TrioStat Three phase

Three phase IGBT delta PWM technology

By

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INTRODUCTION

TRIOSTAT : Three phase Static Voltage Stabilizer

Over a decade ago, MEDI released the first design of Static Voltage Stabilizer using IGBT PWM technology. Our research has never stopped. We are pleased to announce the release of a cutting edge technology development in the field of Static Voltage Stabilizers using IGBTs phase to phase PWM technology called TrioStat.

This is an IGBT based PWM topology three phase static voltage stabilizer up to 200KVA. This is a three phase difference voltage addition / subtraction type Voltage Stabilizer that can be used for buck and boost voltage regulation with an accuracy of +/-1%. The duty-cycle of the PWM is controlled by the DSP which has a PWM resolution of 1ns step so an accuracy of much better than 1% regulation can be obtained.

This is an SMPS type voltage stabilizer for mains voltage (AC input and AC output). This is a phase to phase PWM switching topology where **PWM is made directly in 3-Phase AC-to-AC**, without adding any harmonic distortion. In this topology there is no need to convert the AC input to DC and again convert it back to regulated AC output. This simplifies the design, reduces the component count and improves the efficiency and reliability.

The power stage is a phase to phase 3-Phase IGBT chopper control instead of conventional phase to neutral method. The chopping frequency is around 20KHz which ensures absolute silent operation and pure sine wave output (does not produce any waveform distortion). It has a special feature of 'Active Clamping' there is no switching at unclamped inductive load which will cause high surge during turn-off.

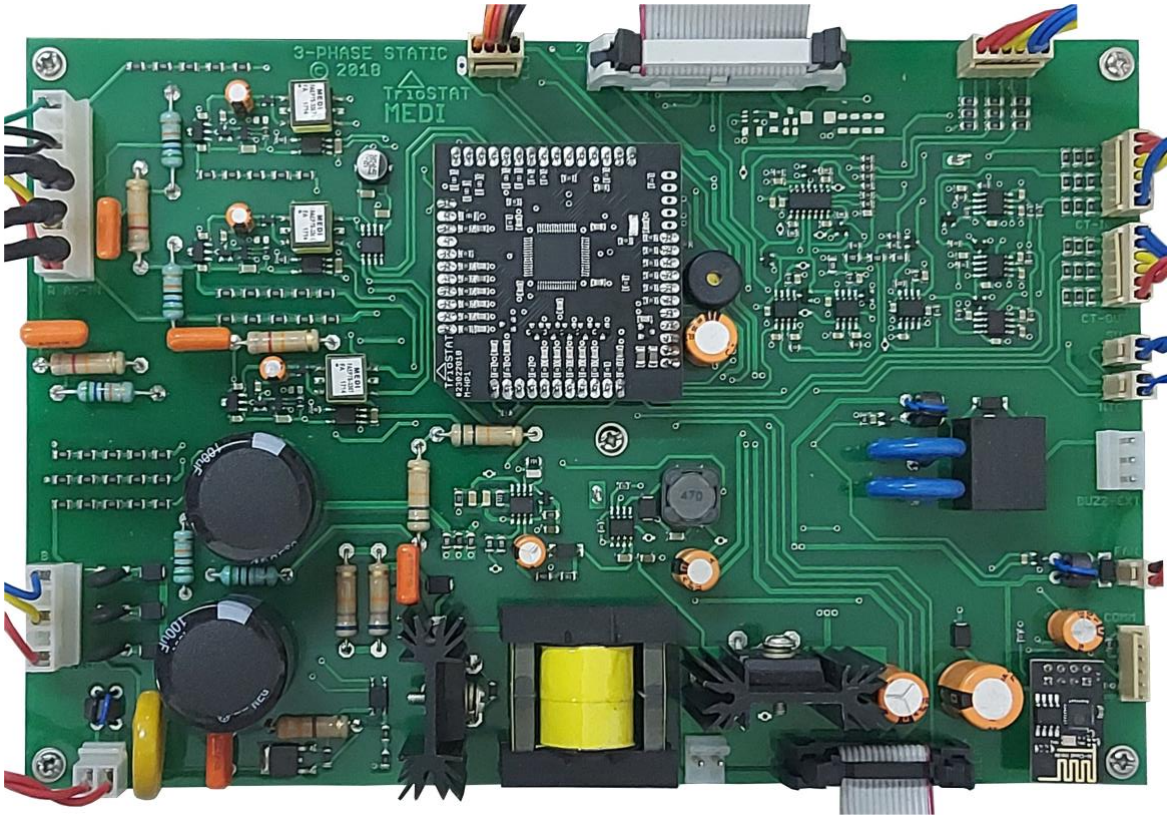
The control section is based on dsPIC controller which ensures quick correction of output which is not possible in conventional relay type or SCR tap changing stabilizer or servo controlled stabilizers. The circuit is having LCD display which will show all parameters like: input voltage, output voltage, connected load, your company name (We will program your company name in the dsPIC at the time of technology transfer) etc. All the parameters can be monitored using Wifi.

Since the circuit is fully solid state (no mechanical or moving parts) there will not be any wear and tear like the brush tear in servo stabilizer or relay degrading in relay based stabilizer.

This is especially useful in places where we need very fast correction speed, constant output voltage, overload current limiting and short circuit protection, soft start, high voltage cut-off and low voltage cut-off, uninterrupted automatic bypass, no wear and tear, long life and maintenance free which is impossible with other conventional type of stabilizers.

Why phase to phase correction??

In three phase commonly available voltage stabilizers are all correcting neutral to phase - relay type, servo stabilizer, SCR tap changing, even IGBT PWM type stabilizer. In a neutral to phase PWM system, if the load is non-linear there will be heavy neutral current. In case of imbalanced loads also there will be a neutral current.



TrioStat three phase Static Voltage Stabilizer single card up to 200KVA

The common approach to Static Voltage Stabilizer is, the PWM regulation is done between neutral and phase. However, in TrioStat the PWM regulation is carried out between phase and phase. This leads to a number of advantages –

> For the PWM (voltage regulation) there is no need to depend on the neutral.

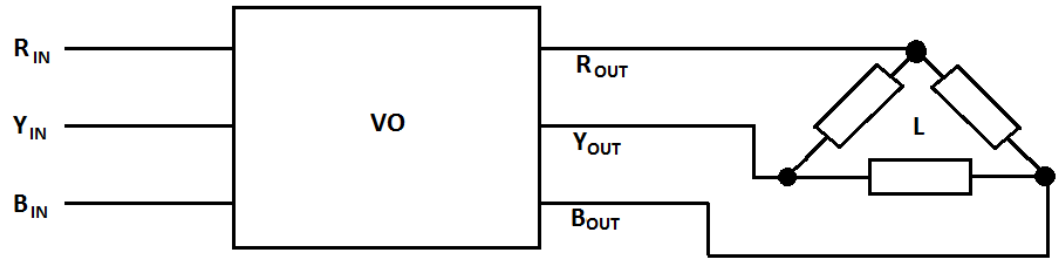
> The neutral will not shift due to IGBT PWM (voltage regulation) – the stabilizer will not cause the neutral to shift, only load or conditions can be responsible for neutral shift.

