

Drive and Motor Protection Made Simple

Presented by: Chad Burks, TCI Central Regional Sales
Manager



 *Advancing Power Quality*

Harmonic Solutions



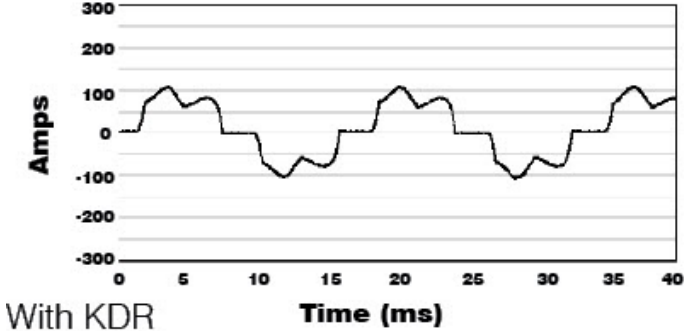
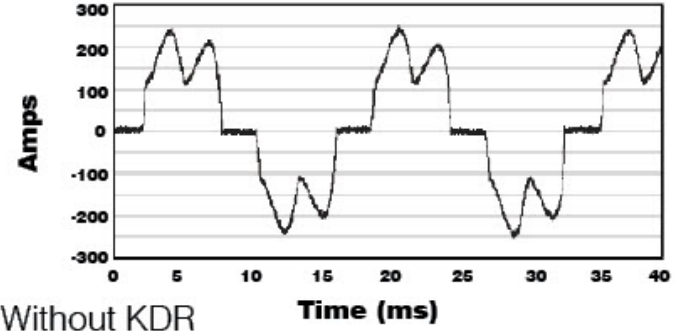
6 Pulse Drive +
Line Reactor / DC Choke
Passive Filter
Active Filter



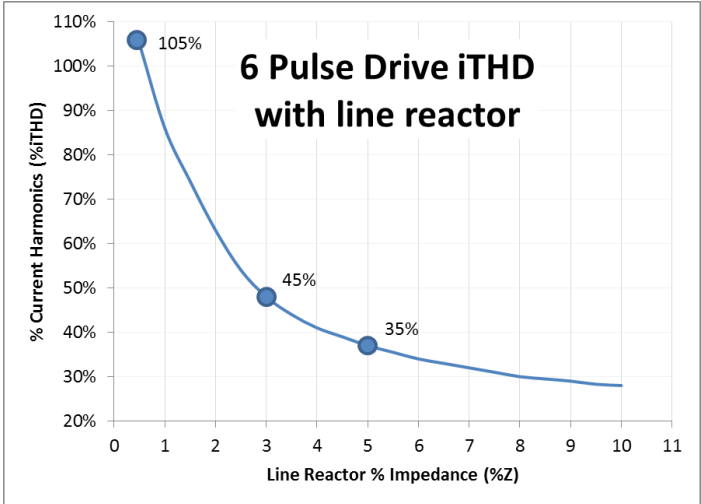
Built In Solutions
12 Pulse
18 Pulse
Active Front End

AC Line Reactors

- Dual Purpose: harmonic mitigation, transient blocker to protect diode front ends from surges
- Impedance – slows the rate of change in AC waveform
- Impedance Choices – 3%, 5%, 10%
- Prolongs the life of drive components
- Series Passive device



