International Copper Association India
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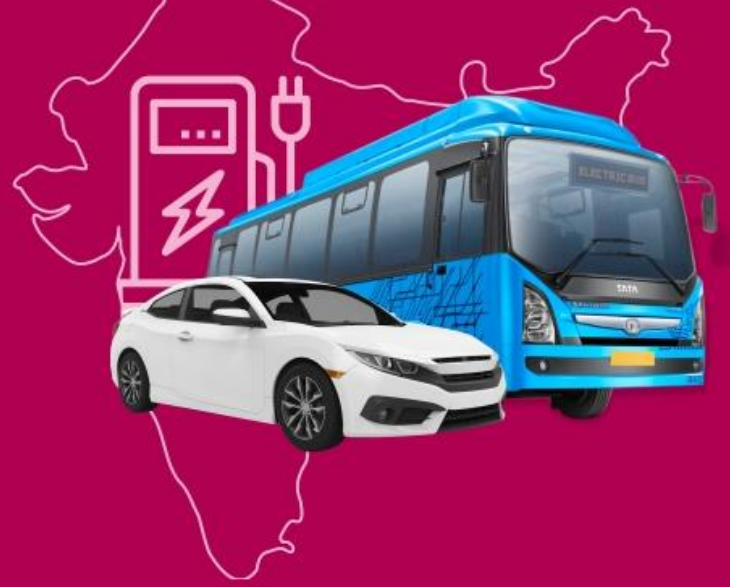
WEBINAR
30th October, Friday
4 pm to 5.30 pm



India's Electric Mobility Ambitions

Can Power Quality issues lead to a flat tyre?

PQ in practice, understanding the ghosts on the grid.....

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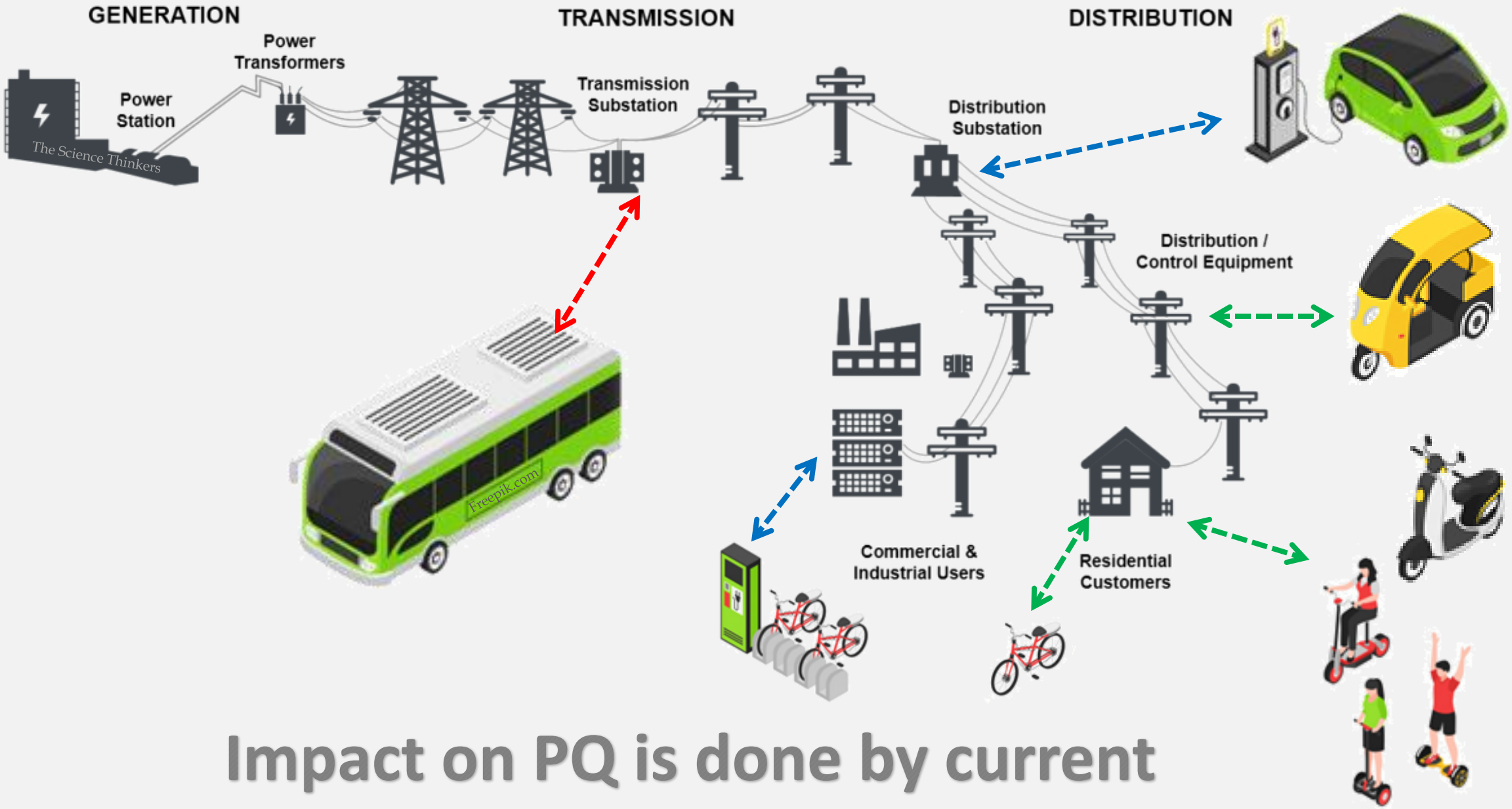
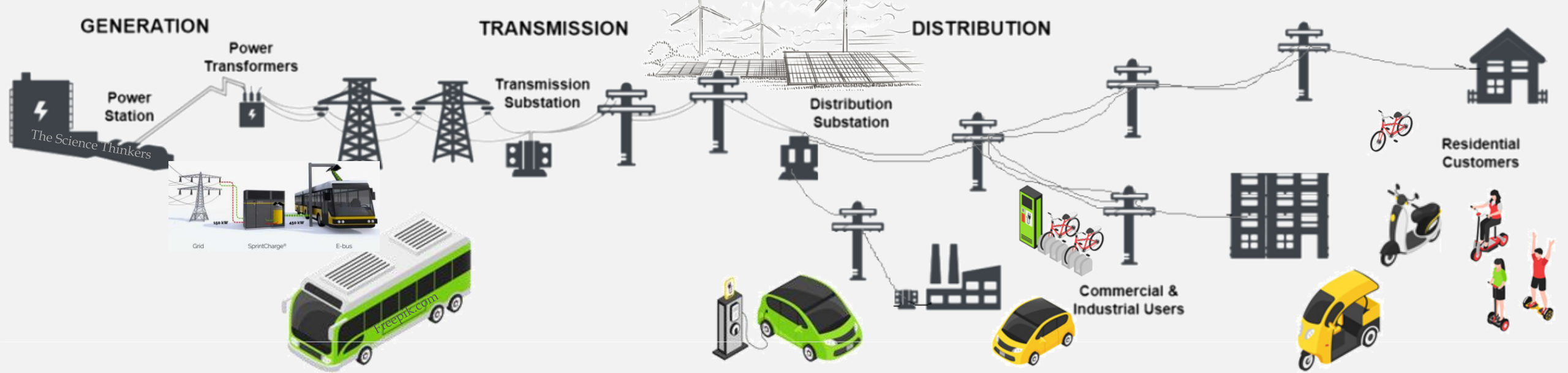
E. (Epko) Horstman MBSE BEng
30-10-2020

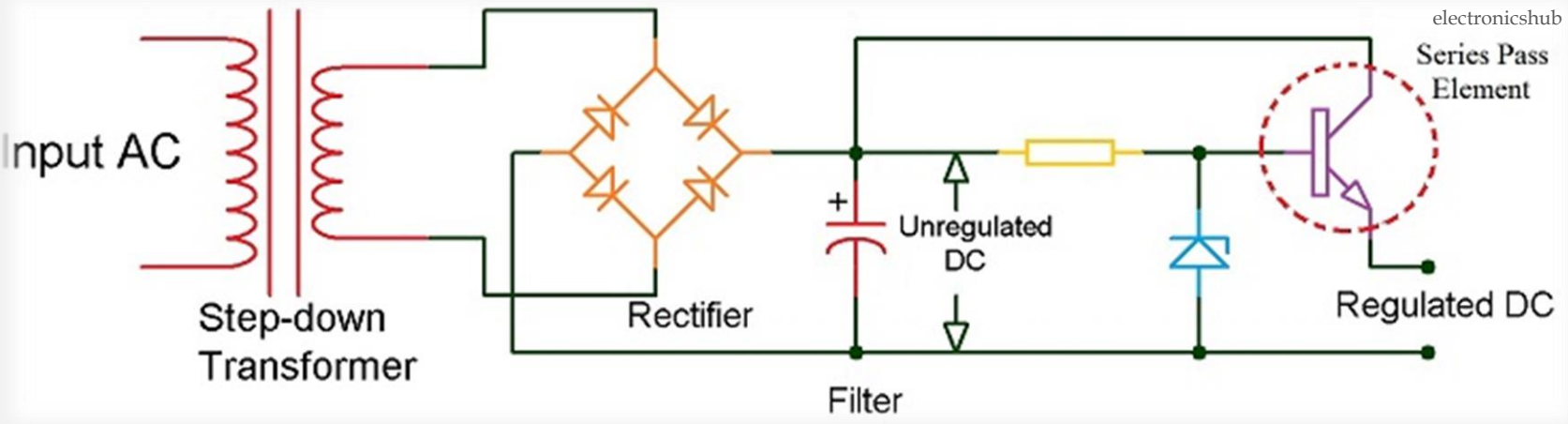


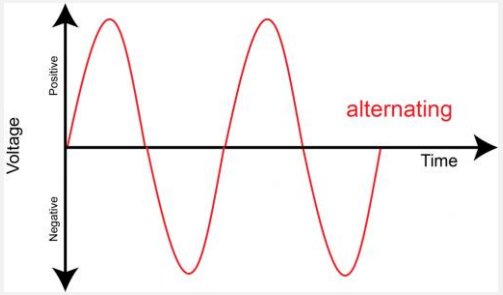
Impact on PQ is done by current

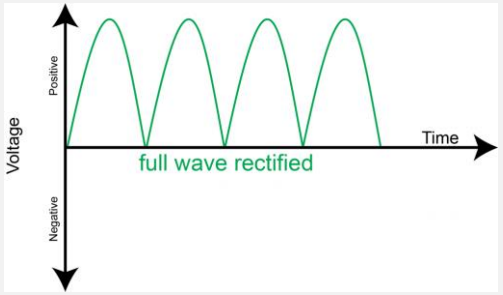


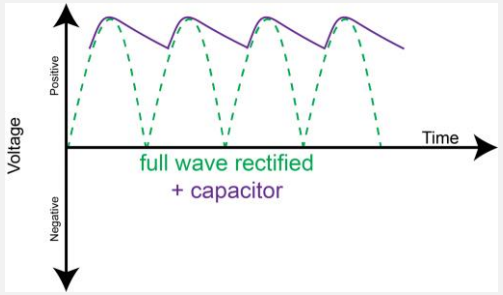
POC	HVAC grid mode 4	MVAC grid mode 4	LVAC mode 3	LVAC mode 3/2/1
	High power DC	DC fast charging	3~(+N)	1~+N
	1MW	100-900kW	7-100kW	<7kW
Strength	Stable POC, "noise immune", predictable	Fast		
Weakness	Location, connecting	High load, short time, high investment, battery C factor lifetime/warranty		
Opportunity	Pre charging locally	DSM, V2grid better than PV, swap		
Threat	Connectors, HV lines, non dedicated grid	Noise, connectors, TCO		
Focus on PQ	Energy management policy	Energy management policy		

1~N





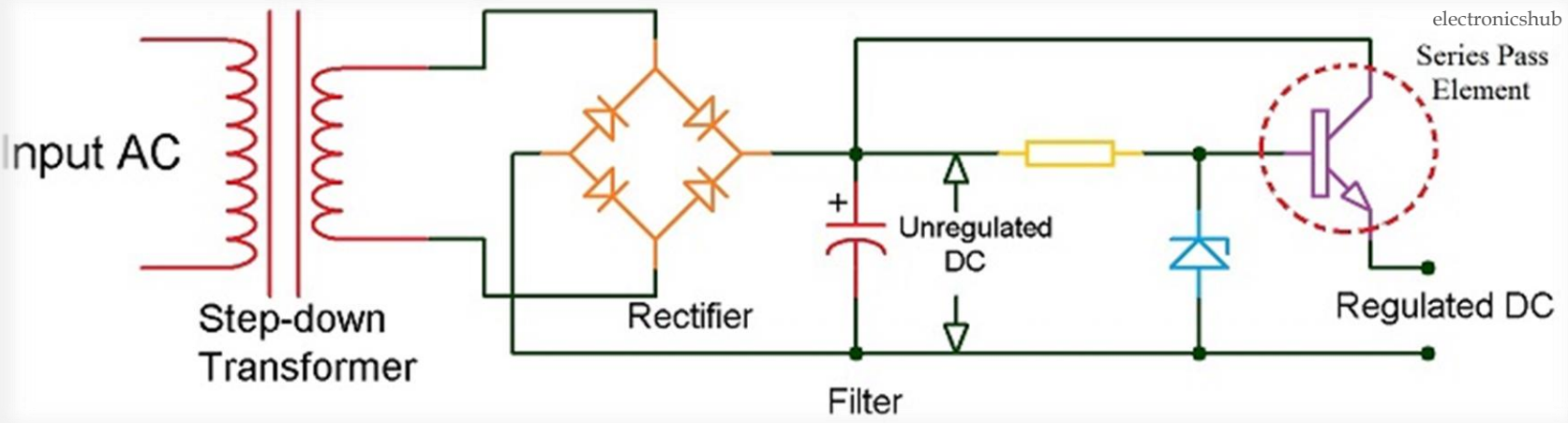


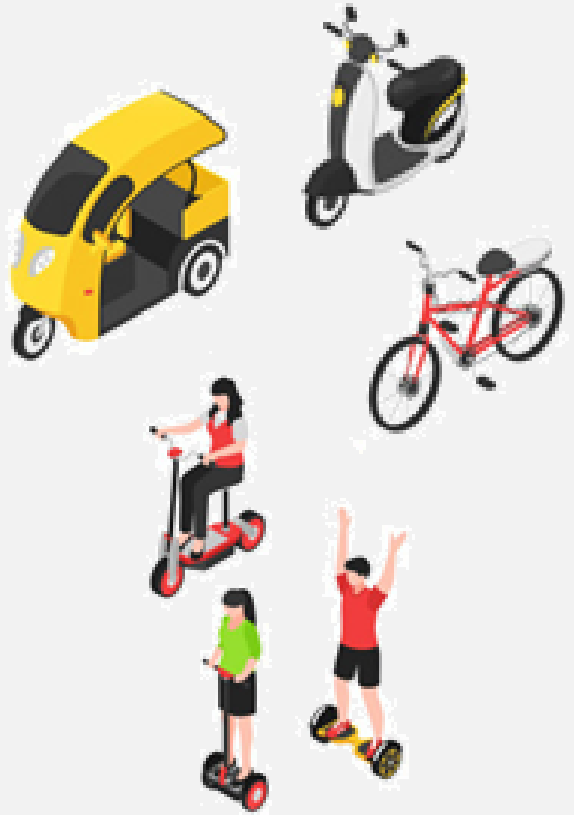


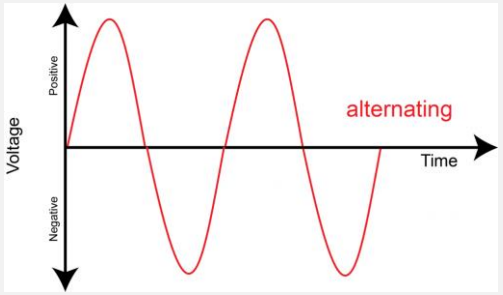
"Linear" period in the grid

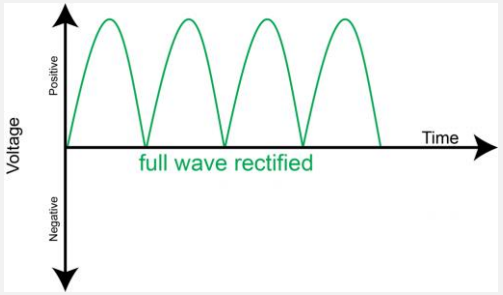
1906 - 1977 impact 1~ EV chargers to power quality was negligible