> Single control card for three phase unit makes the BOM less.

Sometimes, if the input neutral is floating or of high impedance at the time of load imbalance there will be a high drift in voltages in the three phases with respect to neutral of the voltage stabilizer; this will cause reliability issues for the voltage stabilizer. Due to imbalanced load or non-linear load, the voltage stabilizer should handle high neutral current so the voltage stabilizer should be designed in a way it should handle such high currents. Our phase to phase voltage stabilizing topology does not require any neutral to stabilize so these concerns do not come into picture.

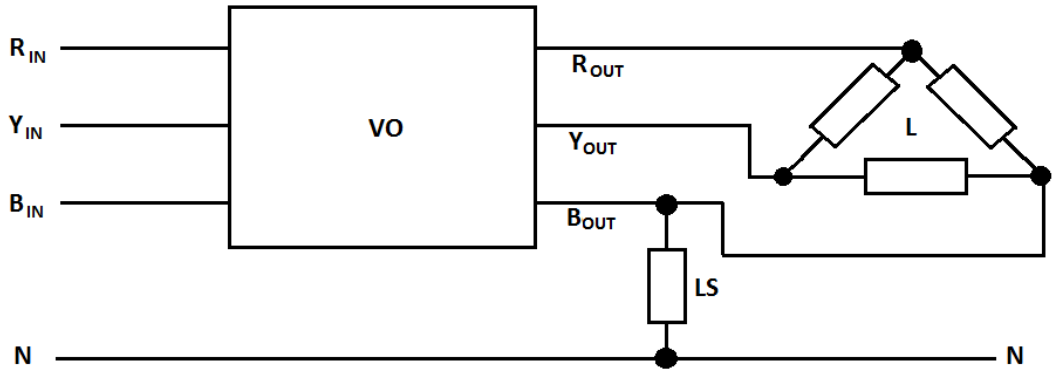
For three phase delta loads like three phase delta motor, delta input transformer etc regulating the voltage with respect to neutral and then feeding to delta is not reliable because it will depend on the neutral's quality. The balance in delta will change if there is any neutral open or neutral floating / high impedance. Phase to phase voltage stabilization is the most reliable method as the regulation of the output voltage is irrespective of the neutral. Neutral floating / high impedance will not affect the regulation of the voltage stabilizer.

For single phase loads, it can be connected from any one of the phases to the existing neutral. See the figure below -



(a)

Connection of 3-Phase Delta Load



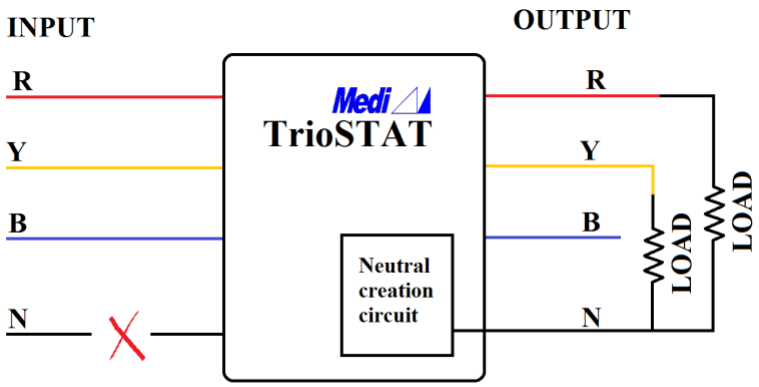
(b)

Connection of 3-Phase Delta Load and single phase load

Other advantage of TrioStat is only three half bridge IGBT modules are needed for three phase buck and boost voltage regulation.

FEATURES

- The PWM is done directly on Phase to Phase, not on neutral to phase. Output is regulated for phase to phase voltage and hence for existing neutral to phase voltage also. So Neutral not required for the working of the unit. PWM type voltage regulation results smooth variation of the voltage and no need of voltage tappings.
- Neutral quality or availability is not affecting the output regulation or working of the unit.



- Optional neutral creation circuit is provided for single phase loads incase of neutral failure
- IGBT based PWM type voltage stabilizer has tight regulation and fast correction speed. Output regulation of +/- 1% unable to achieve with SCR tap changing/ servo stabilizers etc
- Only three half bridge IGBT modules required for the power stage making the cost tremendously low compared to conventional method of twelve half bridge modules for a three phase system
- Direct AC-AC conversion without rectifying to DC improves the efficiency, reliability and reduces the components
- Only the difference power is processed through the system resulting in small size buck-boost transformer and higher efficiency.
- 20KHz PWM control resulting silent operation and no distortion in output waveform.
- Automatic uninterruptable bypass in case of hazard
- Overload and short circuit protection provided
- Technology up to 200KVA three phase
- LCD to display all parameters
- Manual bypass possible
- System has built-in data logger (optional). All parameters are periodically saved to flash memory with date and time stamp.

EFFICIENCY

Efficiency calculation of a 100KVA unit
Input range : 330V to 430V (+/-13%)
Output voltage : 380V +/-1%
Output current : 150A

Transformer loss –
Transformer KVA : 13KVA
Transformer efficiency : 95%
i.e., Transformer loss = 5%
Therefore, 13KVA × 5/100 = 650VA

IGBT conduction loss of FF150R12RT4
IGBT current at full load : 22.8A
Vce(sat) collector-emitter saturation voltage in worst case : 2.1V
i.e., Conduction loss = 22.8A × 2.1V = 47.88W
Therefore, 47.88W × 3 IGBTs = 143.64W

Switching loss at 22.8A
T(on) loss at 22.8A is <4mJ
T(off) loss at 22.8A is <4mJ
T(on) + T(off) loss is <8mJ

Switching loss at 20KHz = 8mJ ×20000Hz = 160000mW
i.e, 160W × 3 IGBTs = 480W

Total loss –
Transformer loss : 650W
IGBT conduction loss : 144W
IGBT switching loss : 480W
Total loss : 1274W
i.e, 1.274KW

$$\text{Overall efficiency} = \frac{(100\text{KW} - 1.274\text{KW})}{100\text{KW}} \times 100 = 98.726\%$$

