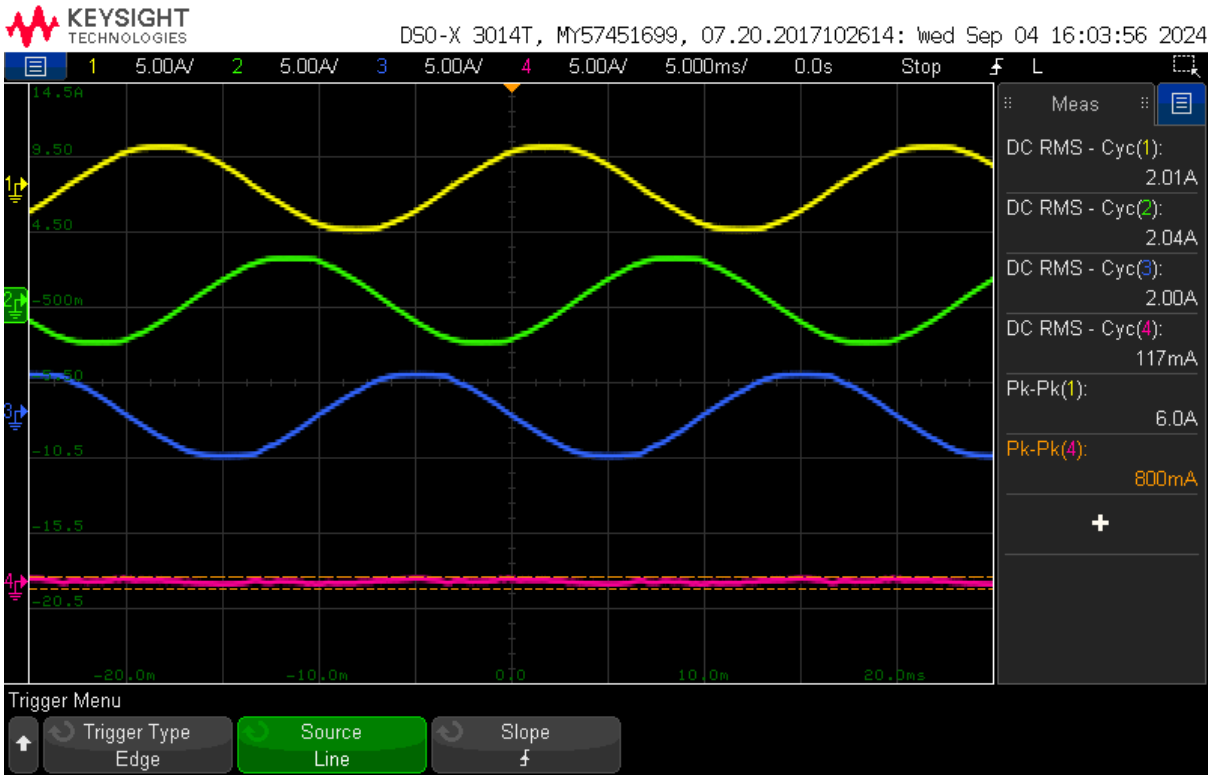



**Figure 18 – MEDI MLS online UPS with APFC. Current in each phase & neutral**

MEDI's UPS design provides current harmonic reduction which reduces the input current crest factor. When using this product, you can avoid adding expensive bulky inductors and capacitors for harmonic filtering.
The combination of reduced current crest factor and neutral current reduction will result in improved overall energy efficiency and reduce the failure of equipment and distribution system.

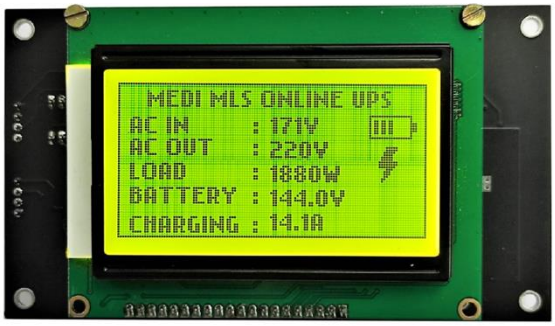
The design also includes communication features like WiFi, net connectivity and Android.

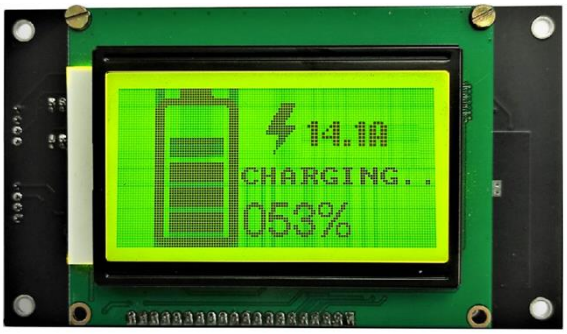
## 4 Line LCD display

A four-line LCD is provided to display all the parameters including the manufacturer's brand name.

## Graphic LCD in ONLINE UPS

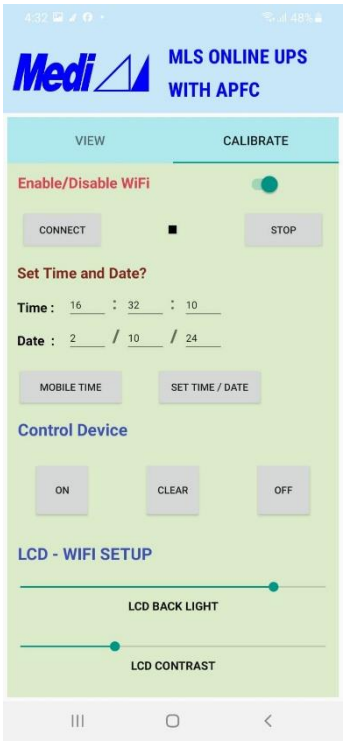
For a more premium product, the option of Graphic LCD is also provided.




## Mobile APP

There is an Android app developed specially for this product that can be used to control and read parameters.



## Technology cost

MLS Online UPS low power 1KVA to 5KVA with APFC – Rs.7,50,000 + tax
BOM of 3KVA – approx. Rs.9,800

The technology cost is at introductory offer for a limited period only. The price will go up without prior notice.