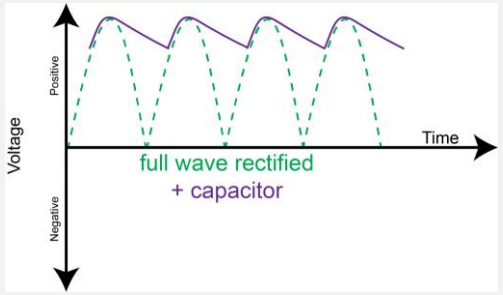
1~N







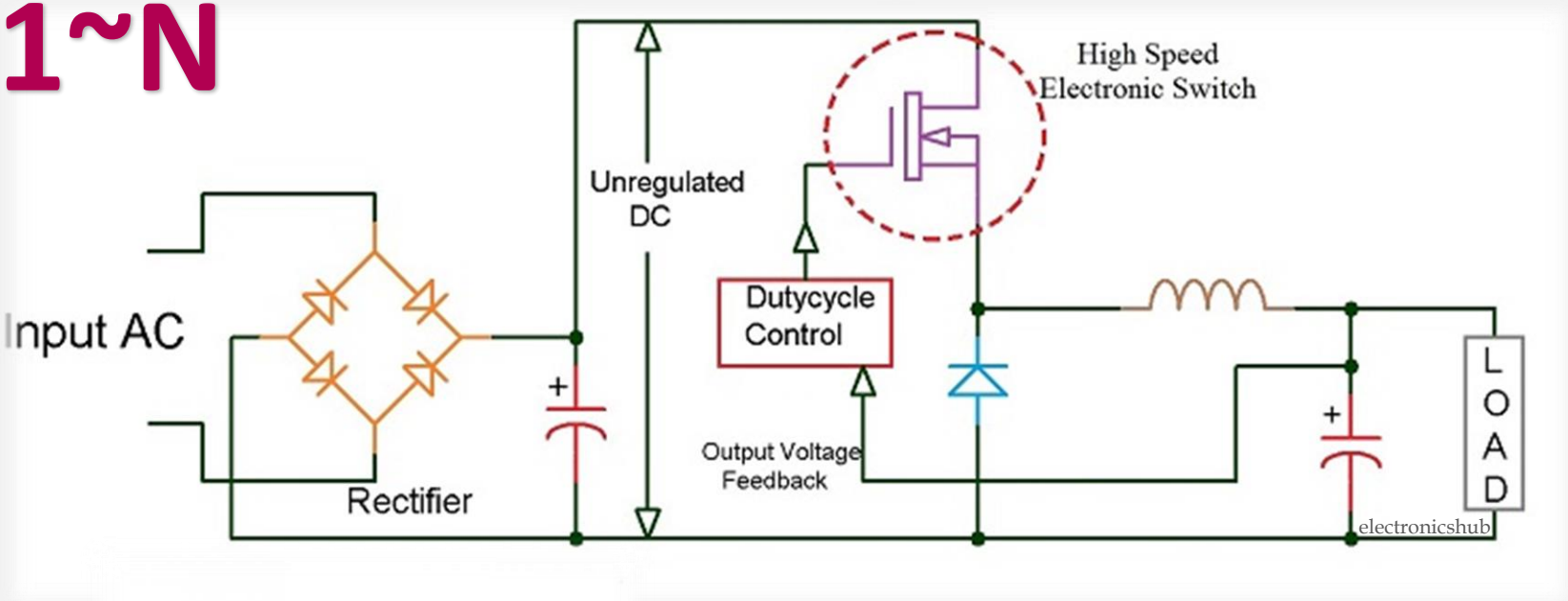


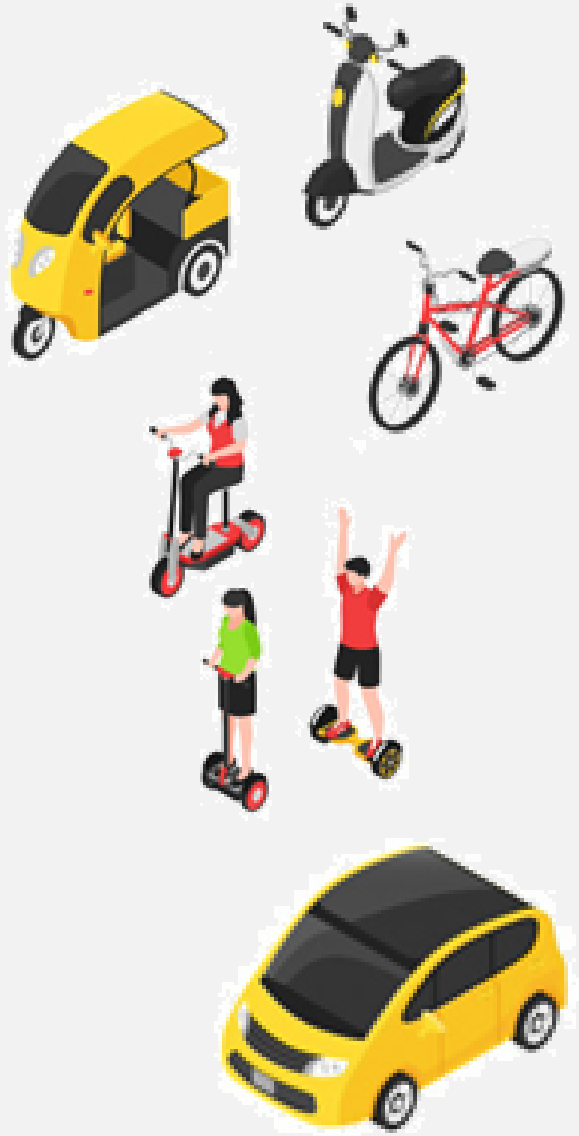


“Linear” period in the grid

Need for lower cost, lightweight, higher efficiency chargers

1~N

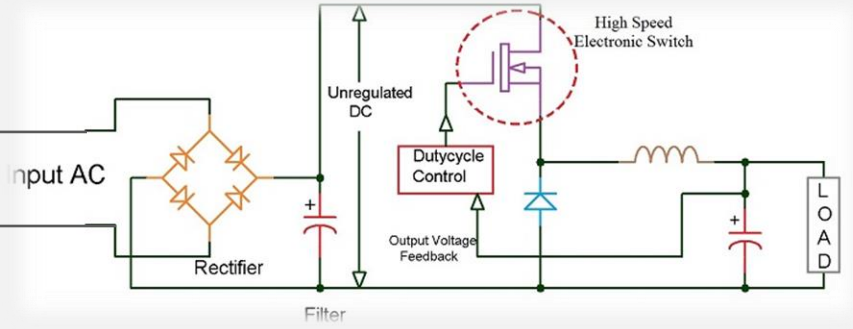


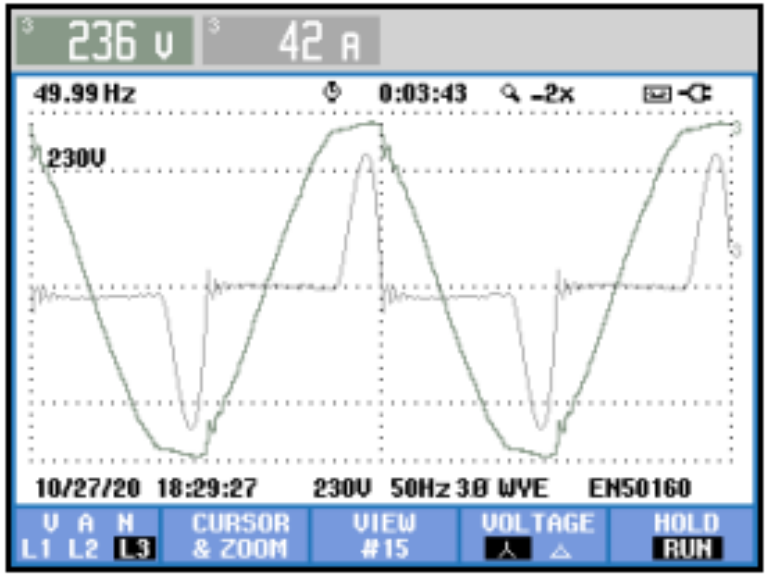


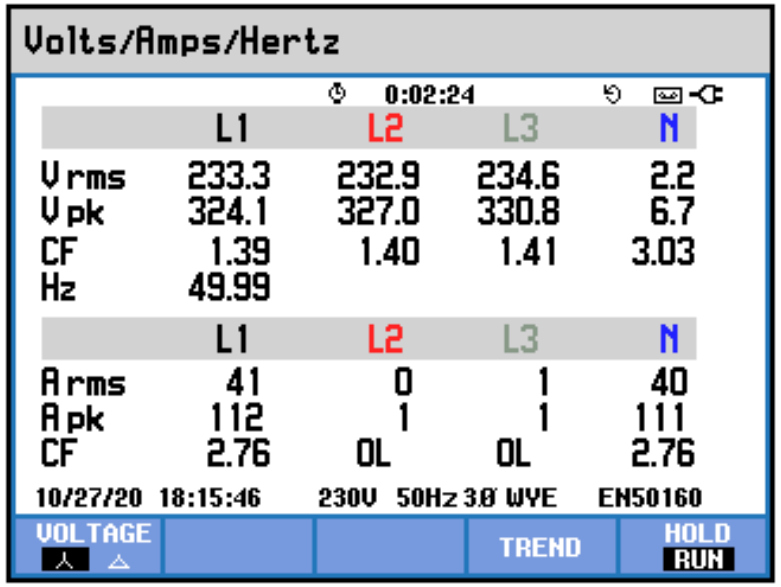
Switch Mode Power Supply - SMPS

From 1980's impact 1~ rectifiers introduced 3rd harmonics to power quality

1~N



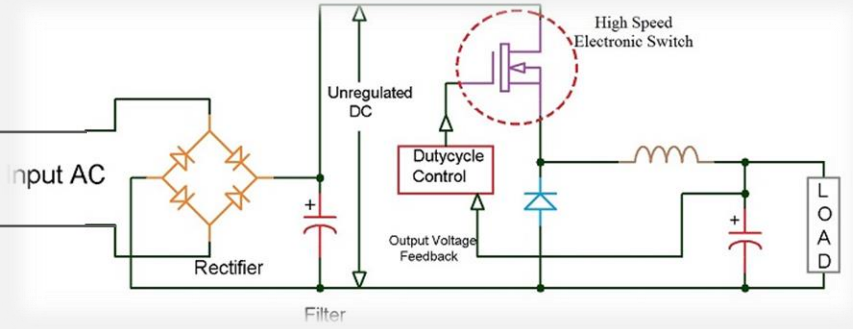


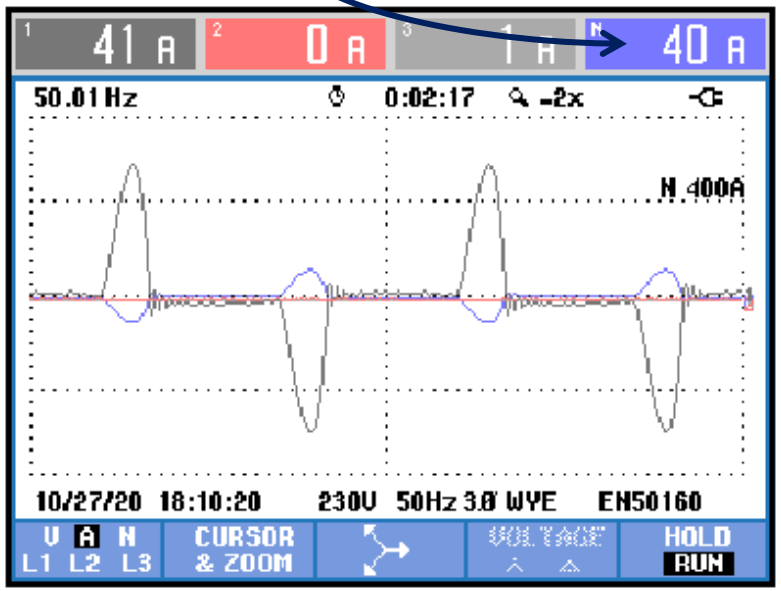


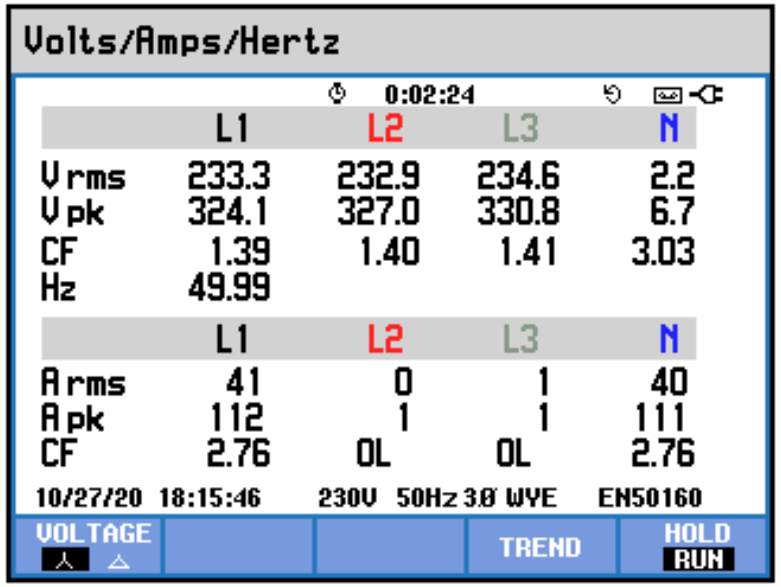
SMPS impact on PQ by high current draw at the peak

EV charger, laptop power supply, LED driver are all SMPS's

1~N



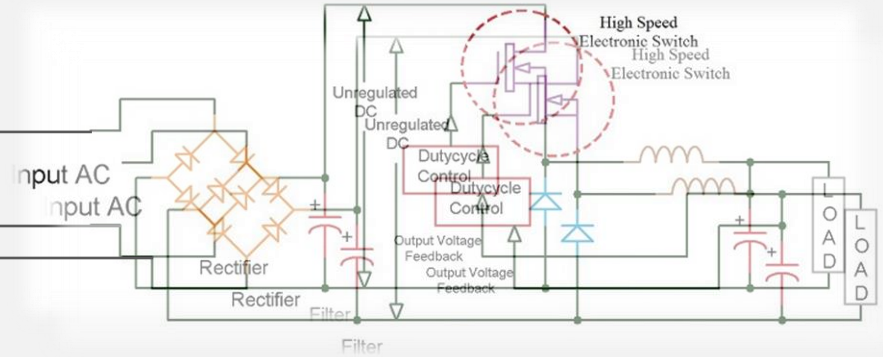


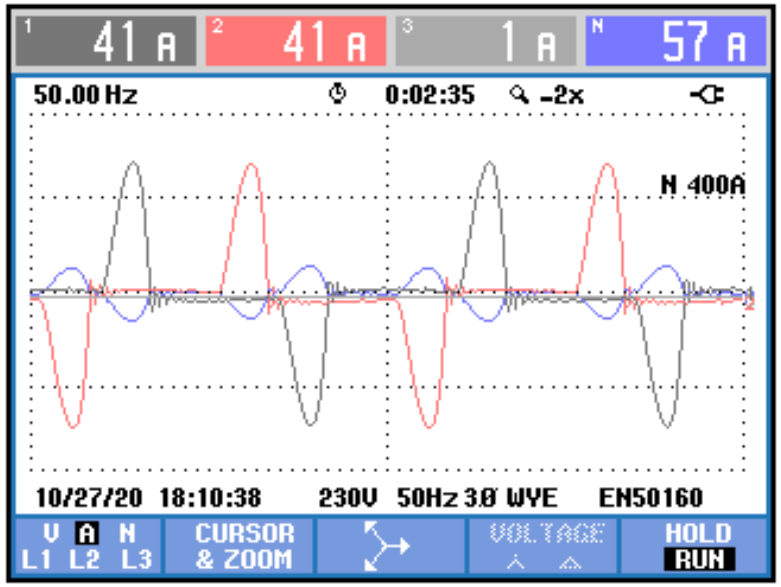


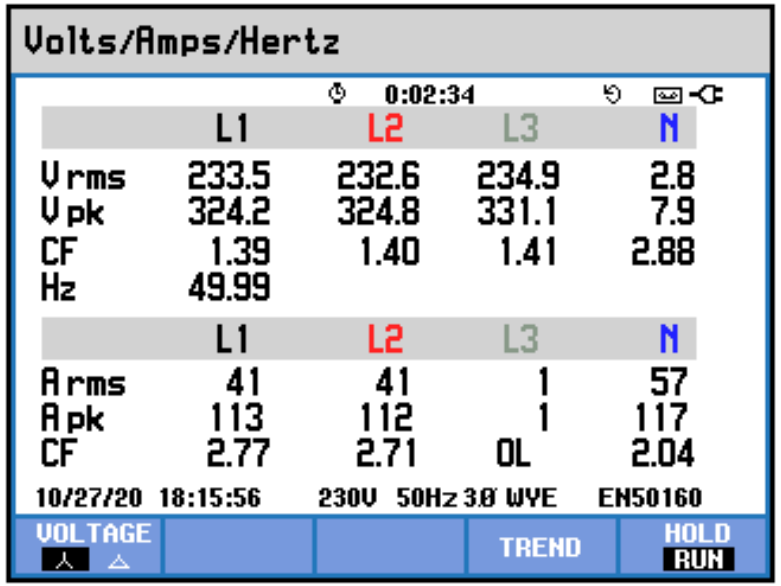
SMPS inrush current impact not in mode 3