Efficiency of a 100KVA system is 98.726%

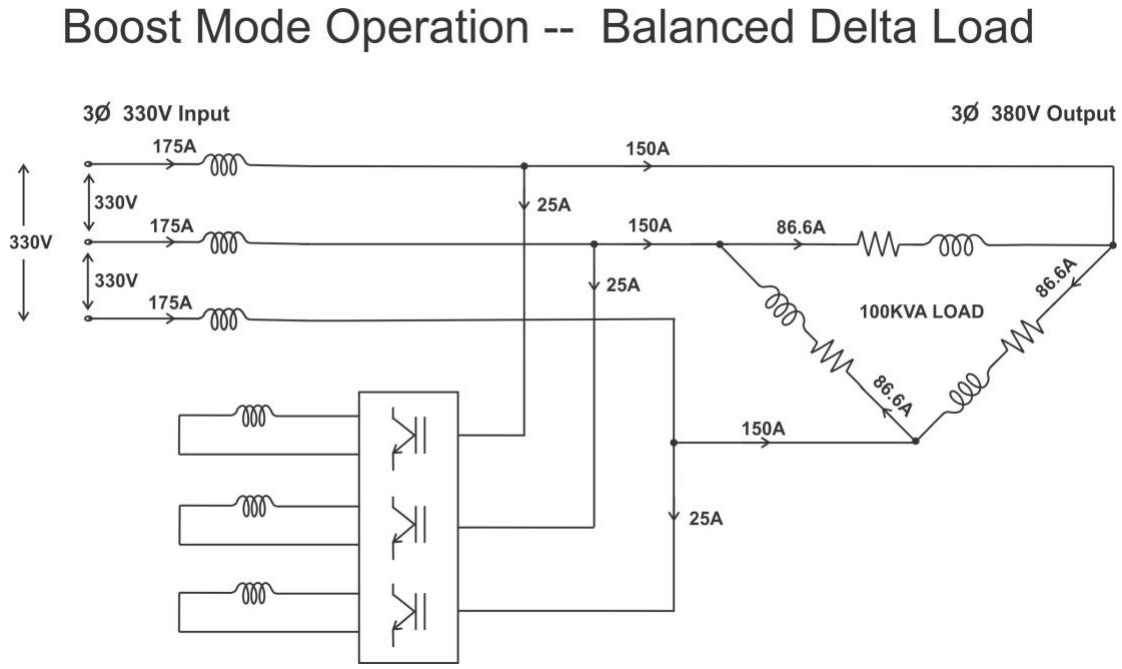


figure 1

In figure 1, you can see the boost mode current and voltage for delta balanced load

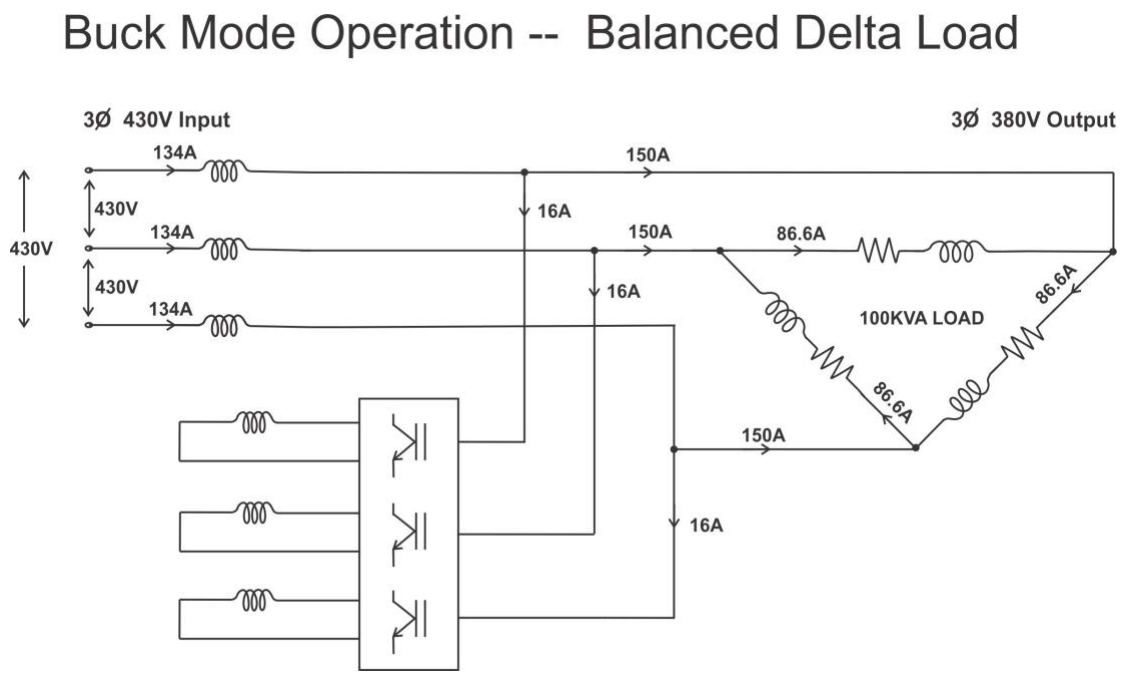


figure 2

In figure 2, you can see the buck mode current and voltage for delta balanced load

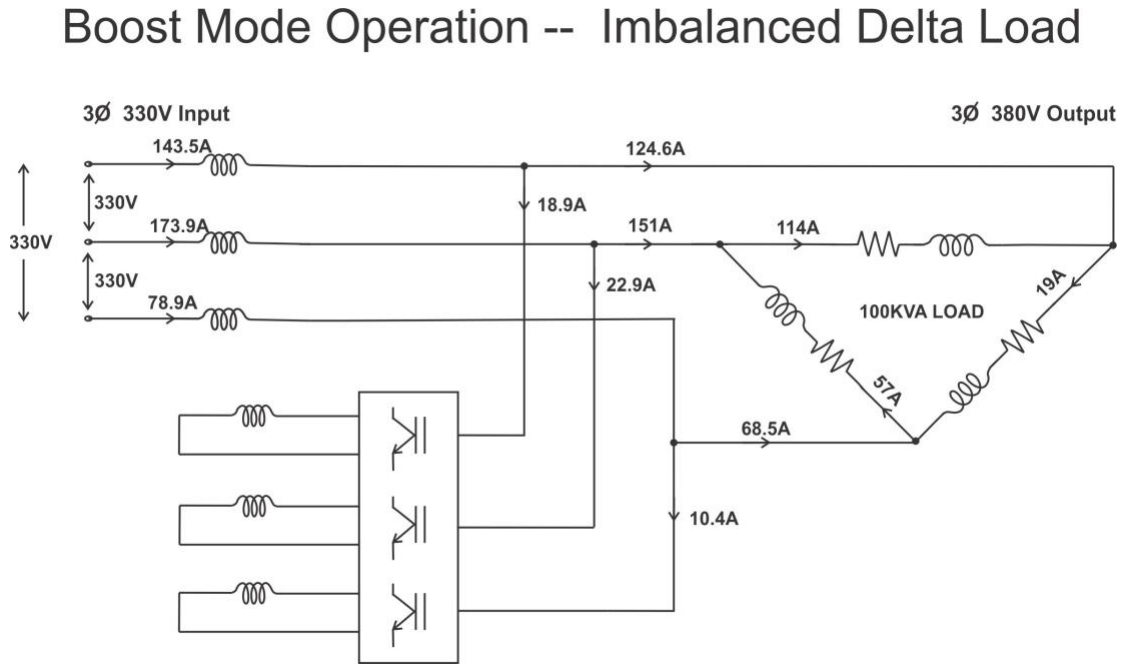


figure 3

In figure 3, you can see the boost mode current and voltage for delta imbalanced load