Harmonic Reduction



Voltage Drop

Impedance %	Voltage Drop
3%	0.0%
5%	1.2%
7%	2.4%
10%	3.7%

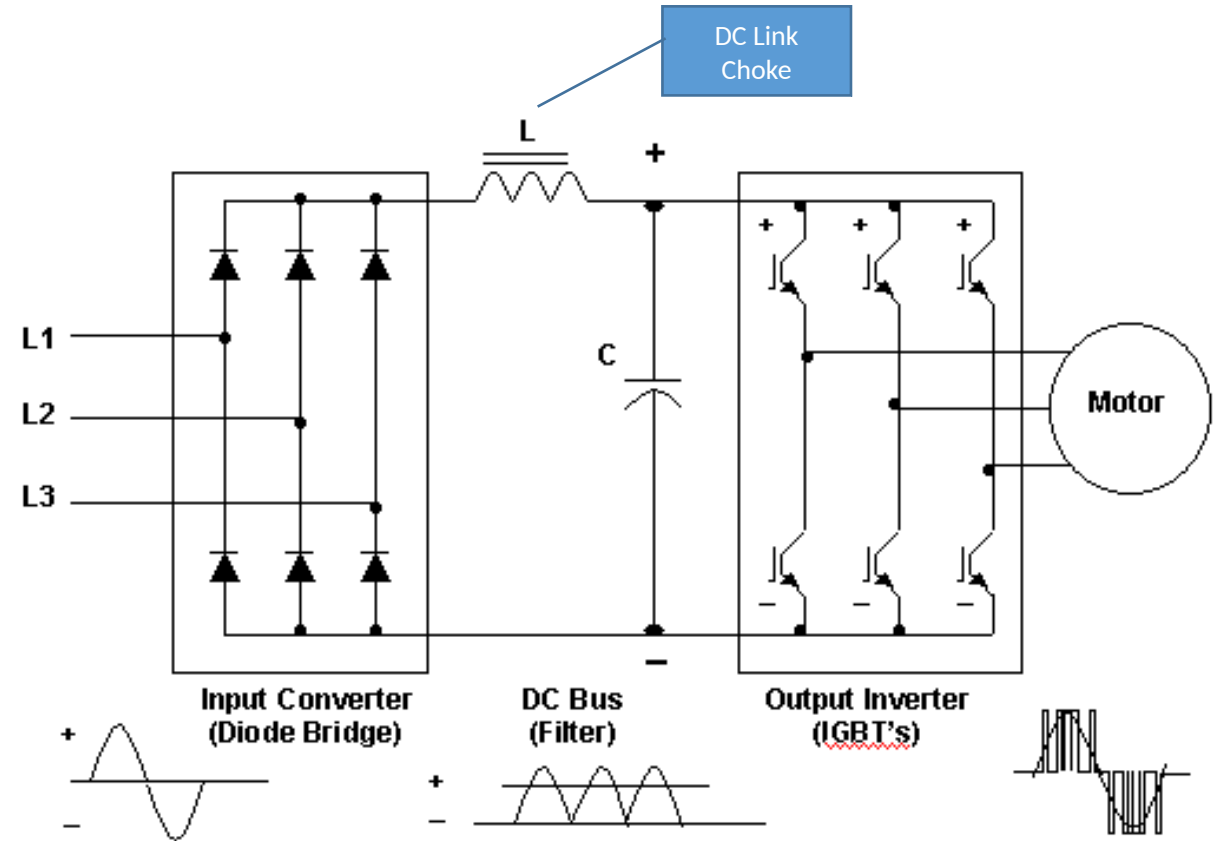
Line Reactors and DC Link Chokes

Very similar, but location is everything.

A DC Choke smooths the DC bus ripple, reduces harmonics but does not protect the diode bridge! About half the impedance value of an AC reactor unless located on the + & - of the DC bus.

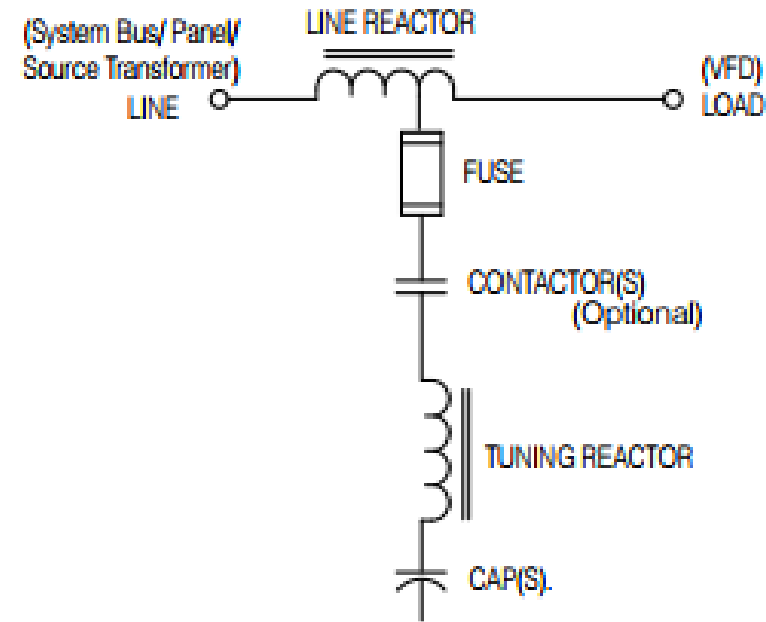
Many drive manufacturers recommend installing line reactors on the drive.