Inrush currents mode 1 can trip earth leakage and overcurrent protection devices

2~N







Current in the neutral is higher than phase, normally at 3~ N reduces (120° verctor)

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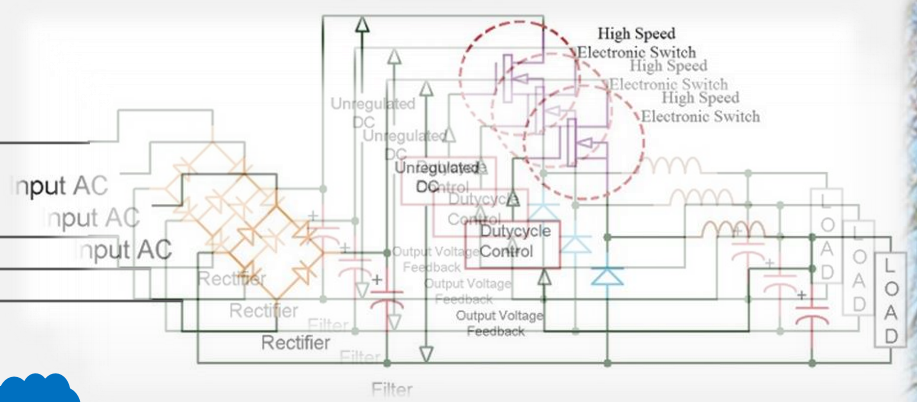
3~N



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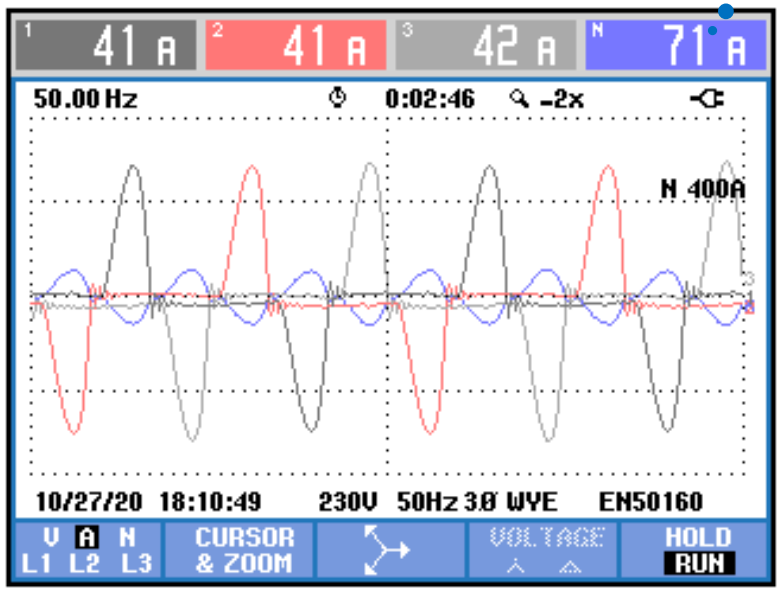

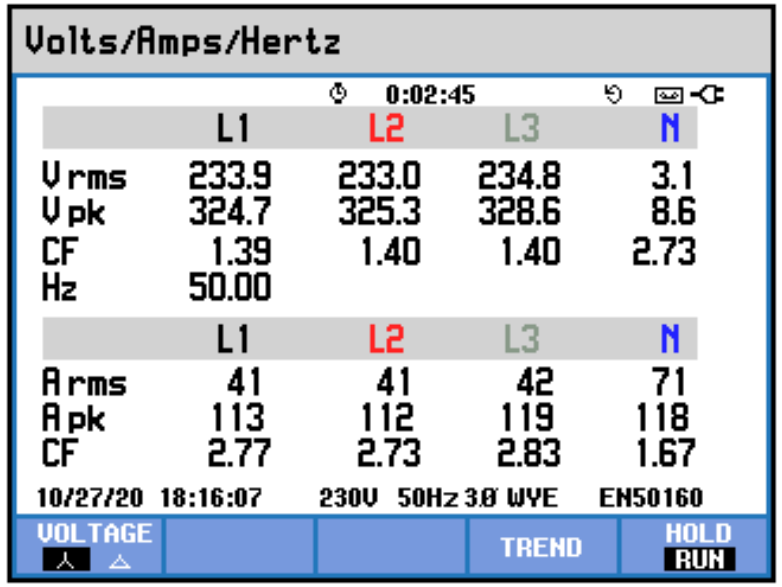

More current in the neutral, than in the 3 phases

1~ rectifiers introduce 3rd harmonics to power quality. Halve neutral no longer

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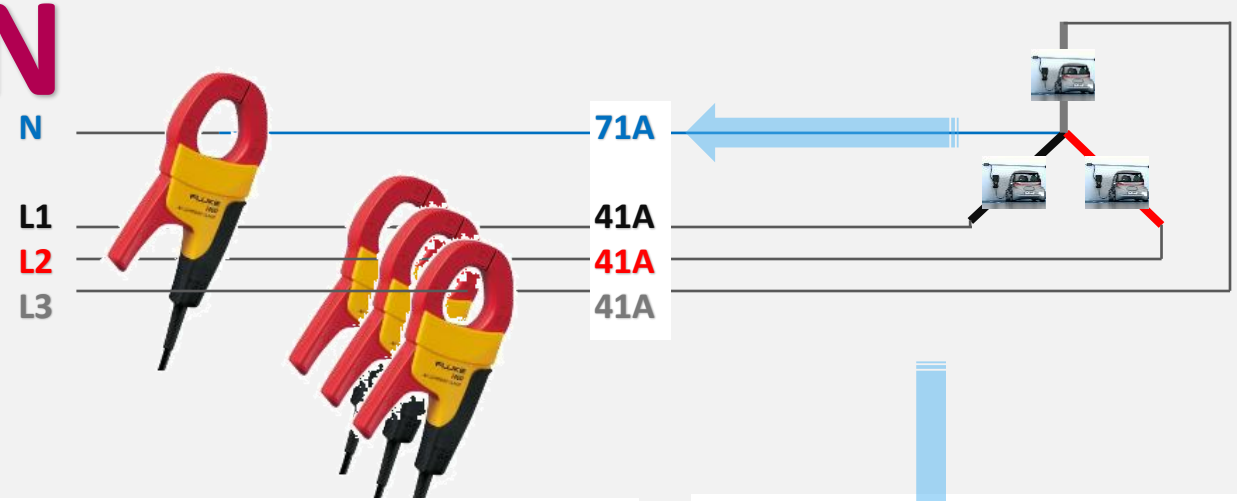
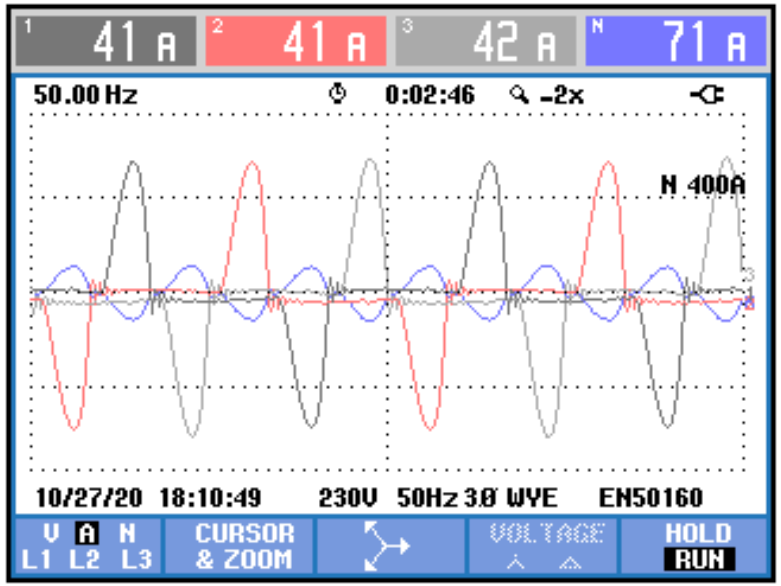
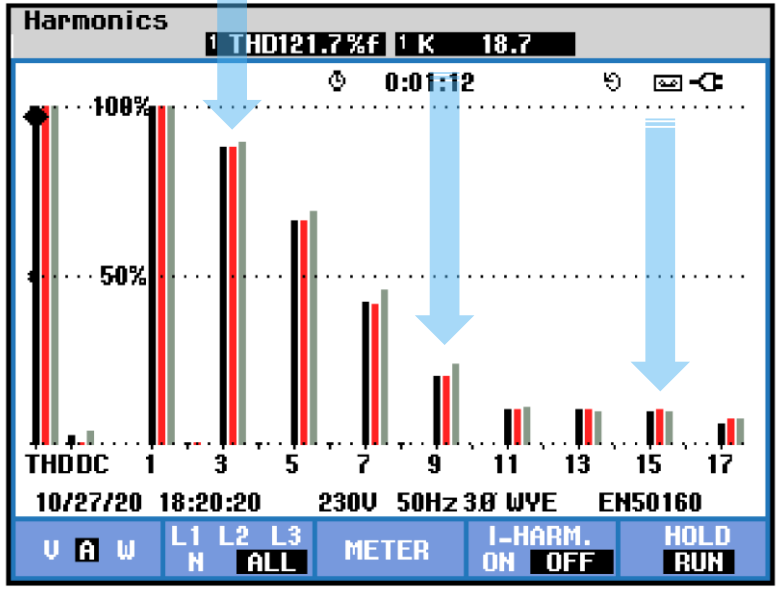
3~N







More current in the neutral, than in the 3 phases

The 3rd harmonic series sum themselves in the neutral. Design bigger N wire in cables

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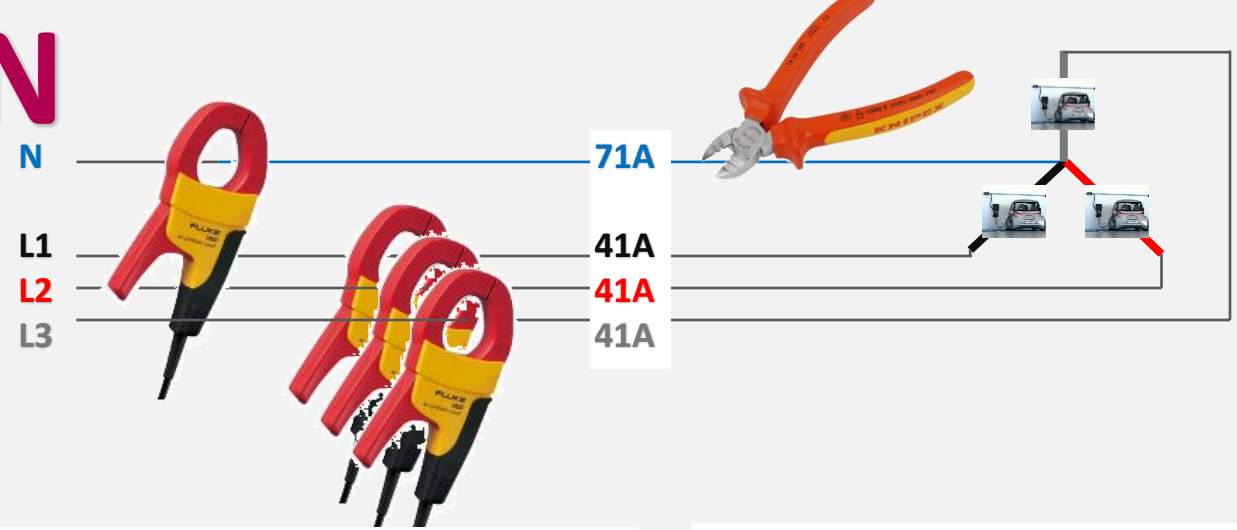
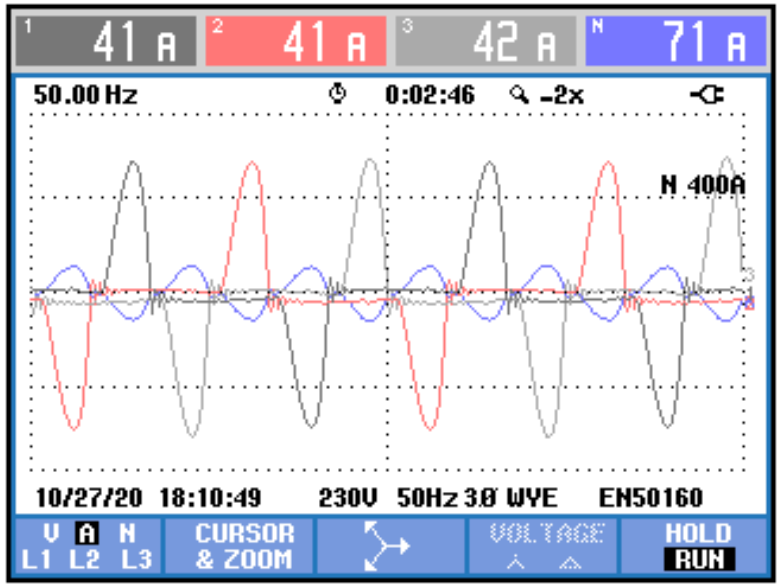
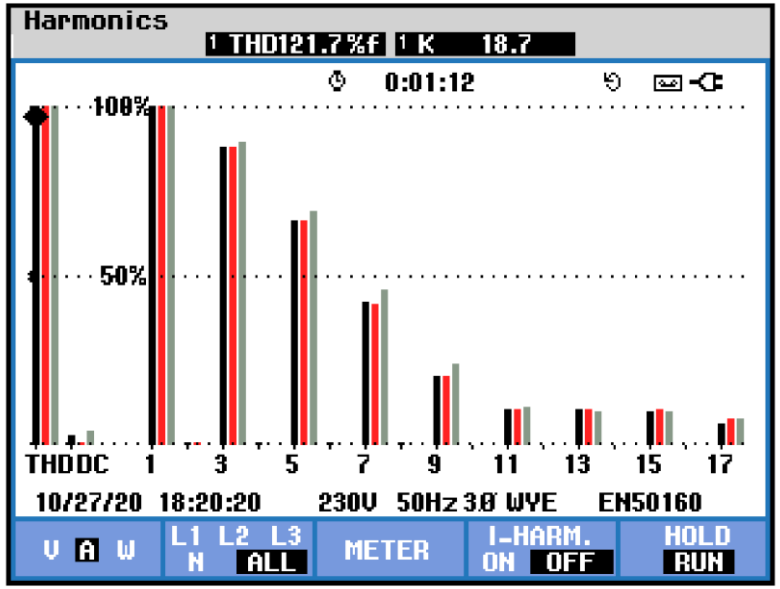
3~N