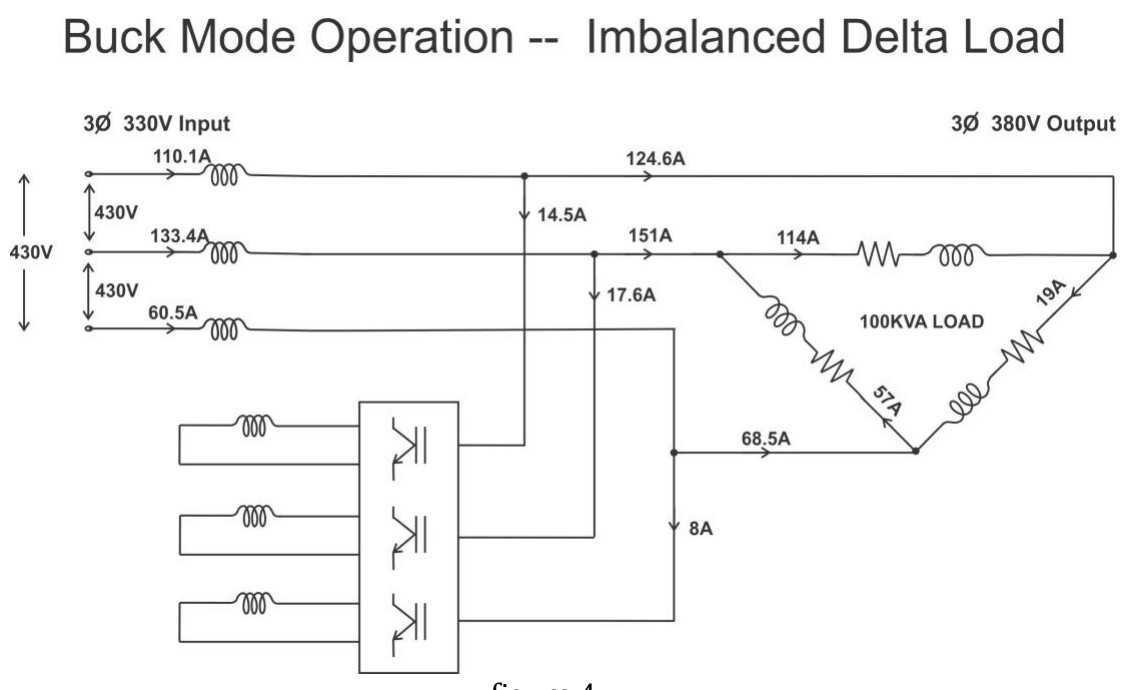


figure 4

In figure 4, you can see the buck mode current and voltage for delta imbalanced load

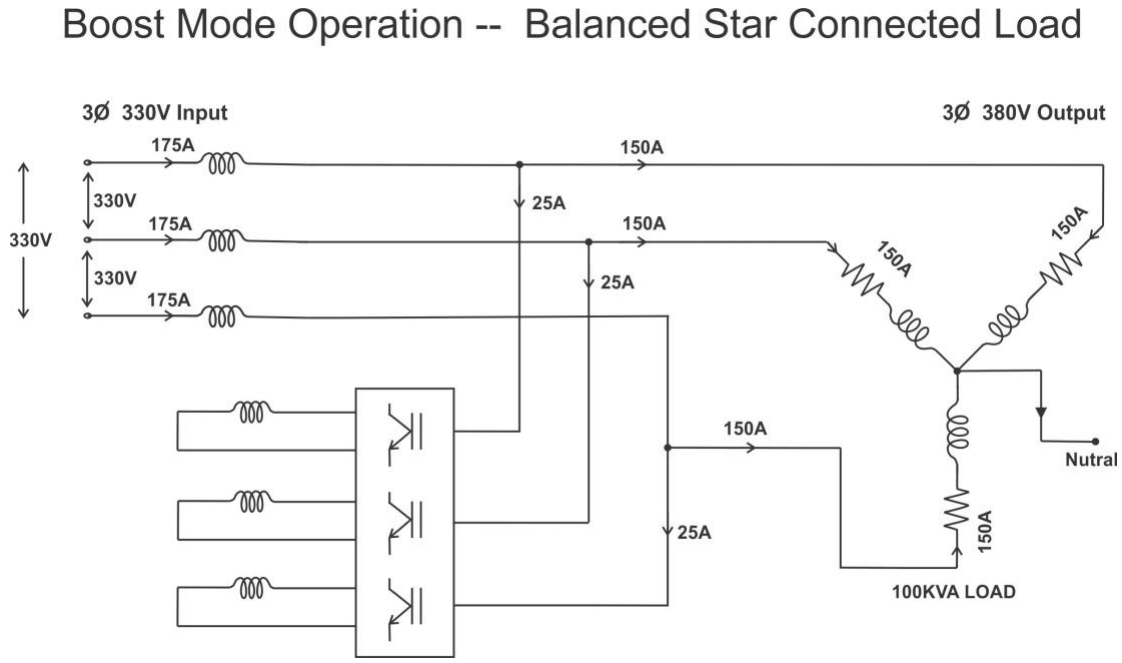


figure 5

In figure 5, you can see the boost mode current and voltage for star balanced load