Line Reactor

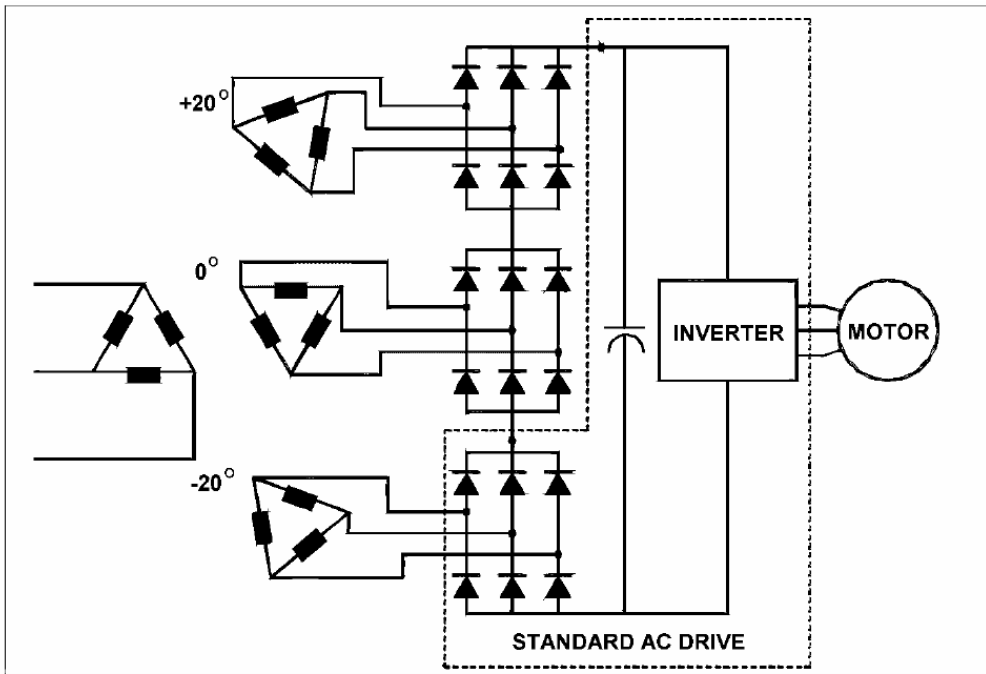


Passive Harmonic Filters

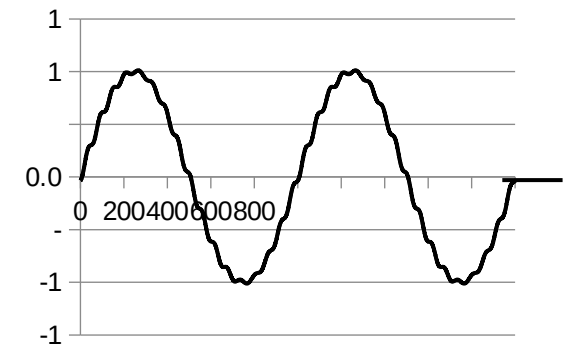
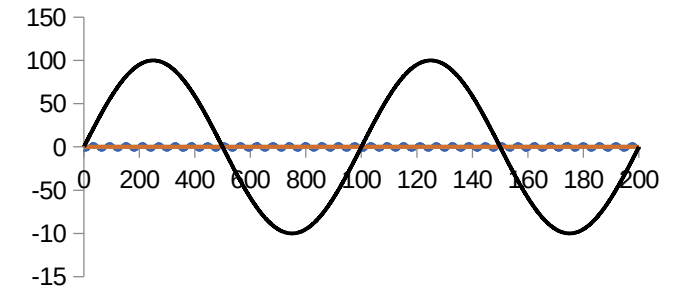
- Harmonic reduction to 5% ITHD.
- Broadband filter with a 5th harmonic trap
- Use when need to meet IEEE-519 specification
- Use built in contactor to protect against leading power factor
- Built in series inductor to protect from resonance issues
- Can be used with Standard Six Pulse VFD.
- Filter Caps may need to be managed....
PF / Generator.



18 Pulse Drive

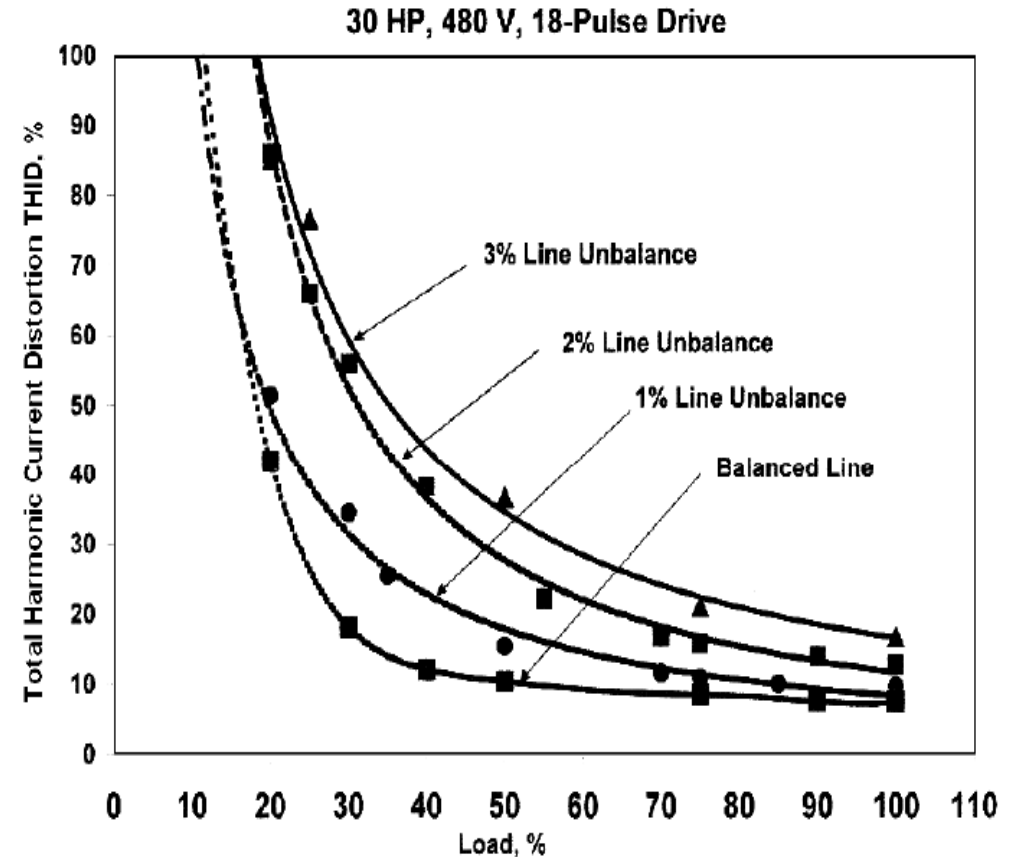


- 5% Solution out of the box. No calculations.
- Phase shifting transformer and more diodes limit harmonics.
- Series Passive device