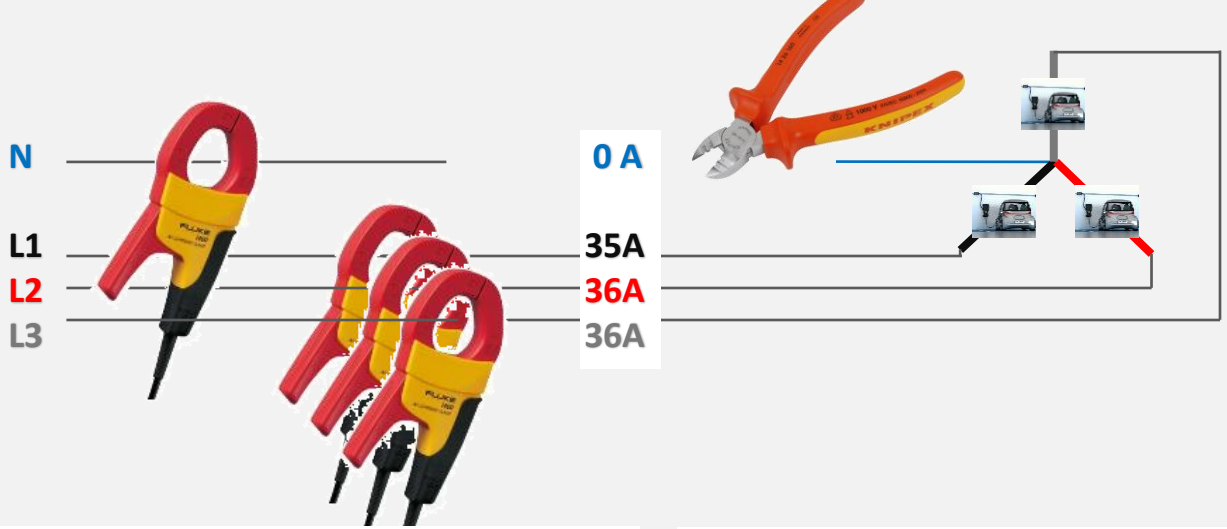


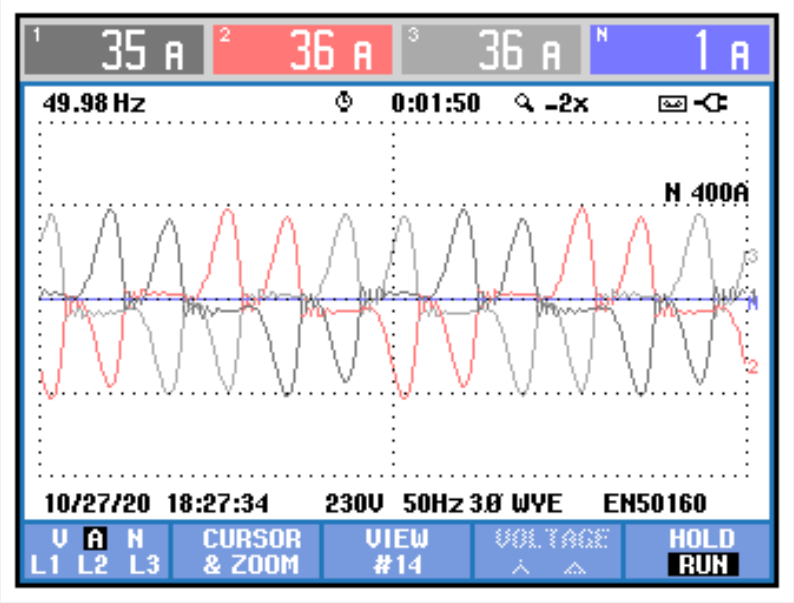


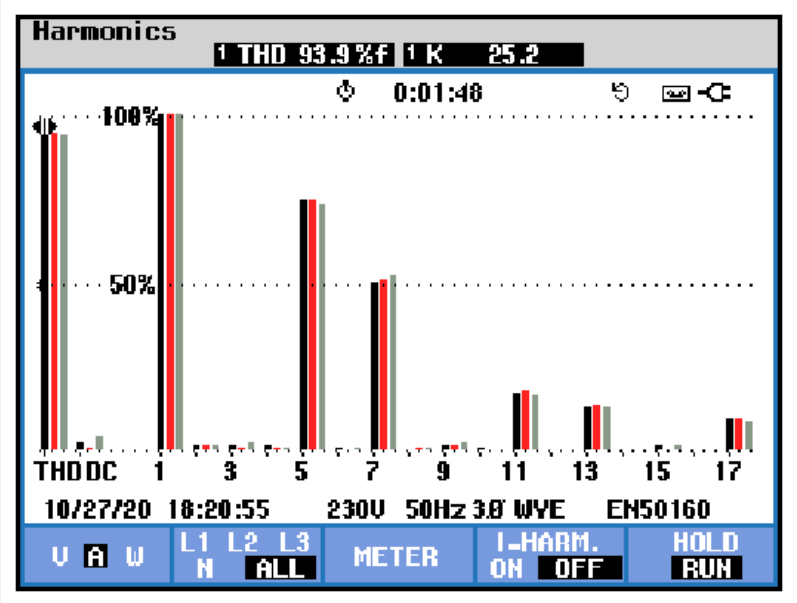
4 diode rectifier so 1+ and 1- = 3rd and 4th

What if the neutral wire melts down…

3~







3rd harmonic neutral currents “are vanished”

THD(i) 29% off, EV cars still charging

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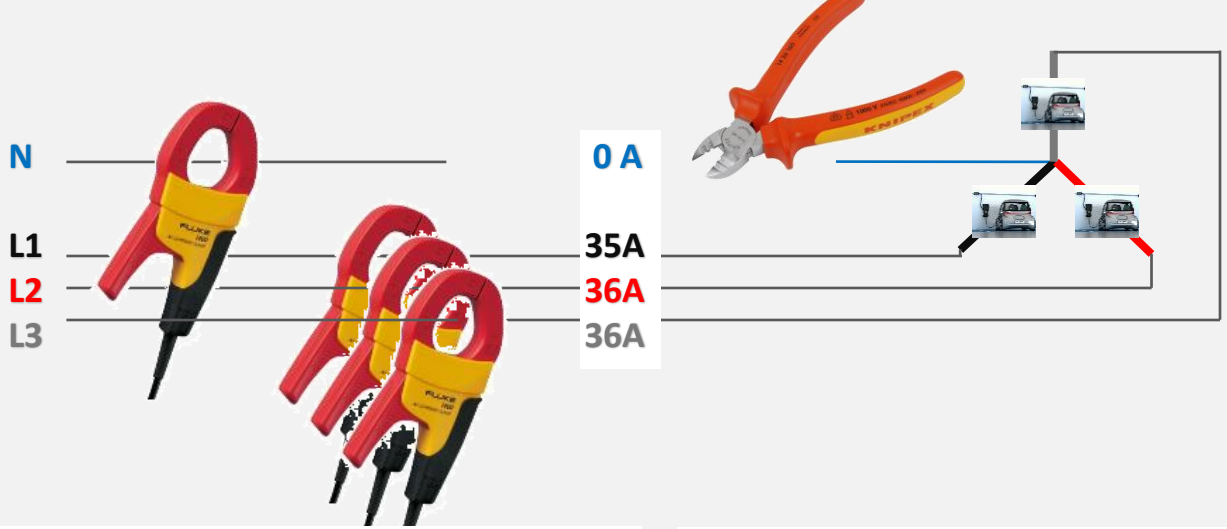
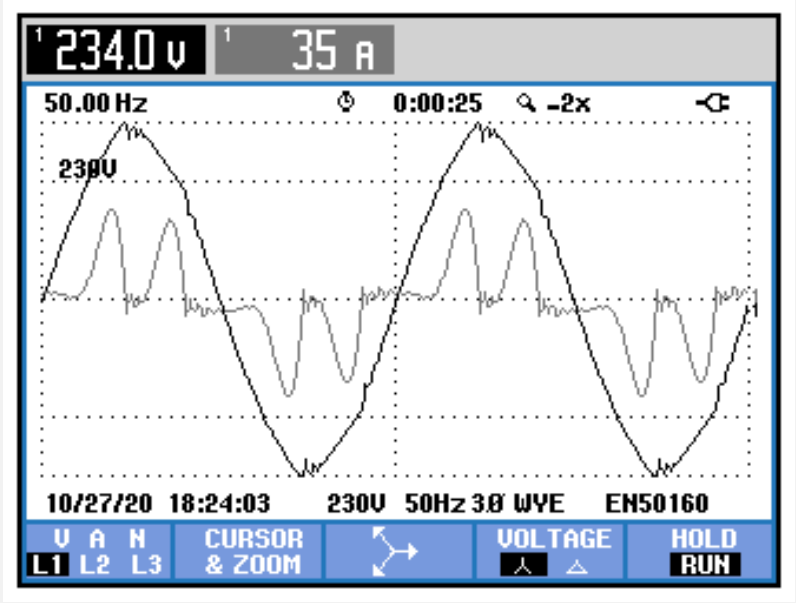
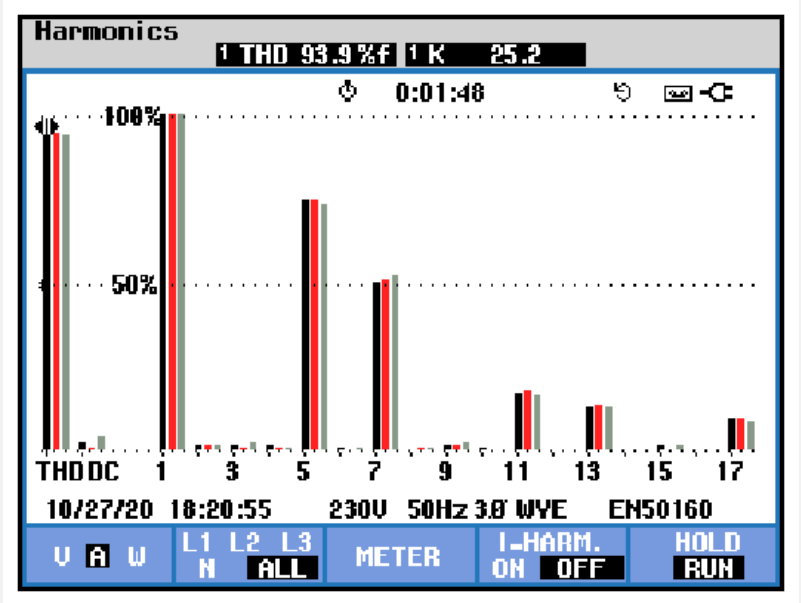
3~







3rd harmonic neutral currents are eliminated

Current looks like 3 phase charger

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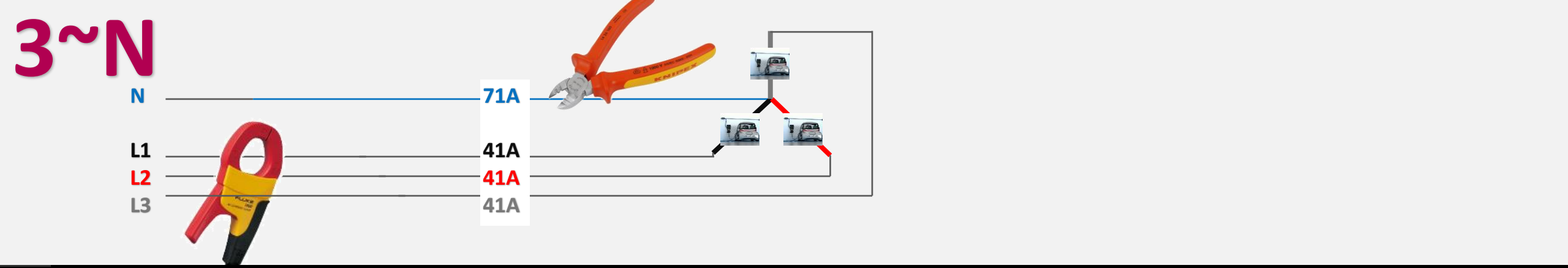
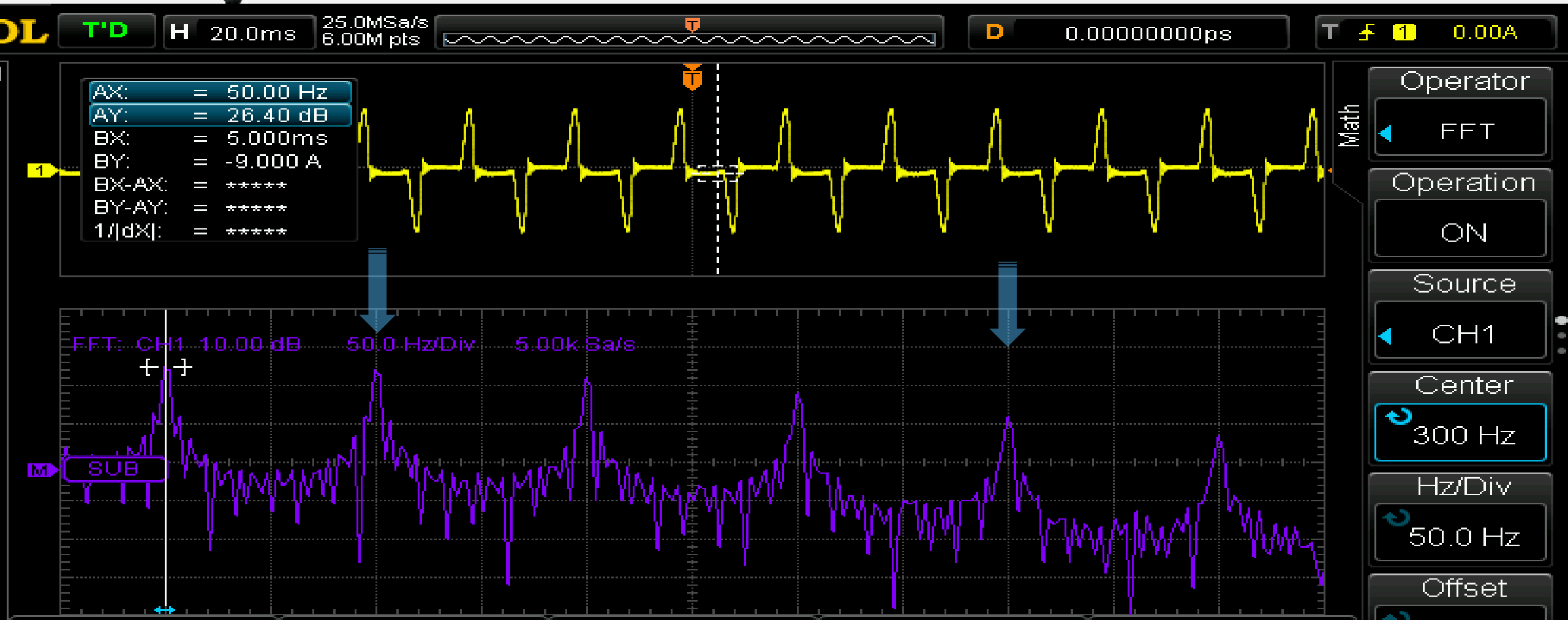
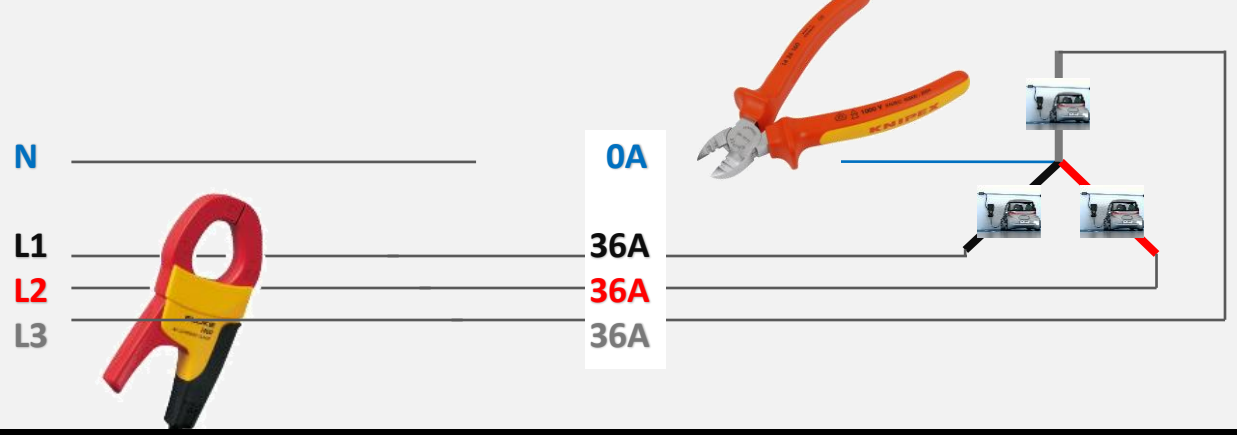
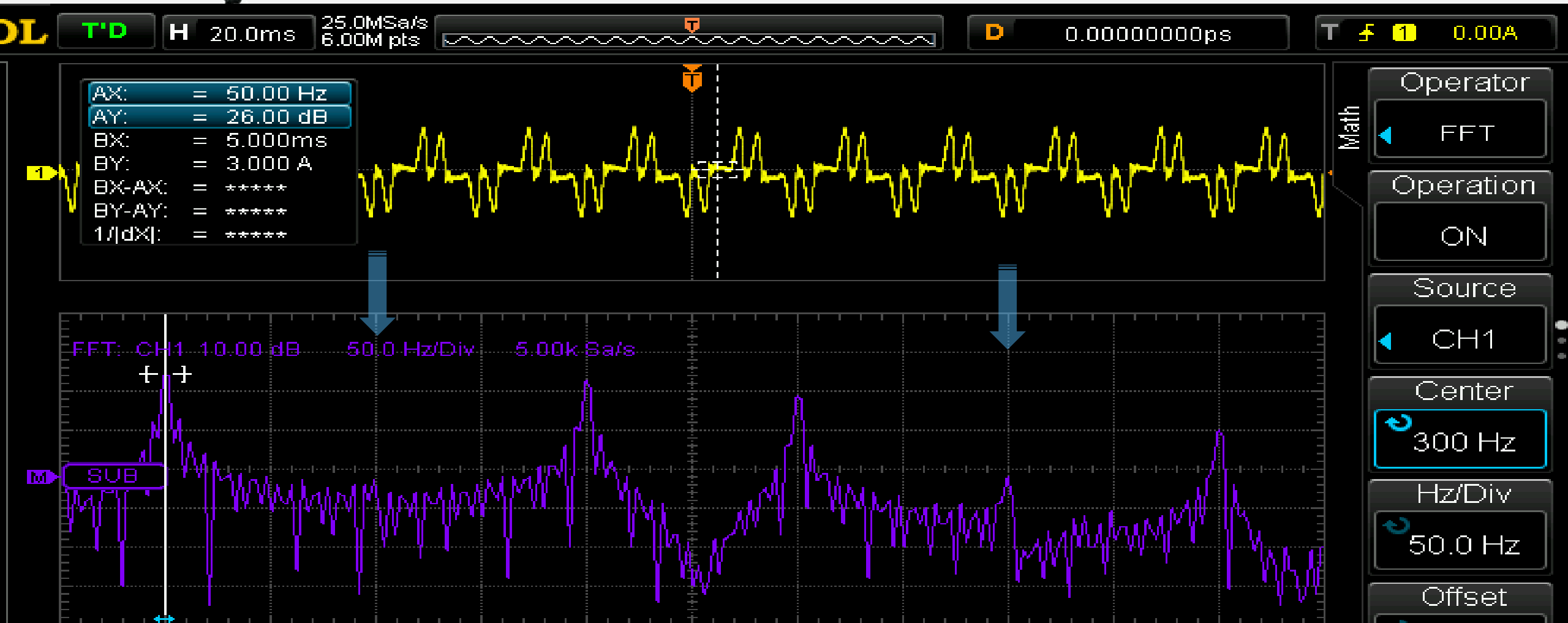
3~N