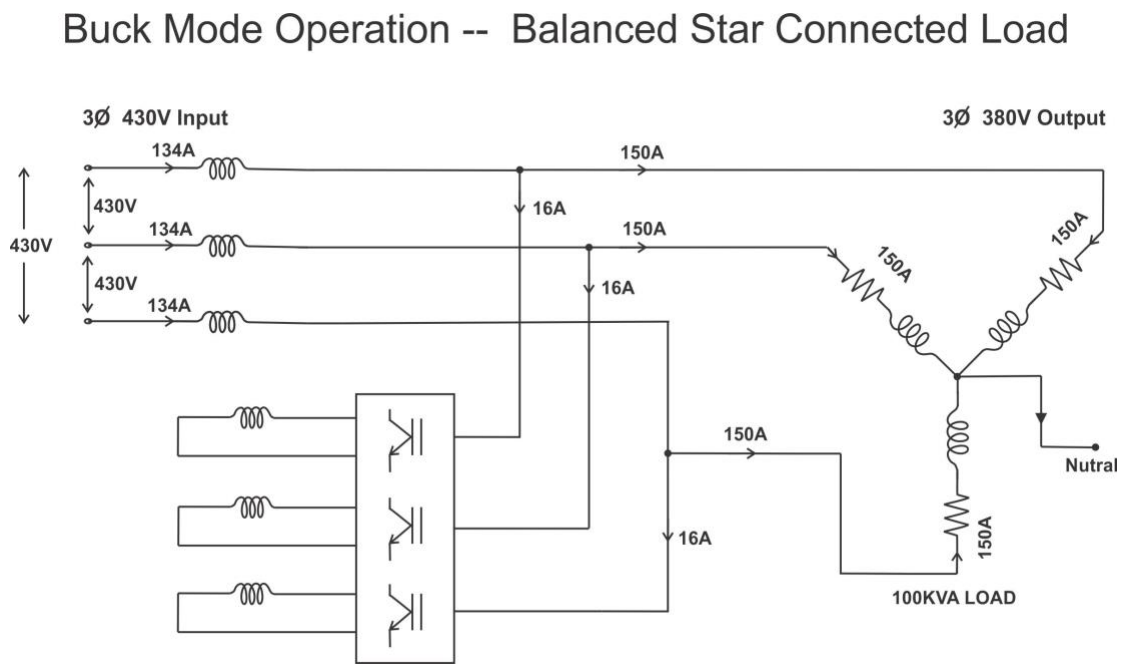


figure 6

In figure 6, you can see the buck mode current and voltage for star balanced load

Bypass arrangements

Internal bypass switch is already provided. This will give a bypass without any interruption in the output. The system will activate the internal bypass when there is any abnormal condition like excess temperature, excess load or any fault in the system. Additionally, if the system needs to be switched out of circuit so the site is supplied with mains electricity supply the system can be incorporated with a Manual Bypass switch.

The system is highly reliable and safe as it is fully electronic, there is no moving part which can cause damage due to wear and tear or require regular maintenance. All protections are inbuilt in the system to protect it in hazardous conditions. Active clamping, IGBT de-saturation protection and soft turn-off, Miller clamping to avoid shoot through conduction in IGBT power stage, short circuit protection, lightning and surge protection, EMI /RFI filter are all included in the system.

Thermal Management

The system will have a temperature sensor on the heatsink where IGBTs are mounted, if the temperature rises above the set limit, the fan will switch on and when the temperature comes down the fan will switch off. If for any reason the fan stops working or gets damaged and the temperature reaches above excess temperature limit, the system will go on automatic bypass without interruption (make before break) and will shut down the PWM. When the temperature reaches back to the safe limit, the stabilizer will come back to normal working without interruption. The system will indicate fault signal through buzzer and display on LCD.

PROTECTIONS

The unit comes with all kinds of protections – high voltage cut, low voltage cut, high temperature, overload / surge protection and short circuit. The system can take up to 10 times surge so running a three phase motor load is convenient. Short circuit protection is provided for both phase to phase and phase to neutral.

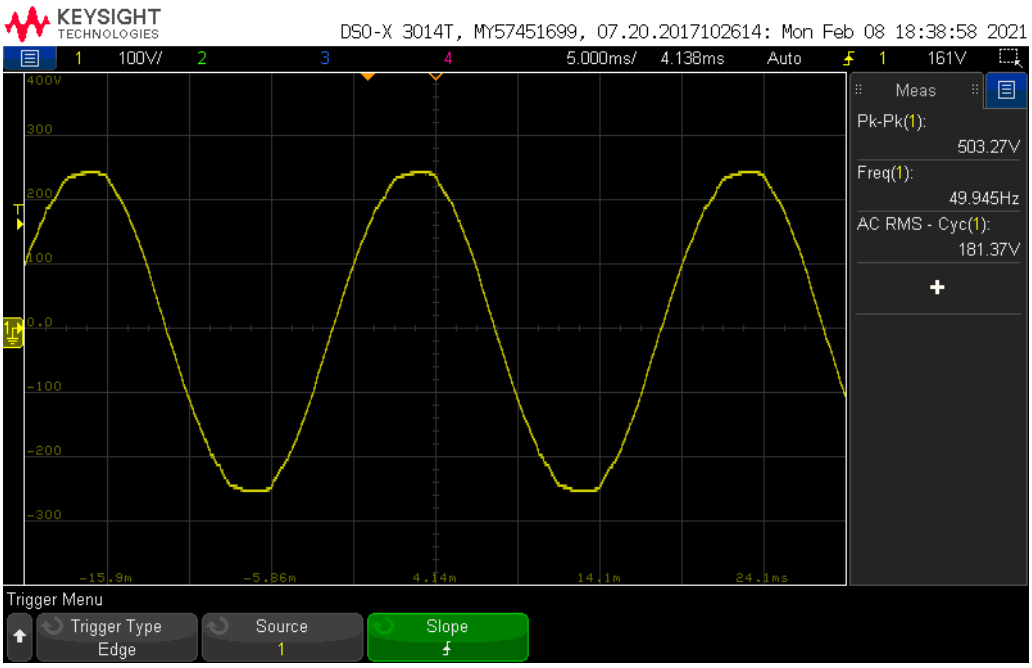
The system can handle all types of loads – inductive, resistive, capacitive, non-linear or any mixed loads. The unit also works in 100% imbalanced load.

Feature of Earth Voltage protection is also provided – the system will sense the Earth Neutral Voltage and will go to cutoff incase of excess voltage. This feature can be enabled (Earth voltage trip level is settable) or disabled as per choice.