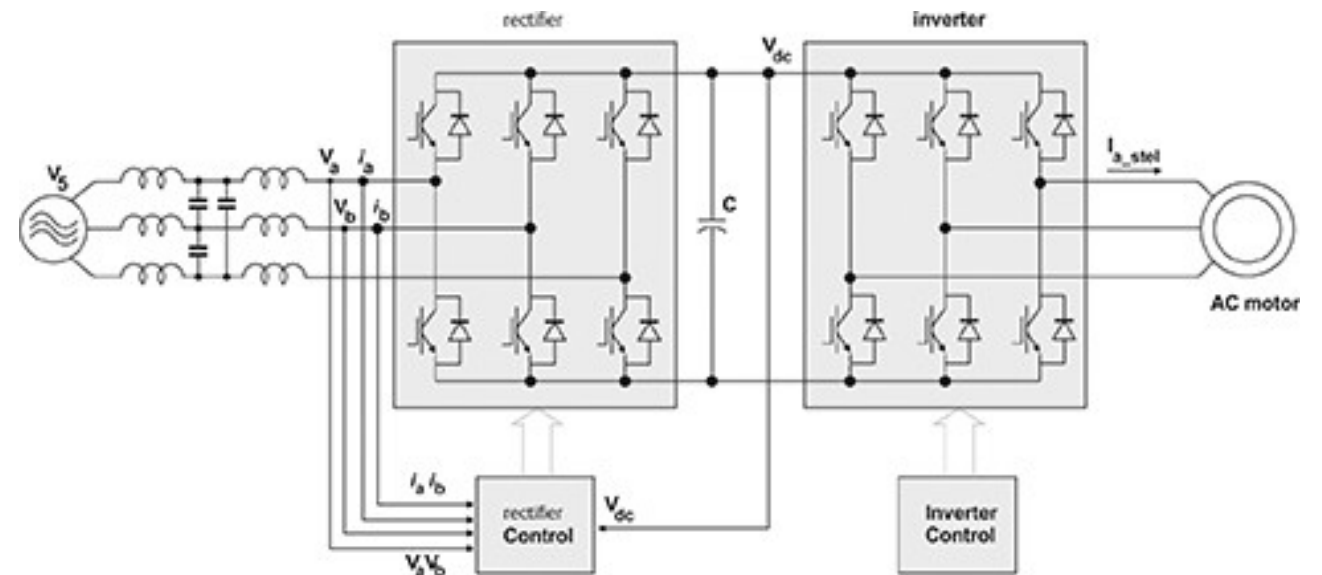
18 Pulse Drive

- Line unbalance reduces performance
- Large Physical Size
- Custom - Long Lead time for Manufacture & Repair
- Cost
- Limited HP Range
- Less efficient than 6 pulse

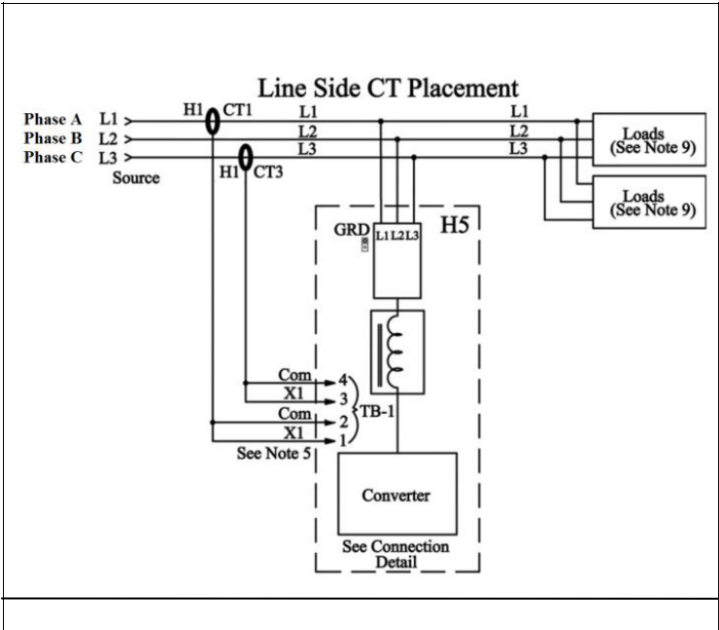


Active Front End Drives

- 5% Solution out of the box. No calculations.
- No major issues with loading or unbalance.
- Ideal for regenerative loads
 - Elevators
 - Cranes
- High components count - equivalent to 2 VFDs and a passive filter
- Larger and more expensive than 6 pulse.
- Devices in series – lower efficiency
- Series active device – in critical path

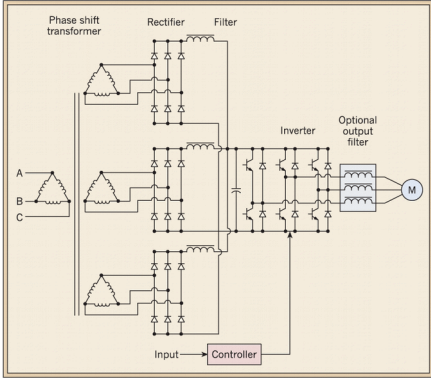


Harmonic correction component in parallel vs series

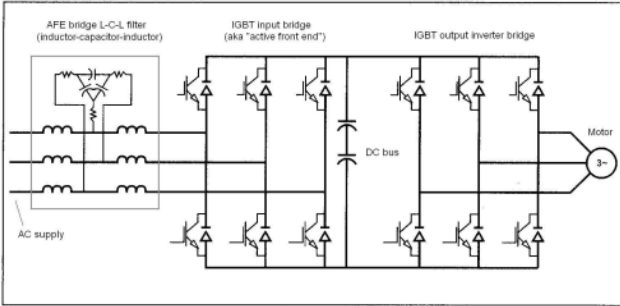


ALC with 6 pulse load

--OR--



18 pulse vfd



AFE vfd

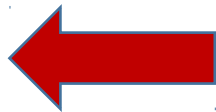
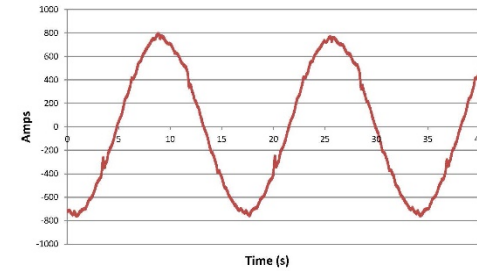
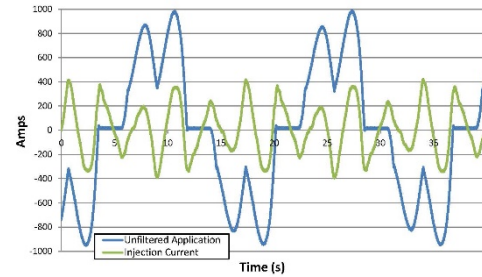
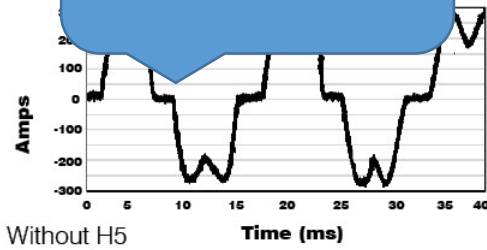
Active Harmonic Filters

- System applied on standard 6 pulse VFDs
- Very cost effective for multiple or redundant drives
- Harmonic reduction – 5% TDD
- Monitors bus, injects counter current to cancel out harmonic currents
- Provides Power Factor Correction
- Corrective Current ratings – 50 to 500 (Can be paralled)
- HMI – Modbus / Ethernet / BACnet
- Shunt active device – not critical path