N
L1
L2
L3
71A
41A
41A
41A

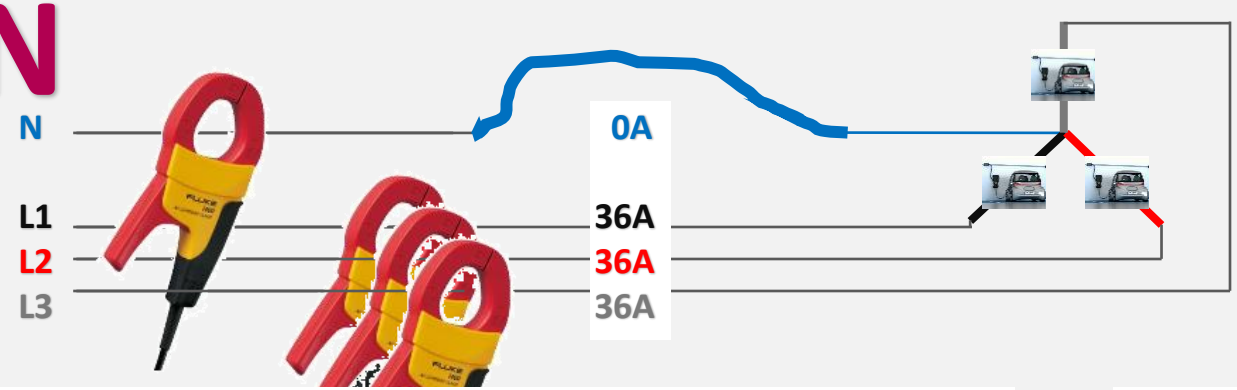

T'D
H 20.0ms
25.0MSa/s
6.00M pts
D 0.00000000ps
T 1 0.00A
AX: = 50.00 Hz
AY: = 26.40 dB
BX: = 5.000ms
BY: = -9.000 A
BX-AX: = *****
BY-AY: = *****
1/|dX|: = *****
FFT: CH1 10.00 dB 50.0 Hz/Div 5.00k Sa/s
SUB
Math
Operator
FFT
Operation
ON
Source
CH1
Center
300 Hz
Hz/Div
50.0 Hz
Offset

3~

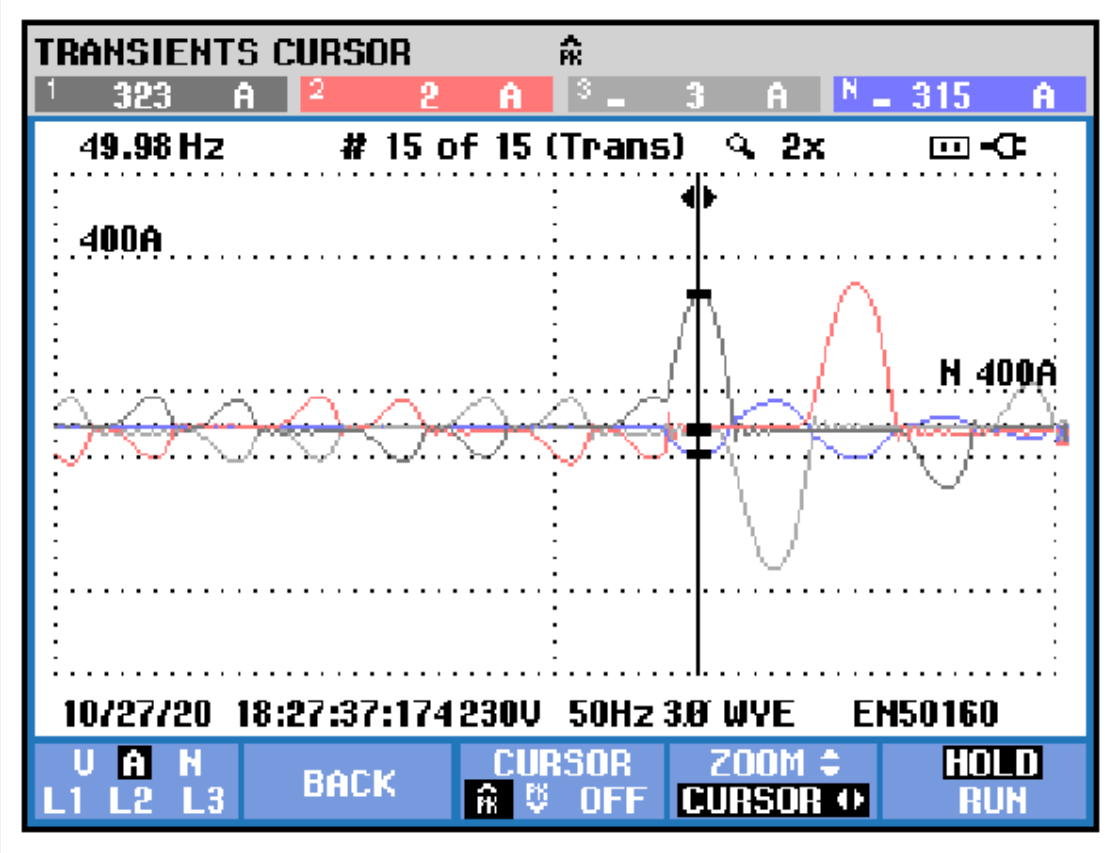

N
L1
L2
L3
0A
36A
36A
36A

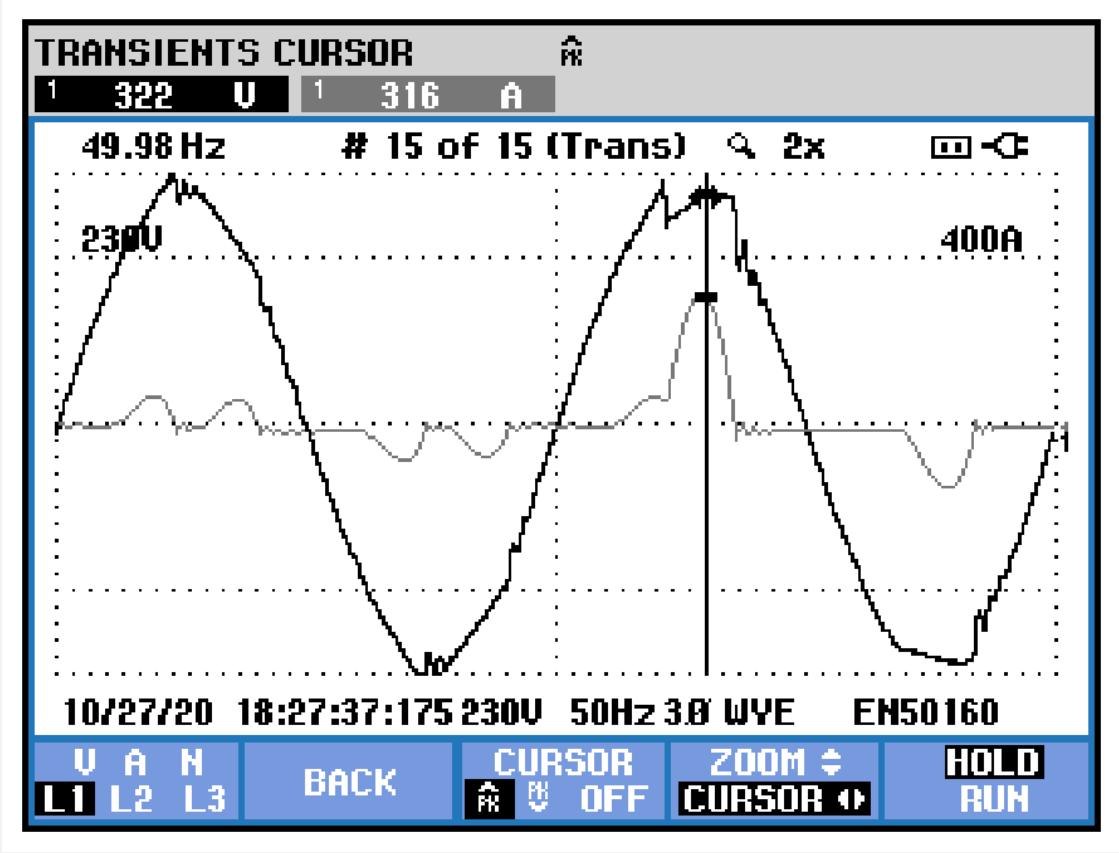

T'D
H 20.0ms
25.0MSa/s
6.00M pts
D 0.00000000ps
T 1 0.00A
AX: = 50.00 Hz
AY: = 26.00 dB
BX: = 5.000ms
BY: = 3.000 A
BX-AX: = *****
BY-AY: = *****
1/|dX|: = *****
FFT: CH1 10.00 dB 50.0 Hz/Div 5.00k Sa/s
SUB
Math
Operator
FFT
Operation
ON
Source
CH1
Center
300 Hz
Hz/Div
50.0 Hz
Offset

3~N



Return of the neutral





Very high inrush currents result in voltage transients

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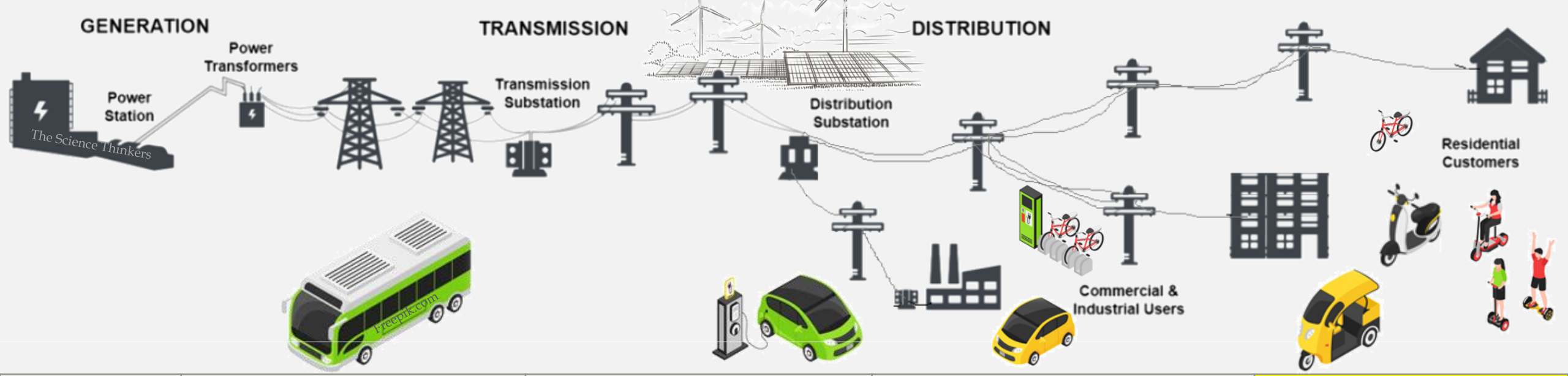
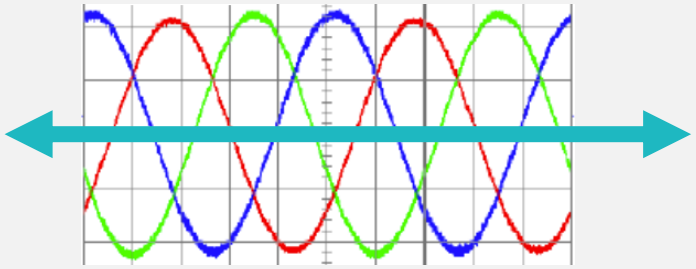
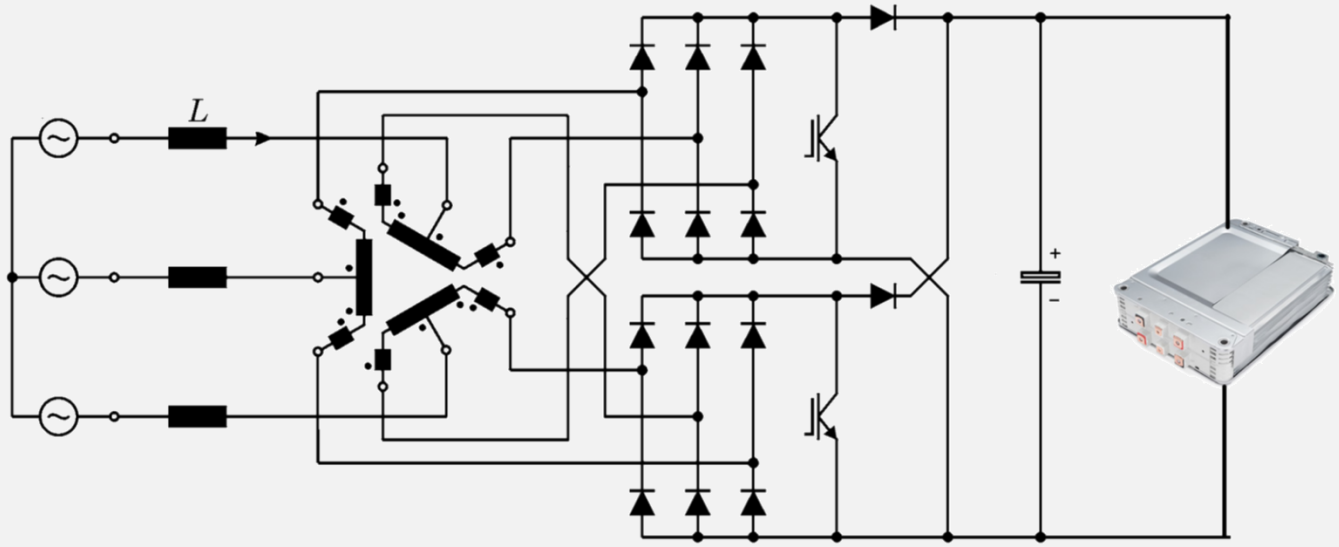
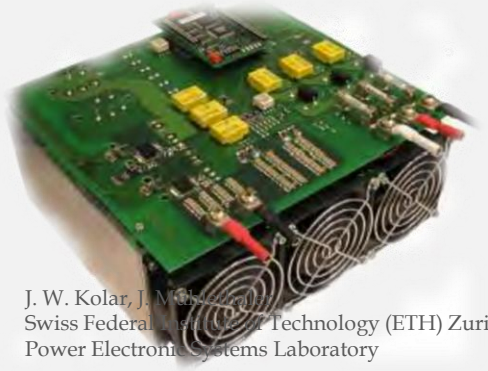


POC	HVAC grid mode 4	MVAC grid mode 4	LVAC mode 3	LVAC mode 3/2/1
	High power DC	DC fast charging	3~(+N)	1~+N
	1MW	100-900kW	7-100kW	<7kW
Strength	Stable POC, "noise immune", predictable	Fast		Universal, almost immune to THD(80v)
Weakness	Location, connecting	High load, short time, high investment, battery C factor lifetime/warranty		3rd harmonic, Neutral, end of line THD, inrush, unbalance, DC offset
Opportunity	Pre charging locally	DSM, V2grid better than PV, swap		Standardization PF = 1
Threat	Connectors, HV lines, non dedicated grid	Noise, connectors, TCO		Al Cables, fire, momentary interruption
Focus on PQ	Energy management policy	Energy management policy		Overdesign N

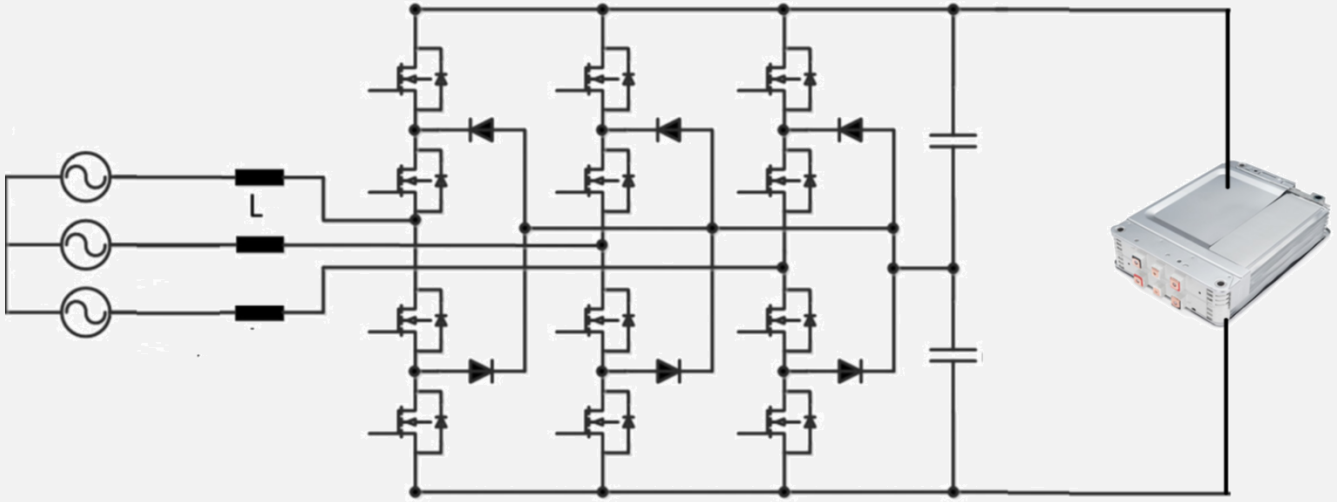
3~ future?