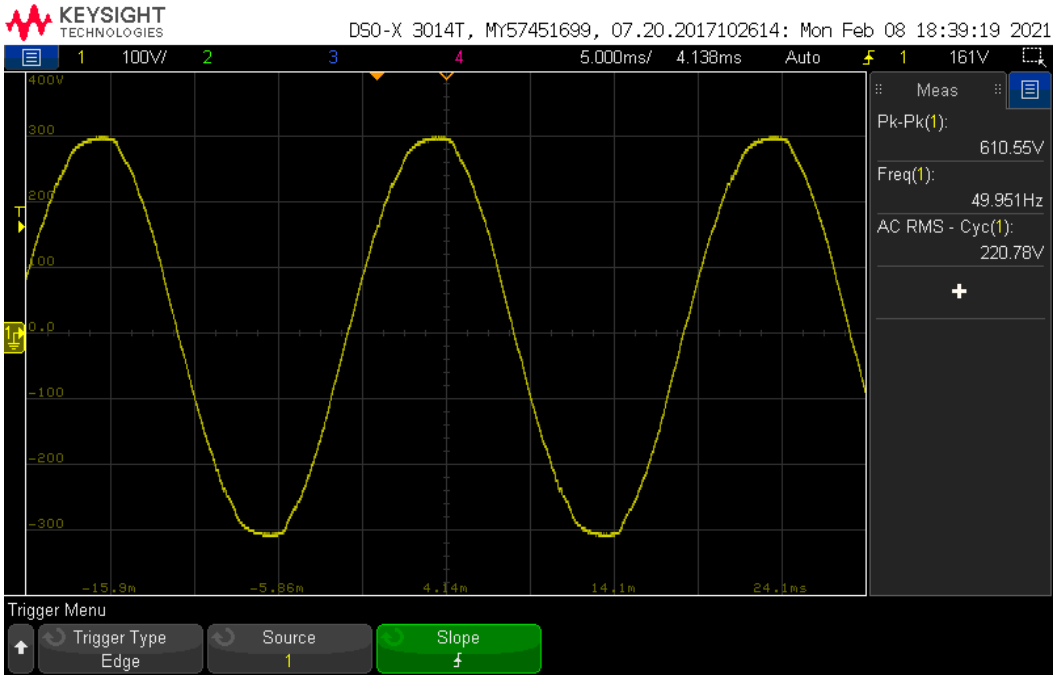
The unit also has incorrect phase sequence protection. This is especially useful in places where three phase motors rotation direction is very important. When this feature is enabled, if the incoming phase sequence is reverse, the unit will not switch on and will display on LCD with warning “Phase Sequence Reverse”.

WAVEFORMS

Input voltage



Output voltage (Input to the IGBT)



Output from the IGBTs going to primary

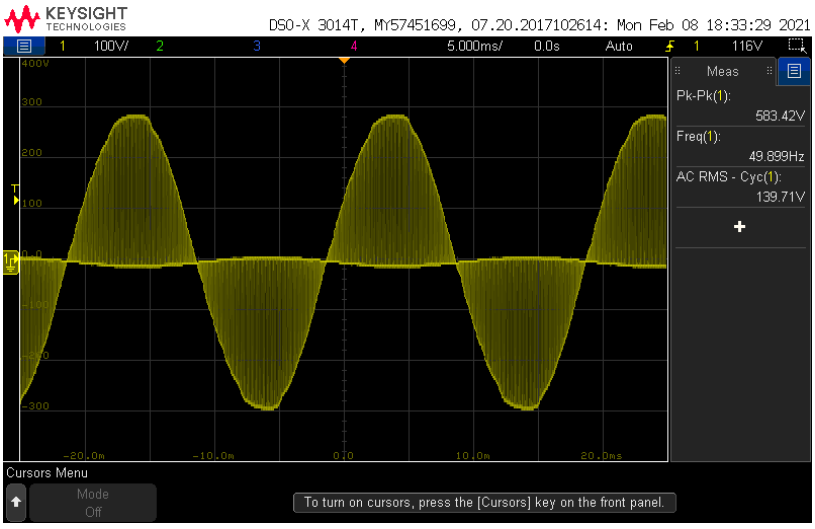


Figure 1: Output from IGBT connected to primary

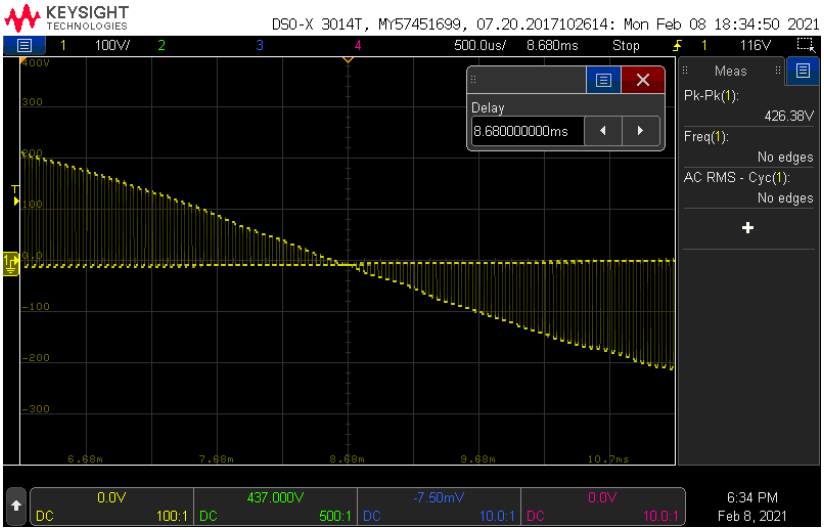


Figure 2: Output from IGBT connected to primary(zoomed)

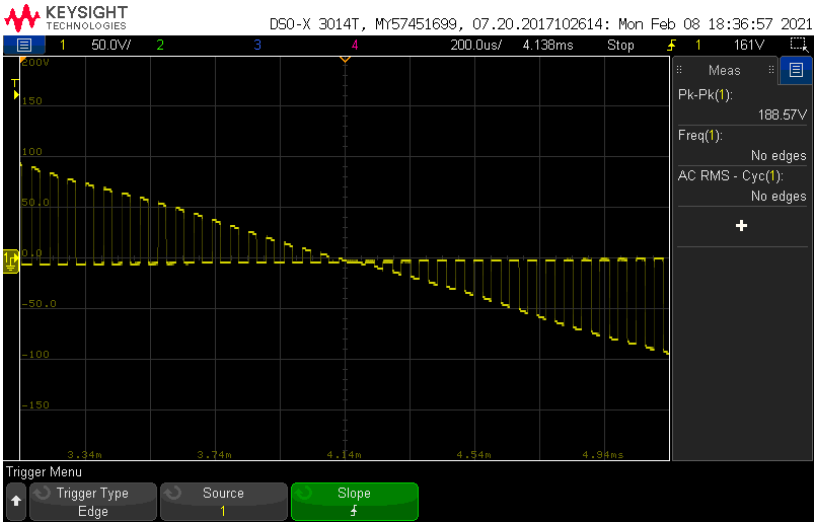


Figure 3: Output from IGBT connected to primary (more zoomed)