Active Harmonic Filter

Need new HGA
"without" image

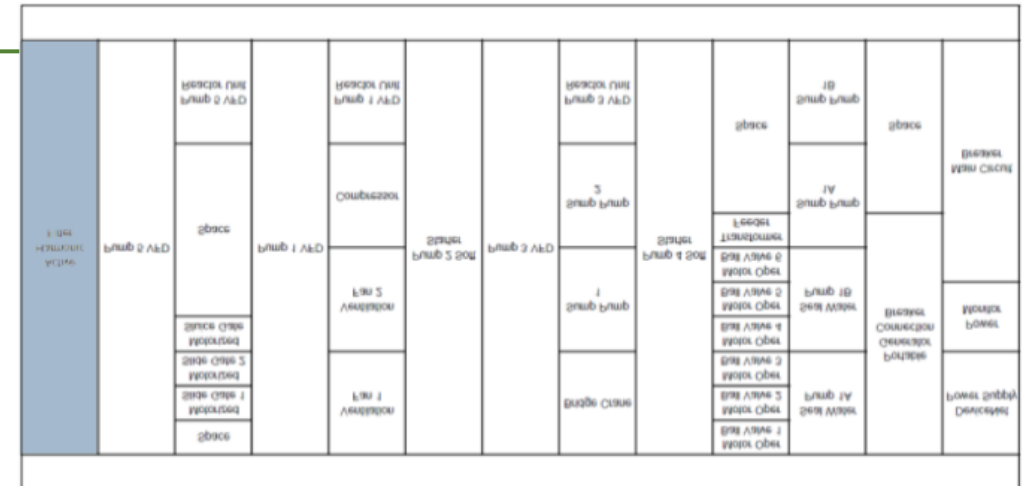


CTs



CTs mounted upstream or downstream of the active filter sense harmonic distortion from the load

The CTs monitor the harmonic distortion on the Bus. The active filter injects the appropriate correction based on loading at the time to eliminate the distortion.



Typical MCC

Active Filter Case Study

- 480V/60Hz
- 600 HP total vfd load (3 x 200HP)
- 50 HP of linear load
- MCC Type 1 enclosure
- Meet IEEE519 (one way or another)

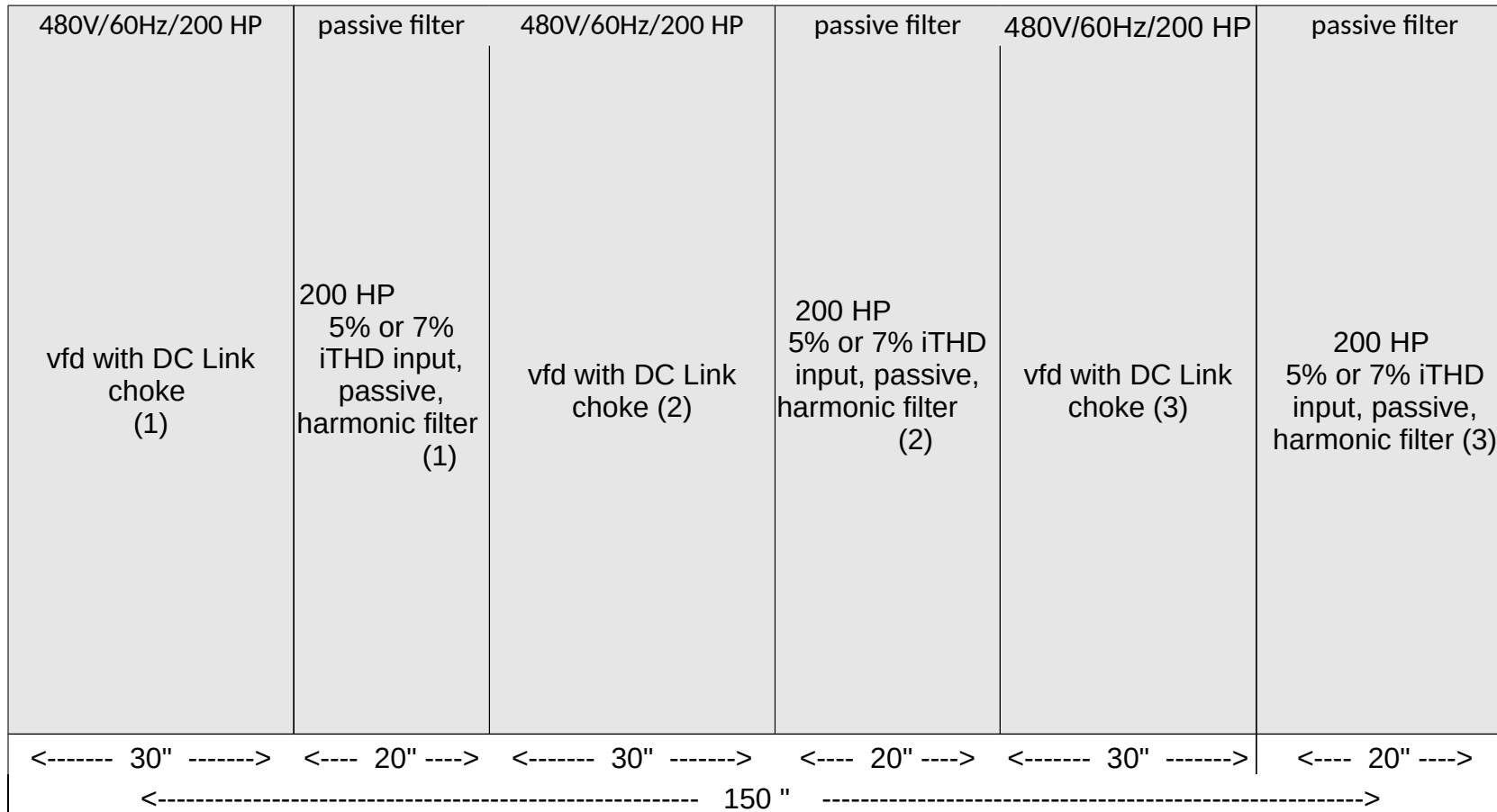
6-pulse vfd's w/DC link choke and 3% AC input line reactor