J. W. Kolar, J. Muhlethaler
Swiss Federal Institute of Technology (ETH) Zurich
Power Electronic Systems Laboratory



Healing impact on PQ

Good design, immune, no emission,

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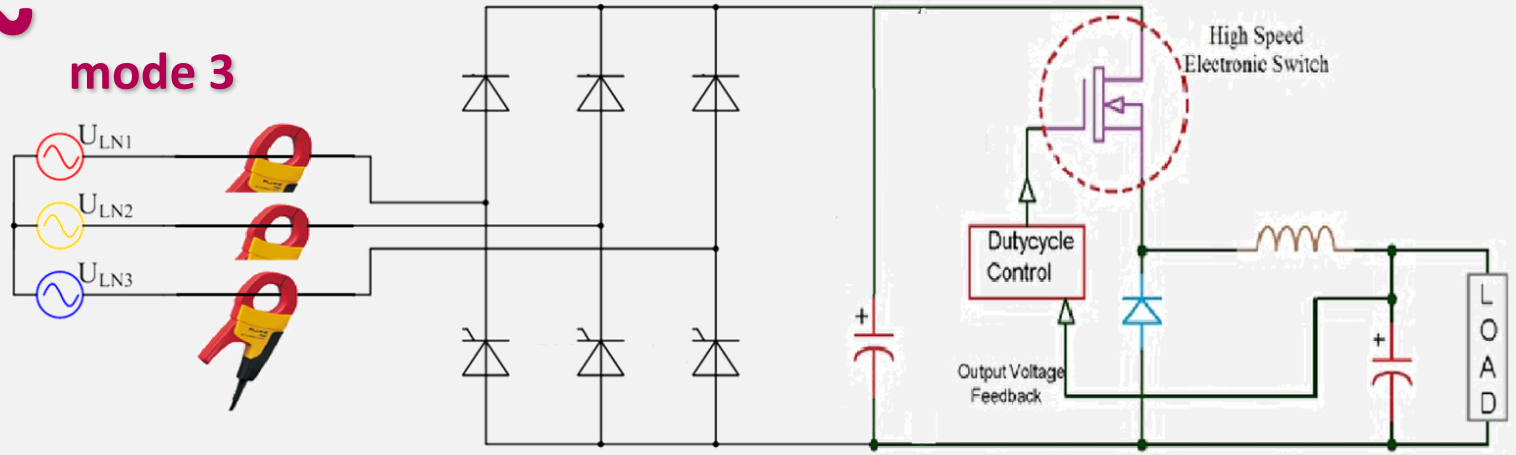
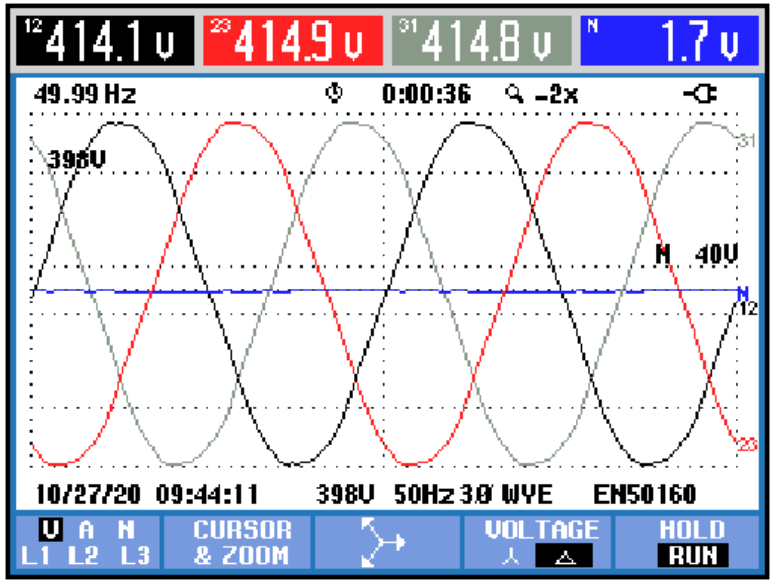
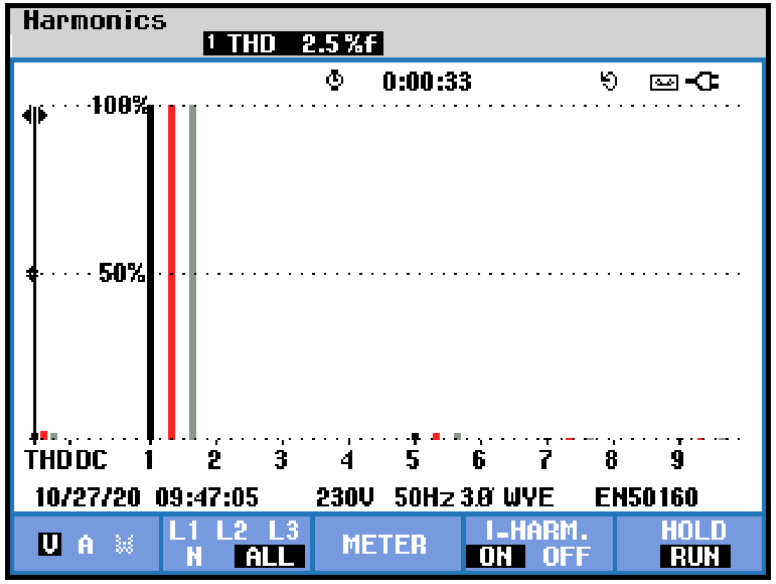
3~ mode 3







3~ SMPS impact on PQ less than 1~

Mode 3 is adapting to the fitness of the grid

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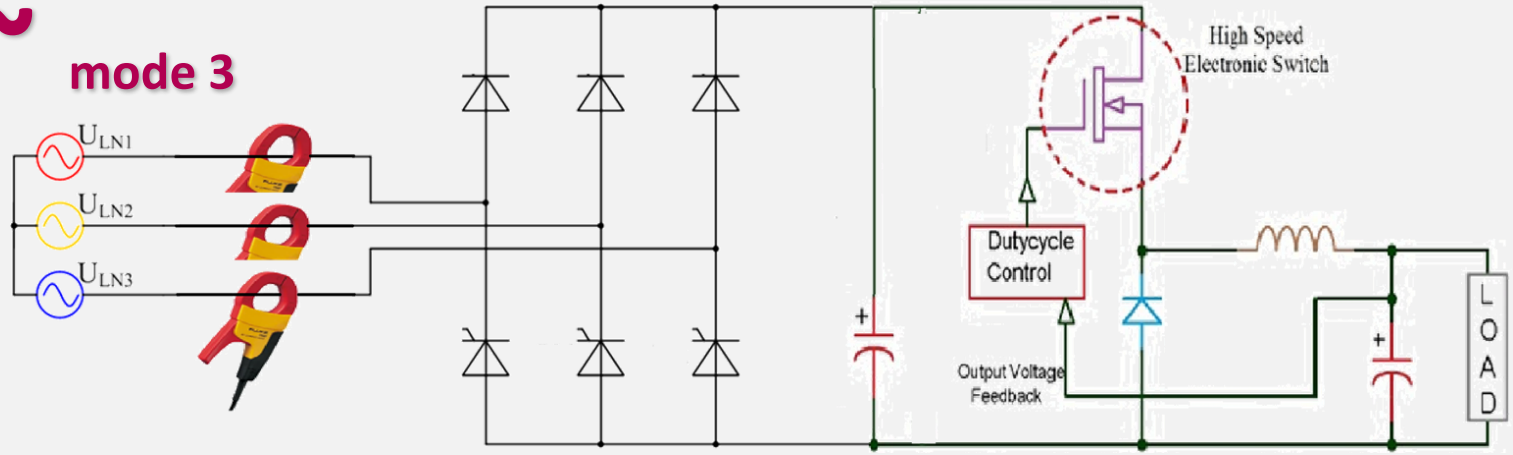
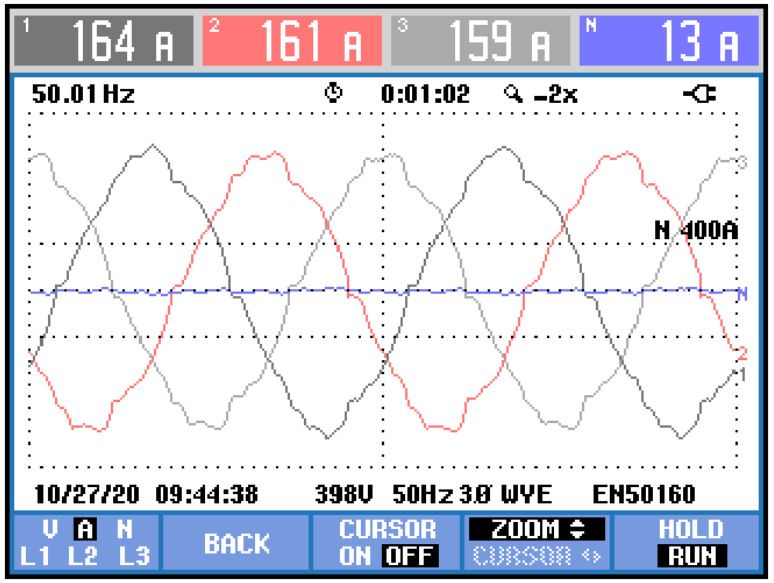
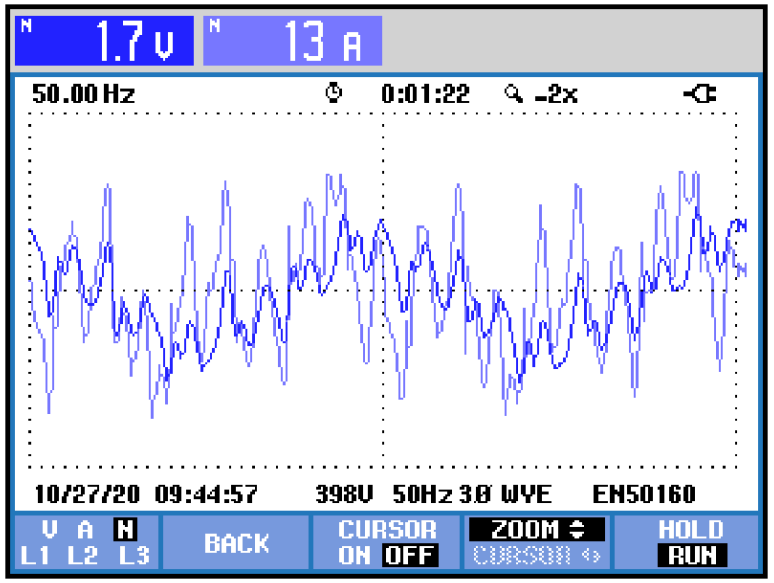
3~ mode 3