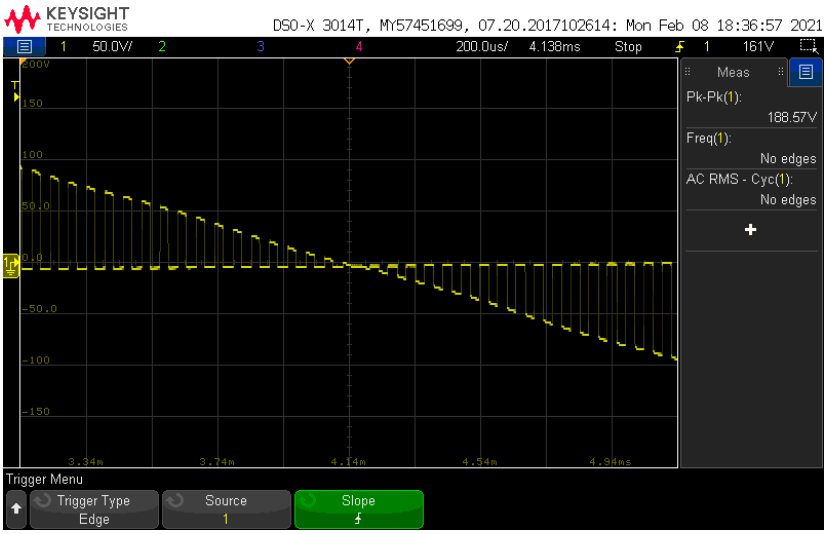
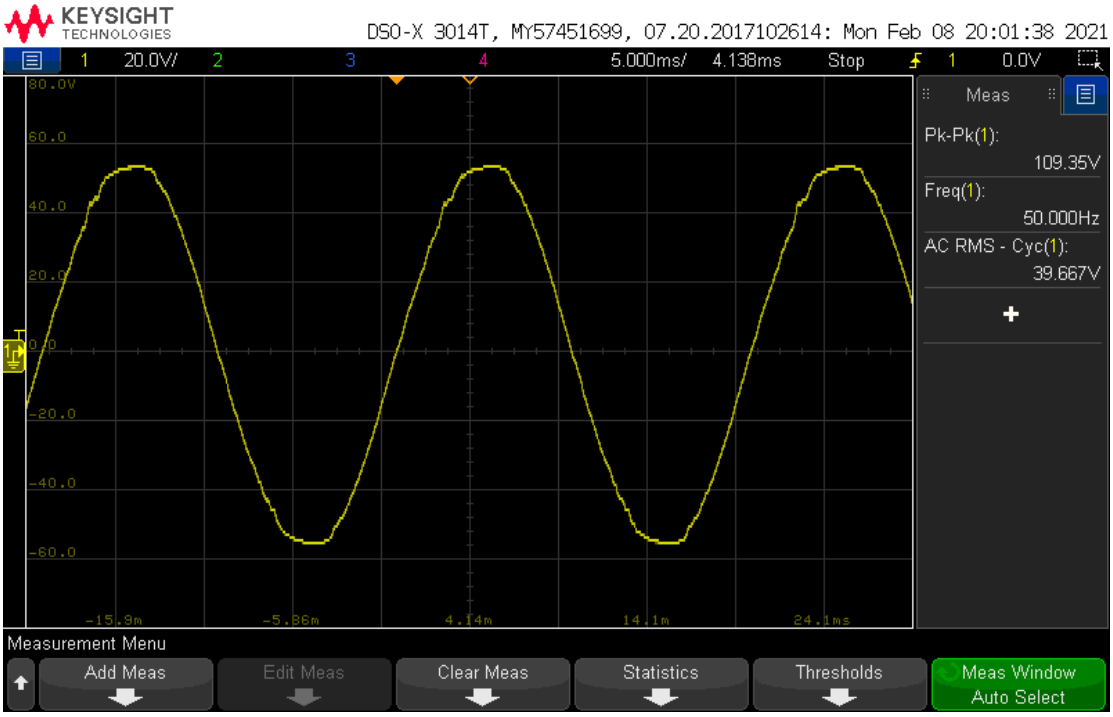


Figure 4: Output from IGBT connected to primary (even more zoomed)

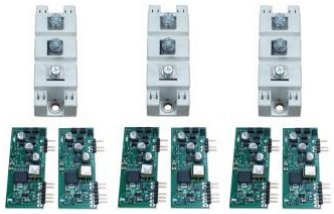
Across secondary of buck boost transformer



Comparison between Servo Stabilizer, QUIKorrect Static Stabilizer and TrioStat three phase Stabilizer

SERVO STABILIZER	QUIKORRECT	TRIOSTAT
Wear and tear with moving parts	No moving part, fully electronic	No moving part, fully electronic
Bulky transformer for full capacity	1/10th size of the rated VA	1/10th size of the rated VA
Single phase & three phase	Single phase & three phase	Three phase only
Individual phase correction possible	Individual phase correction possible.	Individual phase correction not possible. All phases can be increased or decreased together
3 single phase Buck-boost transformer for 3-phase	3 single phase Buck-boost transformer for 3-phase	1 three phase buck-boost transformer for 3-phase
Slow regulation	Tight regulation <1%	Tight regulation <1%
Slow correction speed approx 60V/sec	Super fast correction speed of 20000V/sec	Fast correction speed of 5000/sec
Neutral to phase correction method. Neutral required for operation	Neutral to phase correction method. Neutral required for operation	Phase to phase correction method. Neutral not required for operation
Interruption or cut off during heavy surge load (>10 times of full load)	Uninterrupted bypass during heavy surge load (>10 times of full load)	Uninterrupted bypass during heavy surge load (>10 times of full load)
NA	Uninterrupted restore to stabilizer mode after surge	Uninterrupted restore to stabilizer mode after surge
Oil cooling for high power	Forced air cooling for high power	Forced air cooling for high power

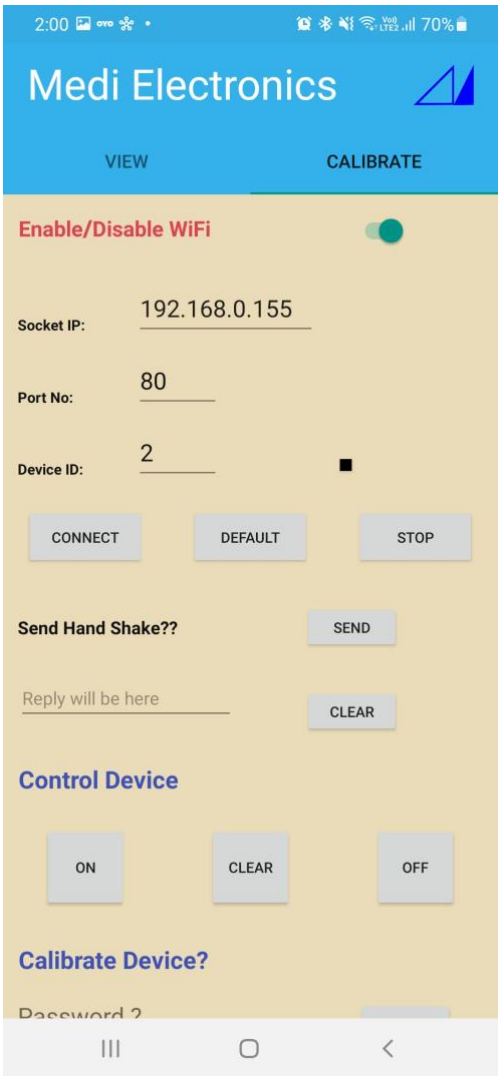
12 IGBT modules and 24 drivers used in existing Static Voltage Stabilizers including QUIKorrect for a three phase stabilizer