480V/60Hz/200 HP	480V/60Hz/200 HP	480V/60Hz/200 HP
vfd with DC Link choke and 3% input line reactor (1)	vfd with DC Link choke and 3% input line reactor (2)	vfd with DC Link choke and 3% input line reactor (3)
<----- 30" ----->	<----- 30" ----->	<----- 30" ----->
<----- 90" ----->		

30 - 39% iTHD at input of each vfd	
Total Sections:	3
Depth:	20"
Weight:	1500 lbs
Losses:	10,296 watts
Footprint:	1800 in ²
Price factor:	100%



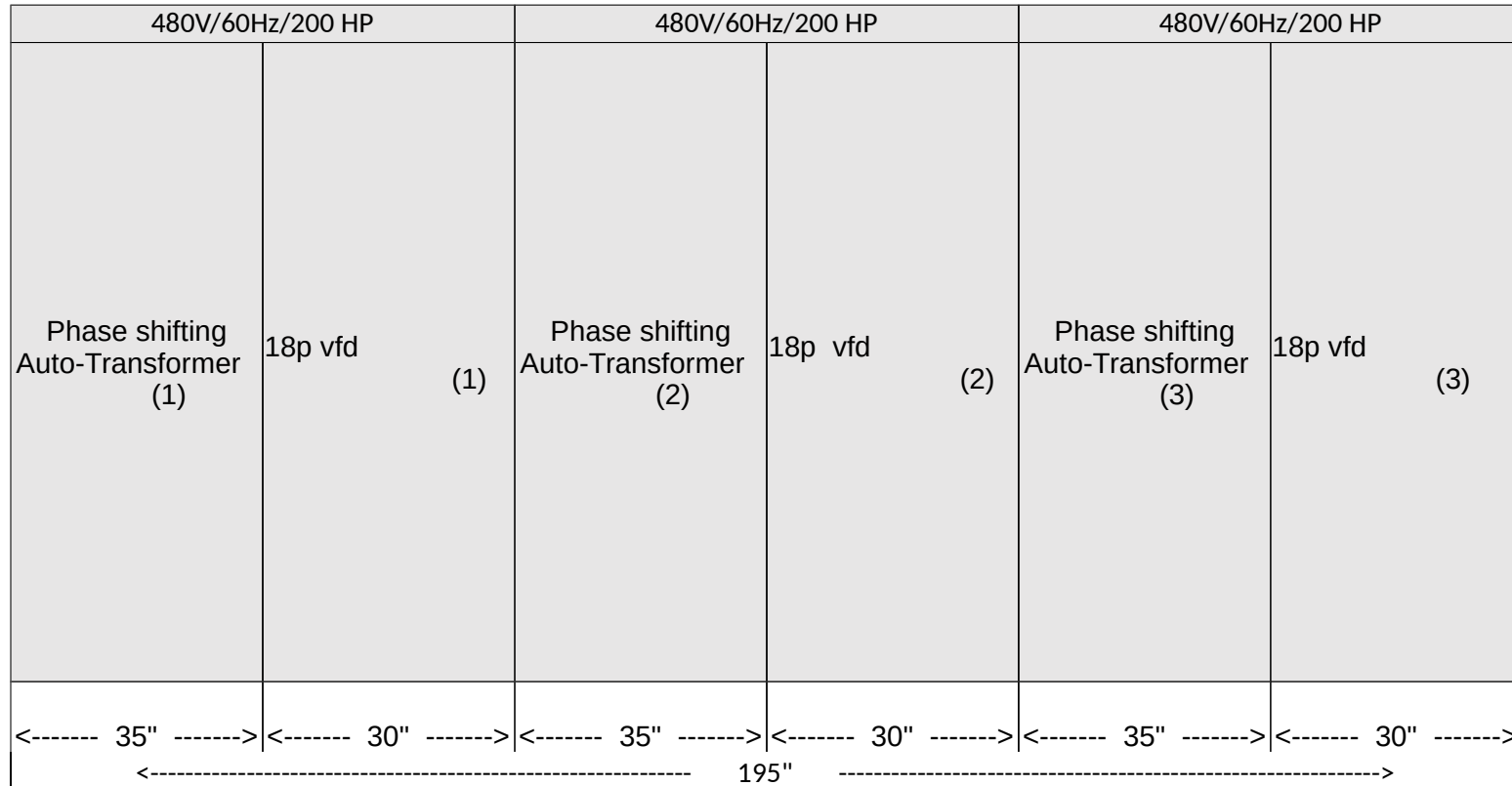
6-pulse vfd's w/DC link choke and passive harmonic filter



5 - 8% iTHD at input of each vfd	
Total Sections:	6
Depth:	20"
Weight:	3,000 lbs
Losses:	11,346 watts
Footprint:	3,000 in ²
Price factor:	158%



18-pulse vfd's w/ phase shifting transformer



<5% iTHD
at input of each vfd

Total Sections: 6
 Depth: 25"
 Weight: 4,175 lbs
 Losses: 18,015 watts
 Footprint: 4,875 in²

Price factor:
386%



6-pulse vfd's w/DC link choke and 3% AC input line reactor & bus applied Active Harmonic Filter