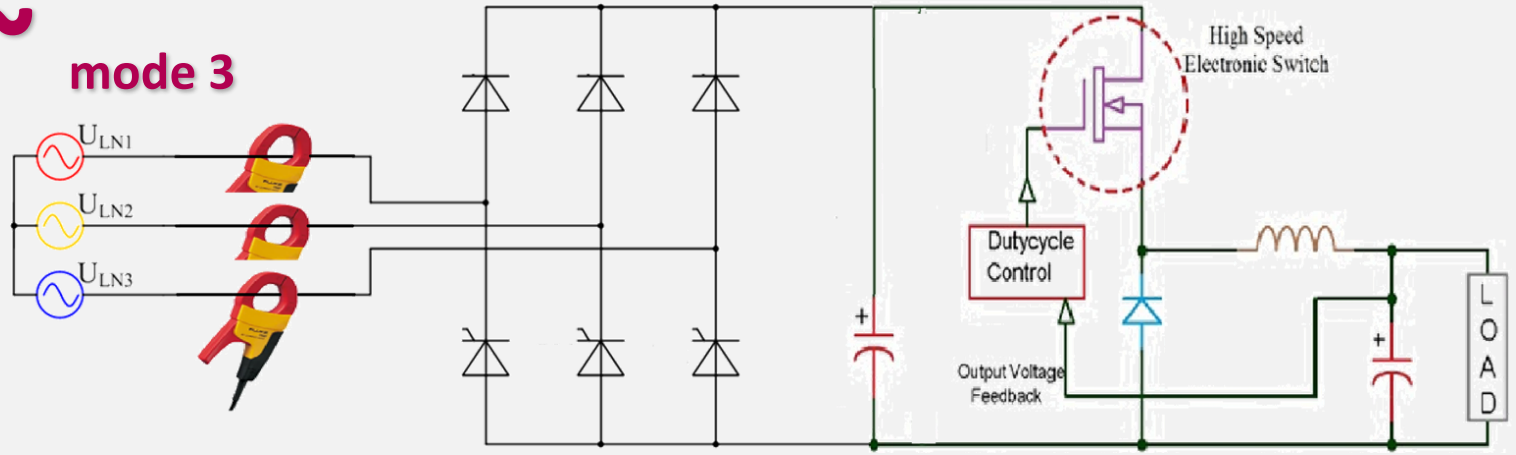


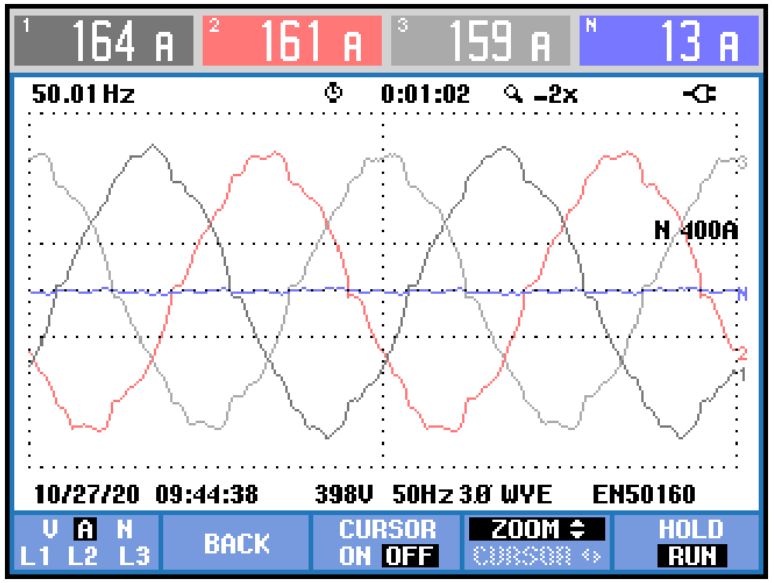


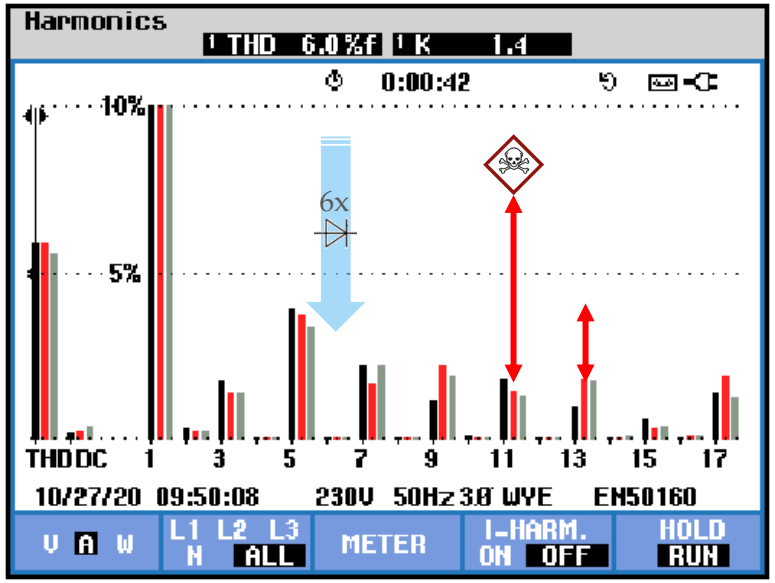


Well designed charger have a specific shunt in series

3~ mode 3





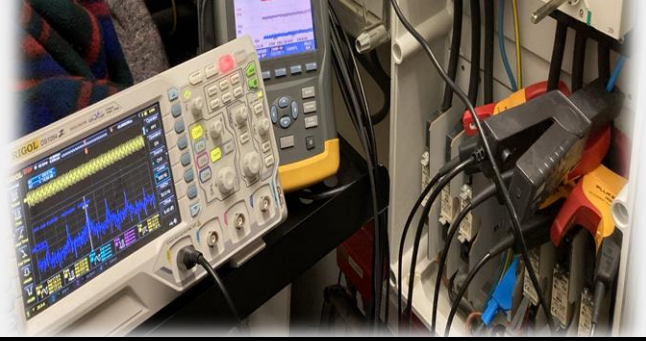


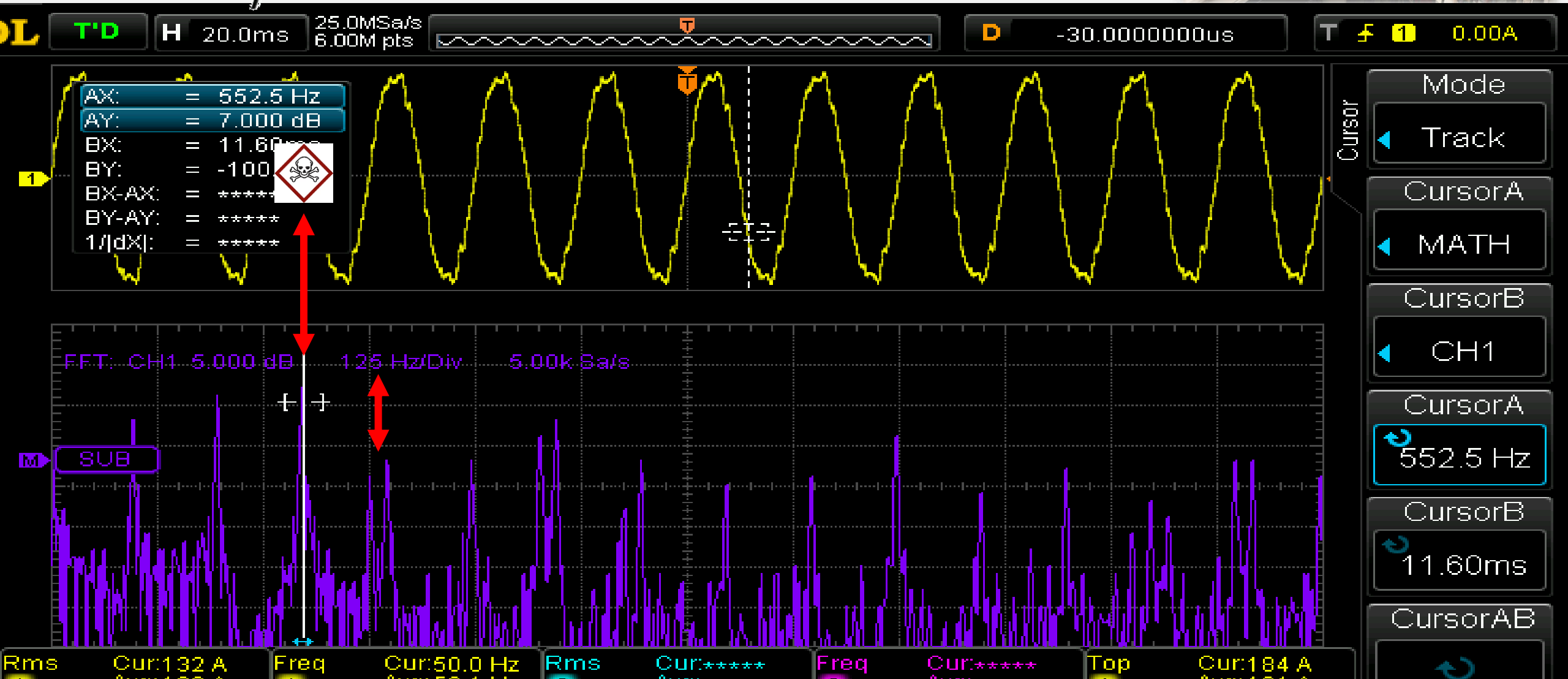
6 diode rectifier so 1+ and 1- = 5th and 7th

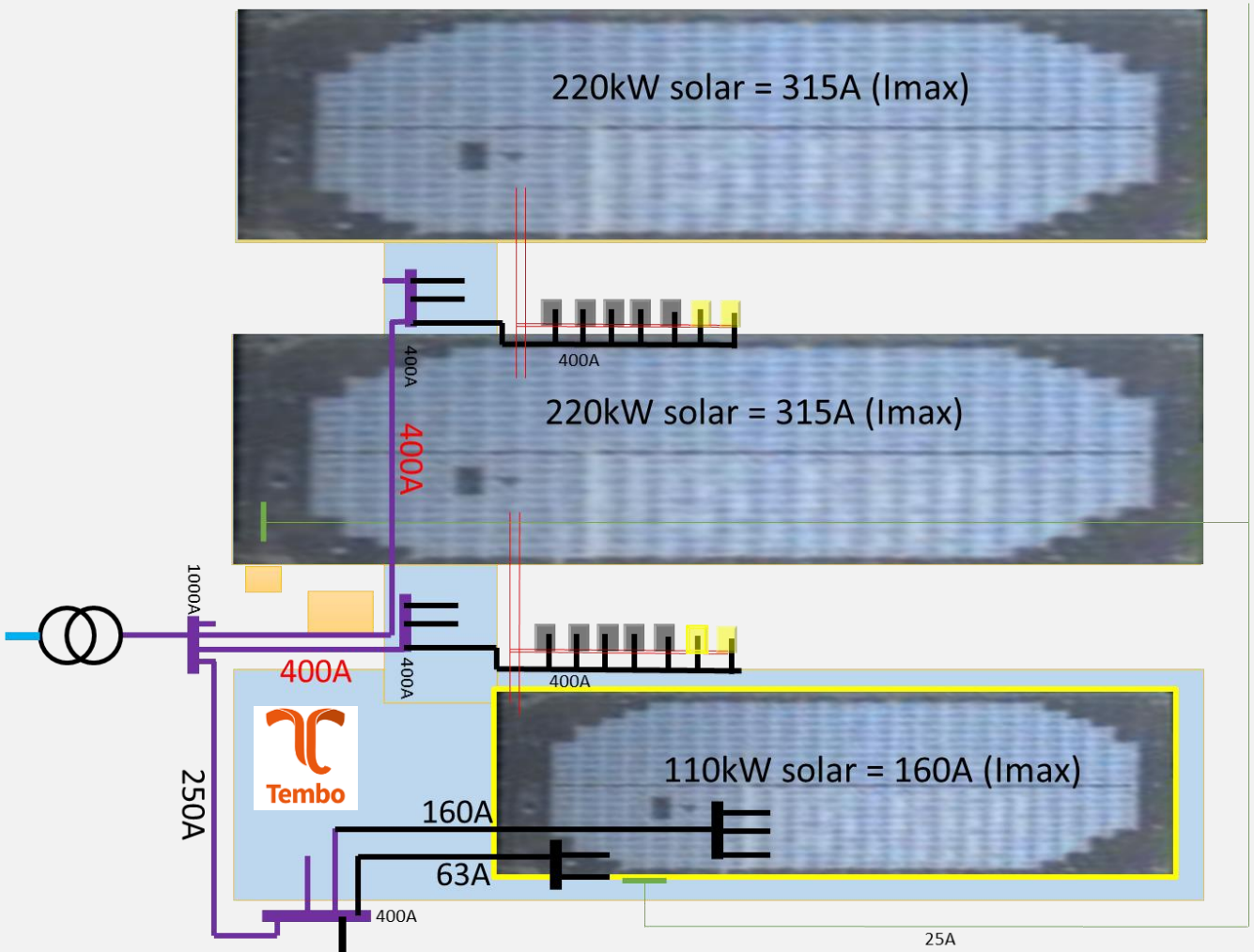
What is wrong with the 11t and 13th current harmonic….

3~N

>100KHz
Analyzer with dc coupling







Tembo factory with charging points

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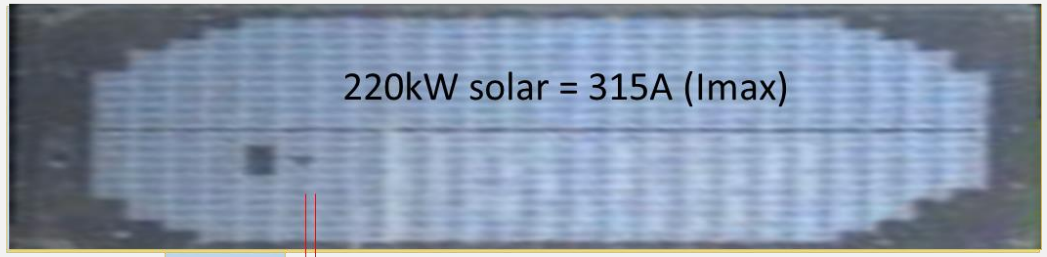

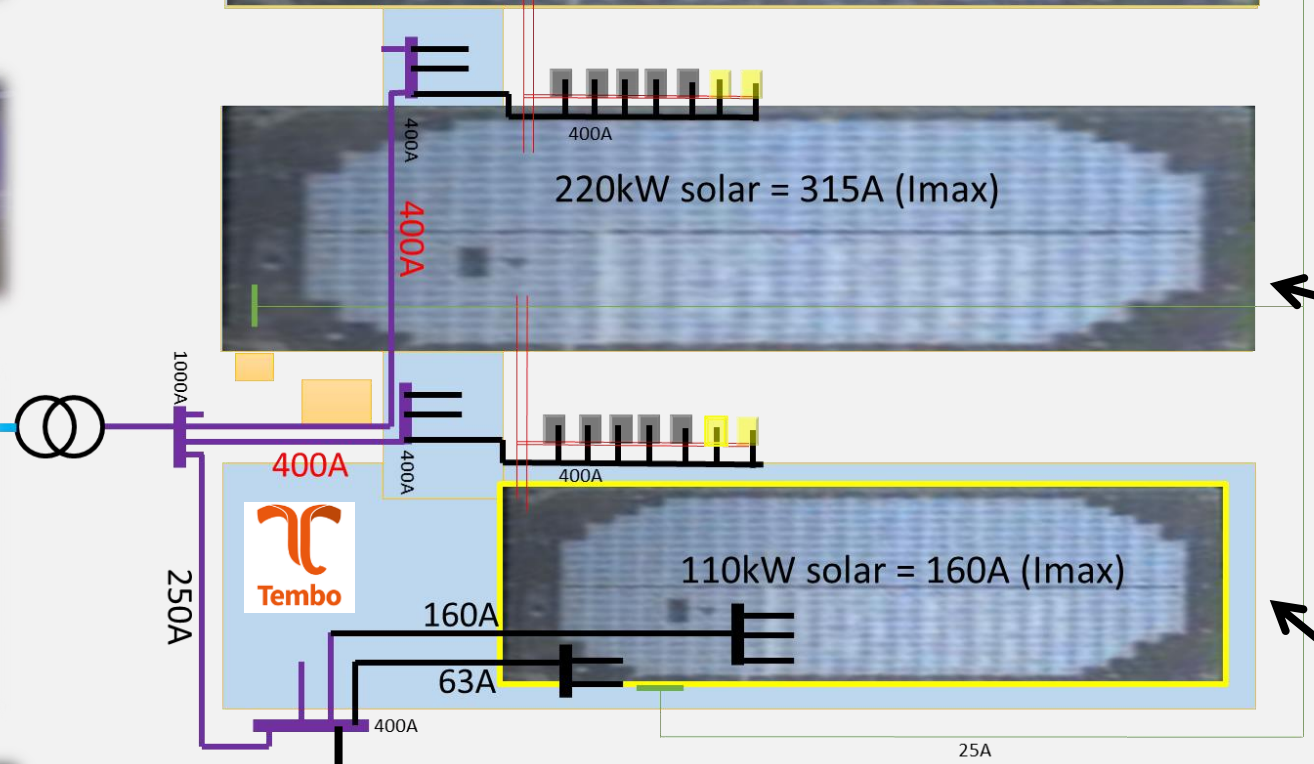

Had unexplainable multiple time issues with the utilities, but not the factory..

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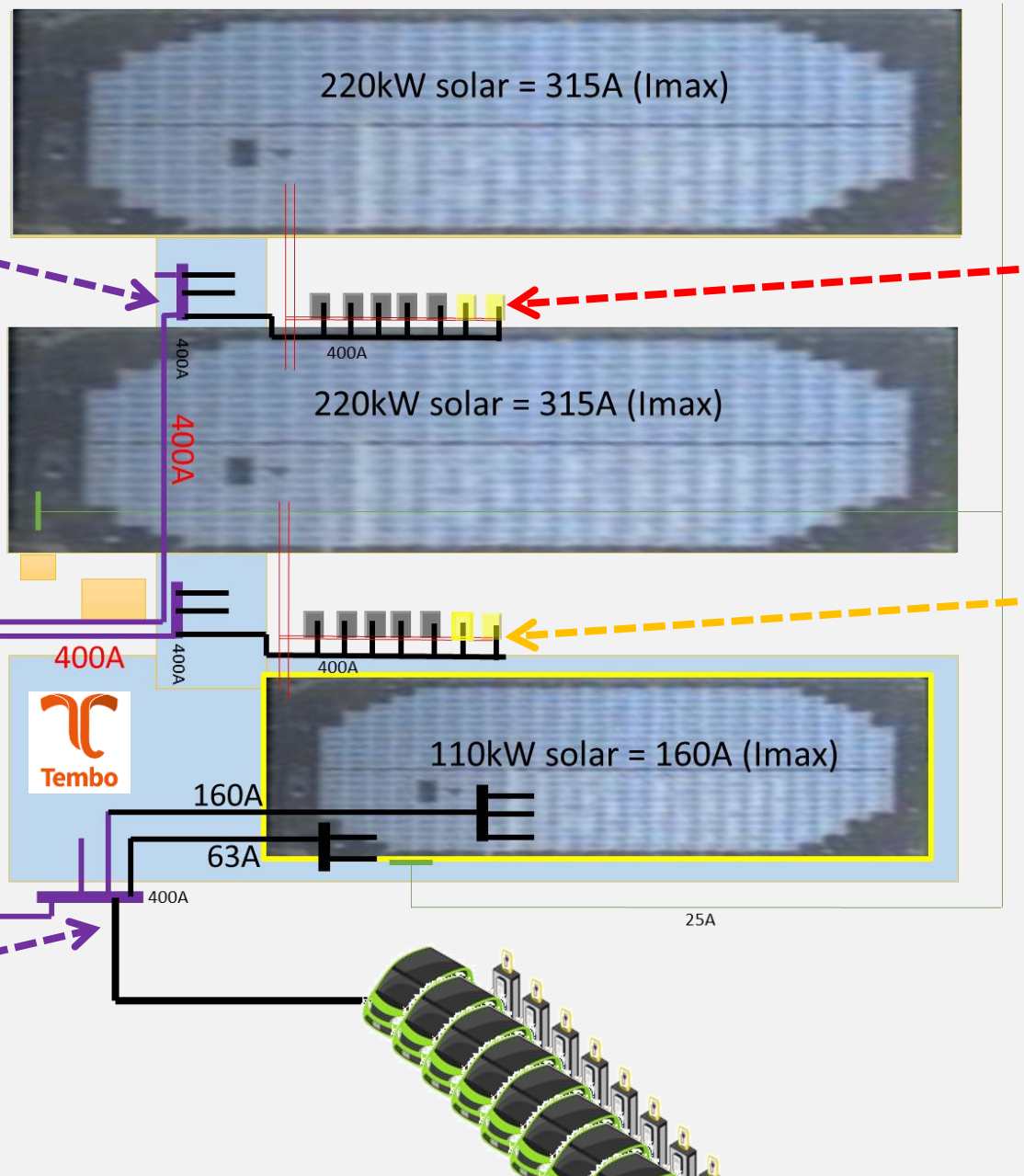