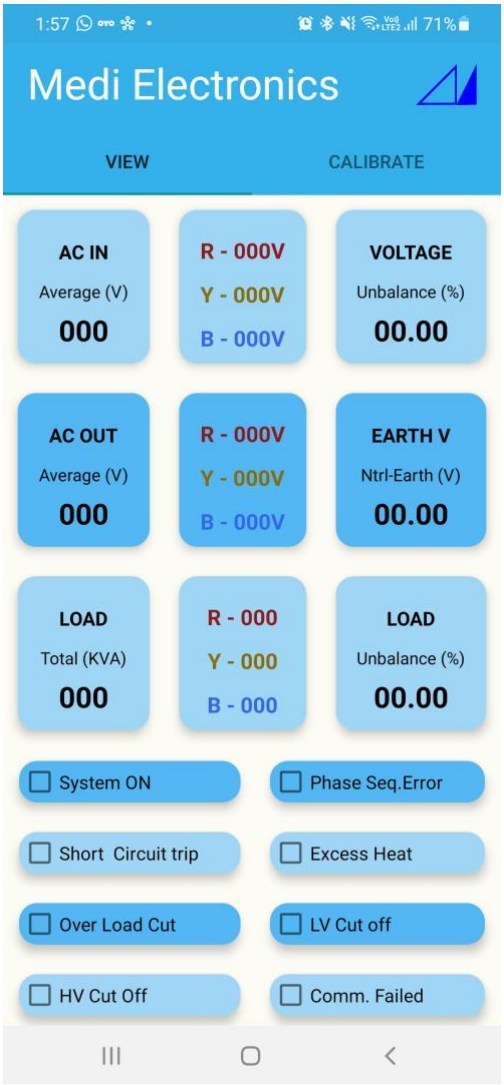


In TrioStat, only 3 IGBT modules and 6 drivers are enough for a three phase stabilizer

Wifi and mobile connectivity

The unit is equipped with Wifi connectivity to mobile phone as well as internet. The parameters can be monitored and controlled using mobile phone.





The system also sends periodic data to the internet server for remote data logger application.

File Home Insert Page Layout Formulas Data Review View

A1 ISTdate

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	ISTdate	Input R	Output R	R Load %	Input Y	Output Y	Y Load %	Input B	Output B	B Load %	PWM Active	Front Switch	System State	Fan On / Off	Overheat
2	05-09-20 9:15	231	219	20	236	219	0	237	219	0	Y	Y	Y	N	N
3	05-09-20 9:16	232	219	20	236	219	0	236	219	0	Y	Y	Y	N	N
4	05-09-20 9:16	233	219	20	236	219	0	234	220	10	Y	Y	Y	N	N
5	05-09-20 9:17	232	219	20	238	219	0	235	220	10	Y	Y	Y	N	N
6	05-09-20 9:17	231	219	30	235	219	0	235	220	10	Y	Y	Y	N	N
7	05-09-20 9:18	233	219	20	235	219	0	233	219	10	Y	Y	Y	N	N
8	05-09-20 9:18	230	220	30	235	219	0	233	219	10	Y	Y	Y	N	N
9	05-09-20 9:19	227	220	30	235	220	0	233	219	10	Y	Y	Y	N	N
10	05-09-20 9:19	227	220	30	235	219	0	233	220	10	Y	Y	Y	N	N
11	05-09-20 9:20	230	219	30	235	219	0	230	219	10	Y	Y	Y	N	N
12	05-09-20 9:20	226	220	30	236	220	0	233	220	10	Y	Y	Y	N	N
13	05-09-20 9:21	229	220	30	236	219	0	233	219	10	Y	Y	Y	N	N
14	05-09-20 9:21	229	219	30	235	220	0	232	219	20	Y	Y	Y	N	N
15	05-09-20 9:22	226	219	30	235	219	0	233	220	20	Y	Y	Y	N	N
16	05-09-20 9:22	229	219	30	236	219	0	232	220	20	Y	Y	Y	N	N
17	05-09-20 9:23	230	219	30	234	219	0	233	219	20	Y	Y	Y	N	N
18	05-09-20 9:23	231	219	30	234	219	0	233	219	20	Y	Y	Y	N	N
19	05-09-20 9:24	231	219	30	235	219	0	232	219	20	Y	Y	Y	N	N
20	05-09-20 9:24	230	220	30	235	219	0	236	220	20	Y	Y	Y	N	N
21	05-09-20 9:25	230	219	30	234	219	0	233	220	20	Y	Y	Y	N	N
22	05-09-20 9:25	231	220	30	235	220	0	232	220	20	Y	Y	Y	N	N
23	05-09-20 9:26	230	219	30	235	220	0	228	219	20	Y	Y	Y	N	N
24	05-09-20 9:26	233	220	30	234	220	0	233	220	20	Y	Y	Y	N	N
25	05-09-20 9:27	229	220	30	234	219	0	232	219	20	Y	Y	Y	N	N
26	05-09-20 9:27	231	220	30	234	220	0	237	220	0	Y	Y	Y	N	N
27	05-09-20 9:28	230	220	30	234	219	0	236	219	0	Y	Y	Y	N	N
28	05-09-20 9:28	229	219	30	235	219	0	236	219	0	Y	Y	Y	N	N
29	05-09-20 9:29	231	220	30	234	220	0	237	219	0	Y	Y	Y	N	N
30	05-09-20 9:29	231	220	30	235	219	0	236	219	0	Y	Y	Y	N	N
31	05-09-20 9:30	231	220	30	235	220	0	237	219	0	Y	Y	Y	N	N
32	05-09-20 9:30	232	220	30	234	219	0	236	220	0	Y	Y	Y	N	N
33	05-09-20 9:31	230	220	30	235	220	0	235	219	10	Y	Y	Y	N	N
34	05-09-20 9:31	232	219	30	234	219	0	233	219	10	Y	Y	Y	N	N

Bill of Material (BOM)

The approximate BOM of a 3phase 75KVA TrioStat = Rs.35,000

The approximate BOM of a 3phase 150KVA TrioStat = Rs.60,000

For video demo of the product, please click -
https://www.youtube.com/watch?v=x-FQRoKR5nQ&t=25s

Technology cost

Technology transfer up to 200KVA three phase – Rs.15 Lacs

Discount of Rs.10 lacs for all customers who have purchased MEDI's QUIKorrect static voltage stabilizer single phase up to 70KVA and three phase up to 200KVA.