Active Filter	480V/60Hz/ 200 HP	480V/60Hz/ 200 HP	480V/60Hz/ 200 HP
ALC200AW00H4000 - CM200A00	vfd with DC Link choke and 3% input line reactor (1)	vfd with DC Link choke and 3% input line reactor (2)	vfd with DC Link choke and 3% input line reactor (3)
<----- 34" ----->	<----- 30" ----->	<----- 30" ----->	<----- 30" ----->
<----- 124" ----->			

<5% iTHD at input of the MCC	
Total Sections:	4
Depth:	20"
Weight:	2105 lbs
Losses:	17,296 watts
Footprint:	2480 in ²
Price factor:	232%



Redundancy Scenerio

Active Filter	480V/60Hz/ 200 HP	480V/60Hz/ 200 HP	480V/60Hz/ 200 HP
ALC150AW00H4000 – CM100A00	vfd with DC Link choke and 3% input line reactor (1)	vfd with DC Link choke and 3% input line reactor (2)	vfd with DC Link choke and 3% input line reactor (R)
<----- 20" ----->	<----- 30" ----->	<----- 30" ----->	<----- 30" ----->
	<----- 110"----->		

<5% iTHD
at input of the MCC

Total Sections: 4
 Depth: 20"
 Weight: 2105 lbs
 Losses: 15,546 watts*
 Footprint: 2200 in²

Price factor: 214%



	18P Drive	AFE Drive	6P Drive + Passive Filter	6P Drive + Active Filter
Single Drive <700HP	+	+	++	-
Single Drive ≥700HP	+	+	+	+
Multiple Drives	-	-	+	++
High Reliability App	-	-	+	++
Rendundant DriveS	-	-	+	+++
Regen App	-	++	+	+



Solution Summary

	performance	losses (kWatts)	weight (lbs)	footprint (in ²)	Price	Lead
6 pulse w/ active harmonic filter	<5% active response to load changes	17.3	2105	2480	232%	Quick Ship
Active Front End (estimate)	<5% active response to load changes	21.3	4500	4800	292%	ETO
18 pulse	<5% (balanced system)	18.0	4175	4875	386%	ETO
6 pulse w/ passive	5% - 8% down to 50% load	11.3	3000	3000	158%	Quick Ship
6 pulse w/ line reactor	30% - 35% at full load	10.3	1500	1800	100%	Quick Ship
6 pulse only	35% - 40% at full load	10.0	1350	1800	97%	Quick Ship



Conclusion

- There are multiple solutions to reducing harmonics
- Bid specs need to include a “system approach”
- Specifying 18 pulse or Active rectifiers locks out potential lower cost, higher reliability, higher efficiency solutions.
- Line reactors make a big difference for all solutions but reduce total cost when used with active filters.
- If your system includes multiple or redundant VFD’s, active filters make a great solution.

Active Harmonic Filter Specifications

Available current ratings

- 50 Amp
- 100 Amp
- 150 Amp
- Voltage ratings: 208V-600V, 3 ph, 60 Hz, three wire systems
- Operating Frequency: 55 Hz to 65 Hz
 - 50Hz available Q3 '19
- Efficiency: > 98%
- Harmonic Reduction: $\leq 5\%$ ITHD (Full Load)
- 200 Amp
- 250 Amp
- 300 Amp
- Response Time: 2-3 cycles
- Agency Approvals: UL and cUL Listed to UL508



- Where To Find It
- How To Log In
- Sections Of The Tool
- Using The Tool
- Basic Principles To Keep in Mind

TCI[®] HARMONICGUARD[®] SOLUTION CENTER

Version 1.00.00

Default Values

Required Values

Report

Enter Power System Information

System Data

System Voltage: 480 VAC

System Frequency: 60 Hz

Transformer: 500 kVA

Transformer Z: 5.75 %

Correction Target

Harmonic Correction

Desired iTDD: 5.0 %

IEEE-519

Power Factor Correction

6 Pulse VFD Data

Internal VFD				Added External	
Qty	VFD HP	DC Choke %	AC Reactor %	Line Reactor %	% Load
3	100	4.0	0.0	5.0	100
0	0	0.0	0.0	0.0	0
0	0	0.0	0.0	0.0	0
0	0	0.0	0.0	0.0	0
0	0	0.0	0.0	0.0	0
0	0	0.0	0.0	0.0	0

VFD w/ Passive Filter

Qty	HP
5%	0
8%	0

Linear Loads

Motor Load: 100 HP

Linear Loads: 0 kVA

Linear Load PF: 1.00

Calculated Solution

78.9 Corrective Current Required

100 Select Active Filter Current Rating

Custom Active Filter Current Rating

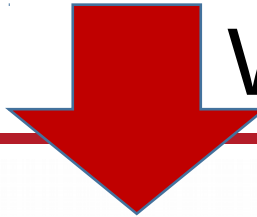
$I_{SC} / I_L: 24$

iTDD with Selected Filter: 4.0% Desired iTDD: 5.0%

Compliant

	With System without		System with
	Active Filter	Active Filter	Corrective Current
Total RMS Current	434.8	427.4	427.6
Fundamental Current	427.0	427.0	427.0
Harmonic Current	81.8	17.1	21.4
iTDD	19.2%	4.0%	5.0%
Reactive Current	168.0	168.0	168.0
kW	326.4	326.4	326.4
kVAR	155.4	140.4	140.8
kVA	361.5	355.3	355.5
Displacement Power Factor	0.92	0.92	0.92
Distortion Power Factor	0.98	1.00	1.00
Total Power Factor	0.90	0.92	0.92

<http://www.transcoil.com/solutioncenter.htm>



Where to Find It

TCI 1-800-824-8282 Solution Center Search TCI...

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HGP with PQconnect

THE FIRST INTELLIGENT PASSIVE FILTER

LEARN MORE!


TCI Company Overview

Who We Are

TCI manufactures active (electronic) and passive (magnetic) products to resolve power quality and harmonic issues associated with industrial power conversion. TCI's experienced staff specializes in developing optimal solutions to achieve IEEE-519 compliance and enhanced motor protection.