One roof with transformer less inverters

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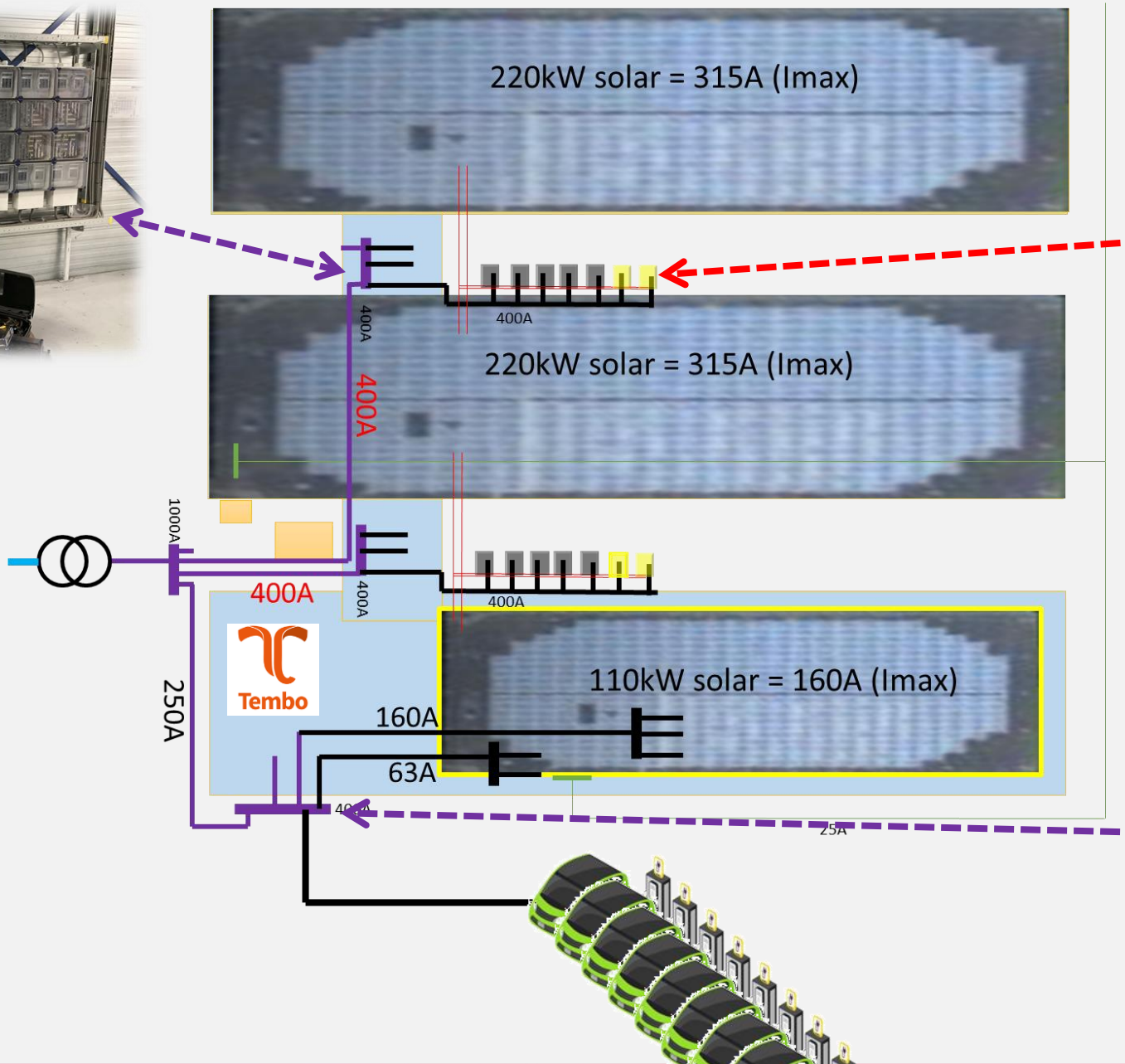

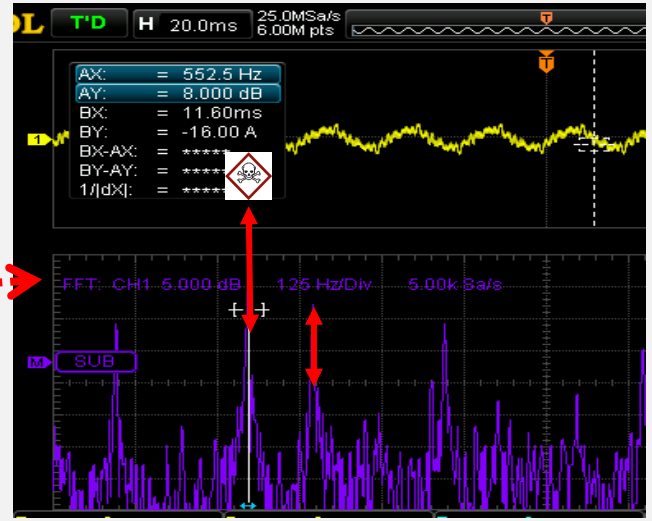

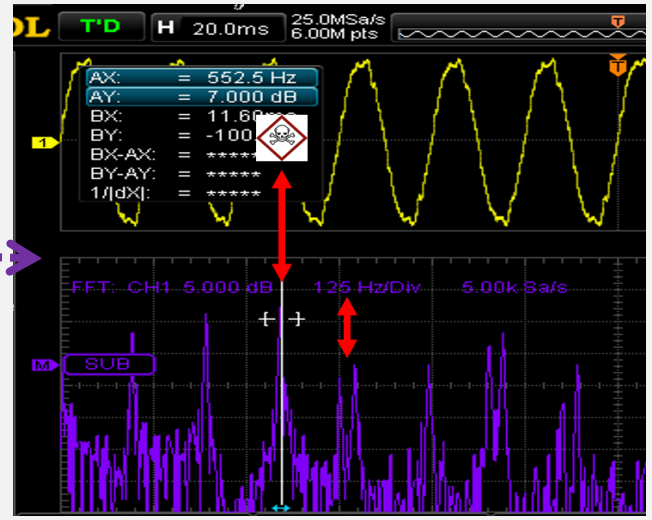

Follow the currentt

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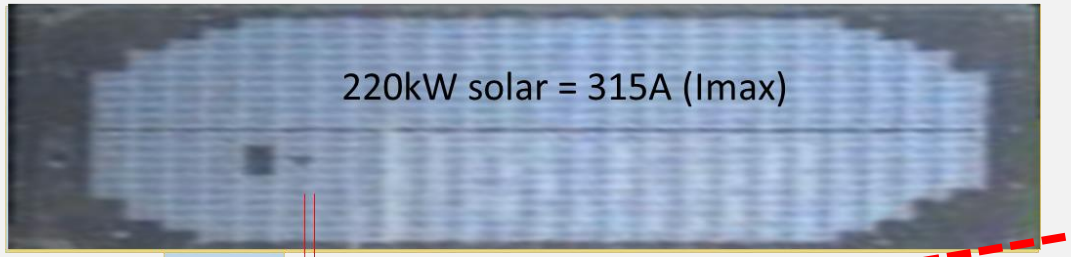

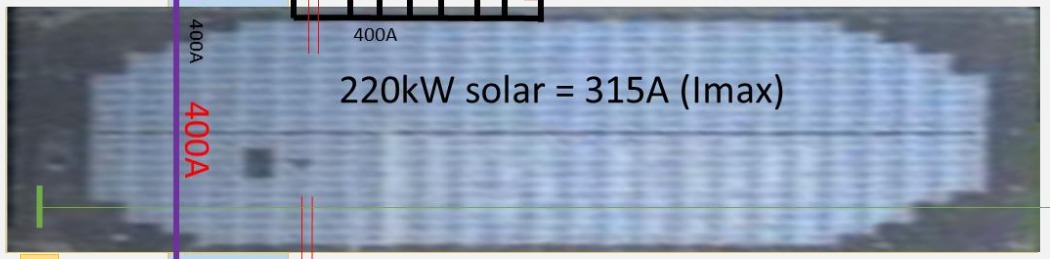

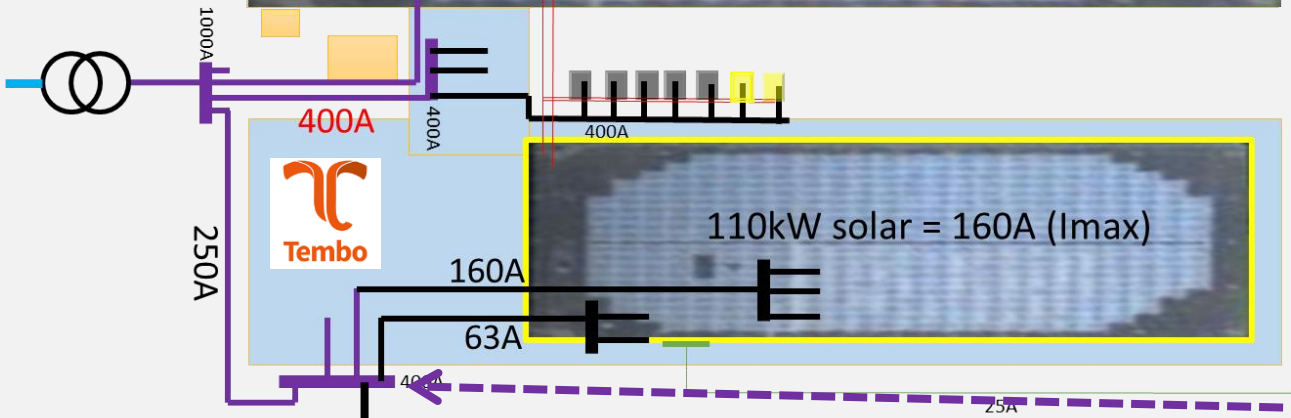

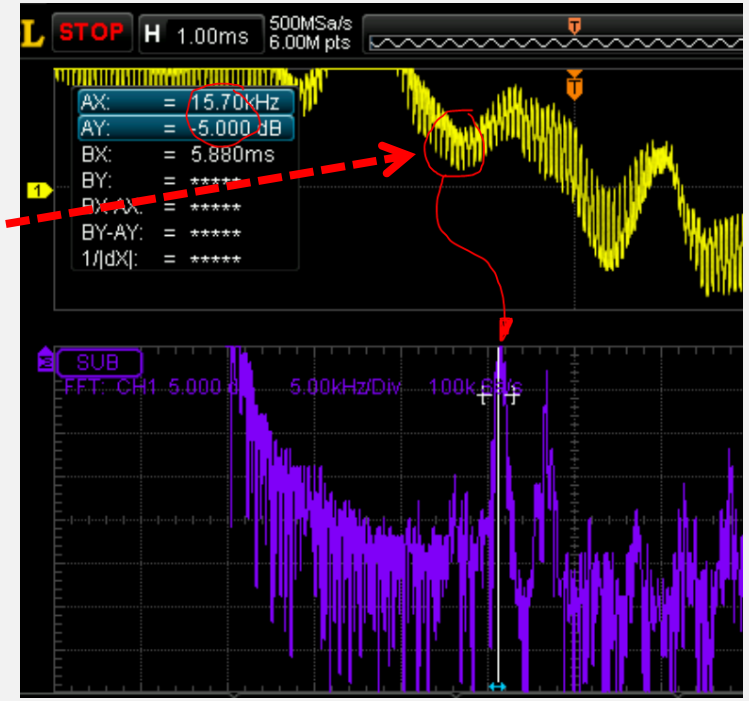

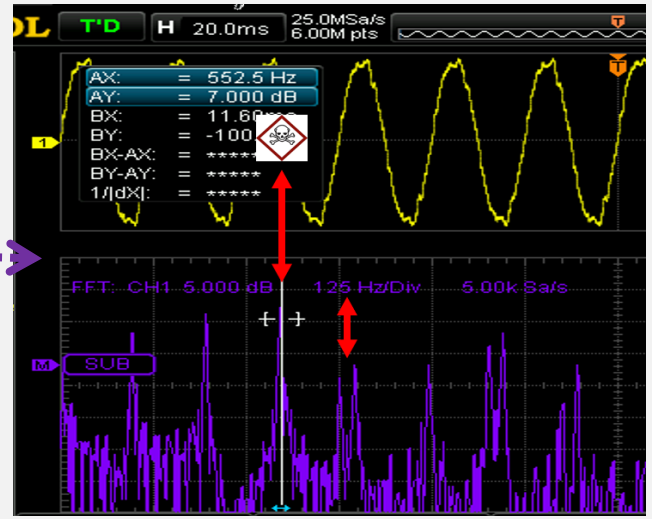

Control and Applications". These inverters, which are aimed at reducing switching losses typically include high voltage switches (e.g. 600V IGBTs) that switch at a frequency around ×10 of the line frequency (50 Hz) or up to 16 kHz.

Switching frequency 15.7kHz…. With dynamic behaver

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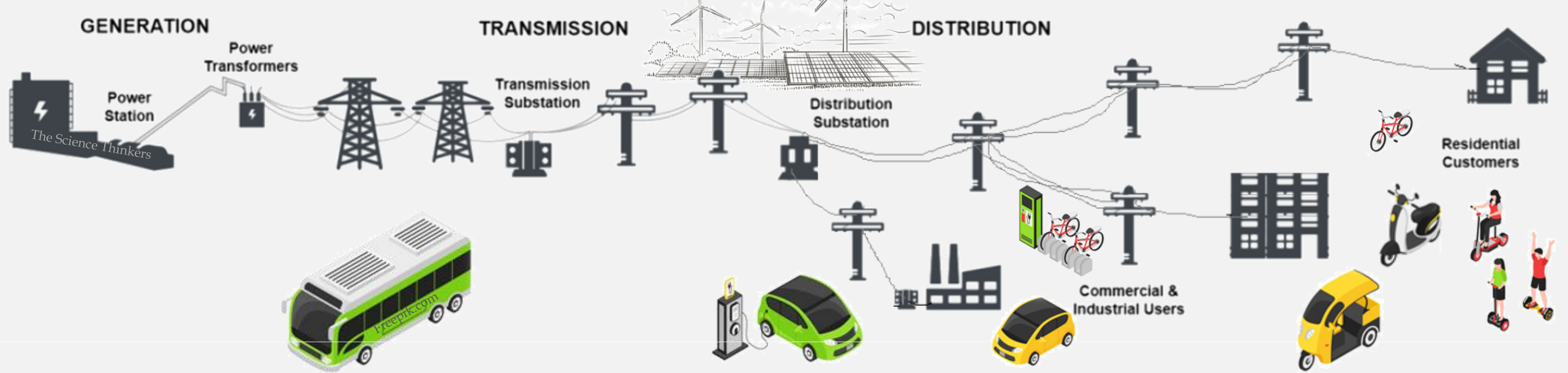

POC	HVAC grid mode 4	MVAC grid mode 4	LVAC mode 3	LVAC mode 3/2/1
	High power DC	*DC fast charging*	*3~(+N)*	*1~+N*
	1MW	*100-900kW*	*7-100kW*	*<7kW*
Strength	Stable POC, "noise immune", predictable	Fast	THD - PF (sin current), balance	Universal, almost immune to THD(80v)
Weakness	Location, connecting	High load, short time, high investment, battery C factor lifetime/warranty	Biggest loads, no PQ system standards, equipment failure, (inv) Phase cancellation	3rd harmonic, Neutral, end of line THD, inrush, unbalance, DC offset
Opportunity	Pre charging locally	DSM, V2grid better than PV, swap	Active harmonic restorer, switching parameters	Standardization PF = 1
Threat	Connectors, HV lines, non dedicated grid	Noise, connectors, TCO	Connectors, passive filters are static	Al Cables, fire, momentary interruption
Focus on PQ	Energy management policy	Energy management policy	Resonance - interaction	Overdesign N

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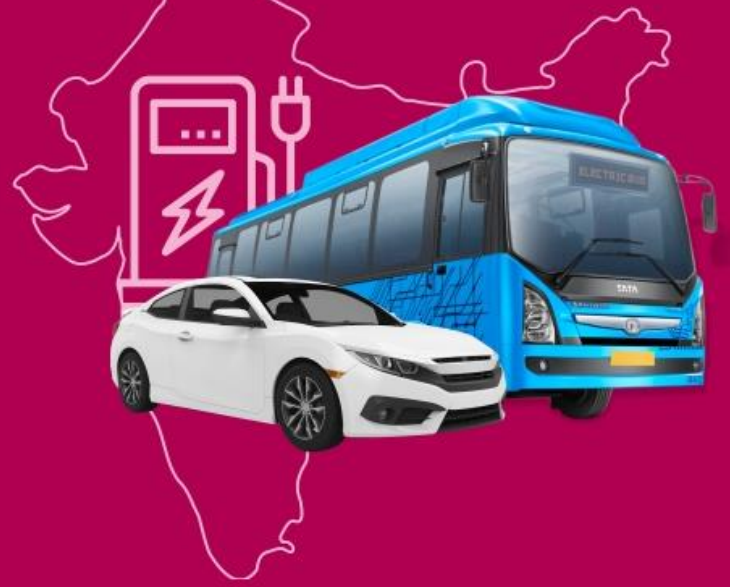
WEBINAR
30th October, Friday
4 pm to 5.30 pm



India's Electric Mobility Ambitions

Can Power Quality issues lead to a flat tyre?

PQ will certainly play a crucial role,
in the ambitious EV roadmap India is facing

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E. (Epko) Horstman MBSE BEng
30-10-2020