TCI partners with electrical and machinery OEMs worldwide, to offer both stand alone and integrated harmonics mitigation and power quality solutions. With over 50 years of experience in solving complex power quality problems, TCI has the expertise to design the right solution for

Where to Find It



Catalog > Solution Center

Solution Center

HARMONICGUARD[®] SOLUTION CENTER

[HarmonicGuard[®] Solution Center](#)

The Solution Center features a dynamic analysis tool that uses your basic system data to generate accurate harmonic and power quality analysis for your unique application. Model an application from utility medium voltage distribution down to individual low voltage linear and non-linear loads within a facility. You're able to set performance targets for harmonics and power factor. Work on your own or in coordination with a TCI representative to determine an optimal solution.

Technical Support

TCI technical support is available to assist with any questions related to this tool.

- Direct Dial: 📞 414-357-4541
- Email: ✉️ tech-support@transcoil.com

TCI has built its reputation on consistently delivering clean power with a full range of harmonic mitigation solutions and expertise. We have been delivering improved power quality, reduced energy costs and extended motor life to our customers for more than 40 years.

TCI's expertise enables us to overcome the most difficult power problems by designing high performing harmonic filtering products and using problem-solving skills and tools to develop solutions for tough applications in a variety of markets. Our practical knowledge of electrical power and experience in industries dependent upon clean power enables us to provide high-performance product design and application support.

The HarmonicGuard[®] Solution Center is an analysis tool that enables users to size filtering solutions to meet harmonic and power factor requirements.

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Web Design & Development by SimDex LLC

How To Log In

1st time user:

- Click on Request Access
- Complete the Request Access Form with your contact info.
- Create Password: you pick
- Accept Terms and Conditions

A screenshot of a web login form. It contains two input fields: 'User Name:' and 'Password:'. Below the fields are two buttons: 'Sign In' and 'Cancel'. Below the buttons is a 'Request Access' button, and at the bottom is a 'Forgot Password?' link.

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Return user:

- Enter Username
- Enter Password
- Accept Terms and Conditions

Sections Of The Tool

Enter Power System Information

<u>1 Transformer Primary</u>	<u>2 Transformer Secondary</u>	<u>3 Secondary Correction Target</u>
Enter Data (optional) <input type="checkbox"/>	Voltage <input type="text" value="480"/> Vrms	Harmonic Correction <input checked="" type="checkbox"/>
Voltage <input type="text" value="38.00"/> kVrms	Frequency <input type="text" value="60"/> Hz	Desired iTDD <input type="text" value="5"/> %
Short Circuit Current <input type="text" value="50.00"/> kArms	Transformer <input type="text" value="1000"/> kVA	<input type="checkbox"/> IEEE-519
	Transformer Z <input type="text" value="5.75"/> %	Power Factor Correction <input type="checkbox"/>

System Voltage
Transformer Data

Harmonic vs. Power Factor Correction
Level of Harmonic Compliance

Sections Of The Tool

System Load detail

4 Non-Linear Loads (20 max)							
Qty	Rectifier Type	HarmonicGuard Drive Applied Passive Filter	VFD HP	Drive Internal Impedance		KDR Line Reactor	% Load
				% DC Choke	% AC Line Reactor	% AC Line Reactor	
0	6 Pulse Diode	None	0	4	0	0	100

Add Non-Linear Load

VFD Detail
 - Motor Load total HP
 - Drive Type

Non-Linear Load HP with passive filters installed
 - 5% passive filters
 - 8% passive filters

VFD BOM
 - Total Summary
 - Individually Recognized
 - Internal Magnetics Detail

External Added Impedance
 - Input Line Reactor in terms of percent Z

Non – Linear Load Characteristics
 - 1 – 100%



Sections Of The Tool

Calculation and Results

Calculate Report Request Quote

Calculated Solution

358.9 Corrective Current Required
200 Select Active Filter Current Rating
Custom Active Filter Current Rating

Secondary Correction Data

iTDD with Selected Filter: 25.8% I_{sc}/I_L : 28.8
vTHD with Selected Filter: 5.4% Desired iTDD: 5.0%
--- iTDD Non-Compliant ---

Power System Electrical Quantities

	Baseline System Without Active Filter	With Active Filter at 200A	With Corrective Current at 358.9A
Total RMS Current	757.6	751.3	728.4
Fundamental Current	727.5	727.5	727.5
Harmonic Current	211.6	187.7	36.4
iTDD%	29.1	25.8	5.0
Reactive Current	227.6	227.6	227.6
vTHD%	6.1	5.4	1.0
kW	574.4	574.4	574.4
kVAR	258.4	245.3	191.7
kVA	629.9	624.6	605.5
Displacement Power Factor	0.95	0.95	0.95
Distortion Power Factor	0.96	0.97	1.00
Total Power Factor	0.91	0.92	0.95

Warning Messages

None

Calculation Icon

System results with software calculated corrective current

Choose size of HGA available for correction

Using Of The Tool

What do you need?

- ❖ Know how IEEE519 is being referred to in the Specification by the Consultant Specification.

- ❖ One line diagram of the electrical system.

- ❖ Knowledge of the Drive Load as it relates to:
 - operational load of vfd's
 - redundancy of vfd's
 - future expansion of load
 - any space limitations to installation location.

Basic Principles to Keep in Mind

- Inductance decreases the amount of corrective current required to meet IEEE519.
- At the same impedance, the inductance of a Line Reactor is more effective than a DC Link Choke (4%Z DC Link has the same results as a 2%Z line reactor)



4% impedance



2% impedance

Basic Principles to Keep in Mind

- Inductance is summative. DC Link + Input Line Reactor is strongly suggested. It reduces the amount of corrective current required to meet the IEEE519 requirement.



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<http://www.transcoil.com/solutioncenter.htm>

Thank you!



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