1336 PLUS II Drive ONLY – Specification]

GENERAL

REFERENCES

The drive is designed to meet the following specifications:

- NFPA 70 - US National Electrical Code
- NEMA ICS 3.1 - Safety standards for Construction and Guide for Selection, Installation and Operation of Adjustable Speed Drive Systems.
- NEMA 250 - Enclosures for Electrical Equipment
- UL 508C - Underwriter's Laboratory
- CAN/CSA-C22 No. 14-M91. - Canadian Standards Association.
- IEC 146 - International Electrical Code.
- IEC 529 – Degree of protection provided by enclosures (IP code).

REGULATORY REQUIREMENTS

The drive conforms to the following requirements:

- NFPA 70
- IEC 146
- EN Standard/CE marked for EMC directives

Emissions	Immunity
EN 50081-1	EN 50082-1
EN 50081-2	EN 50082-2
EN 55011 Class A	IEC 801-1,2,3,4,6,8
EN 55011 Class B	(per EN 50082-1,2)

- IEC 801 EN61800-3
- Low Voltage
  EN50178
  EN60204-1 PREN 50178
- C-UL marking to provide an approved listing for both United States and Canadian users.
- The Manufacturer will furnish the product as listed and classified by Underwriter's Laboratories as suitable for the purpose specified and indicated.

QUALIFICATIONS

MANUFACTURER:
Allen-Bradley entered the AC Variable speed drive market in 1980. Rockwell Automation / Allen-Bradley Standard Drives Business continues to specialize in the design and manufacturing of PWM Adjustable Frequency Drives.

SUPPORT:
Rockwell Automation support, there are specialists at local sales offices and distributor locations across North America and around the world. We also offer Global Technical Services, specializing in a full spectrum of value-added services and expertise to help simplify maintenance and enhance productivity.

CERTIFICATION:
All Allen-Bradley drive manufacturing locations are certified to the ISO-9001 Series of Quality Standards as well as the ISO-14001 Enviromental Standards. This insures all quality and corrective action procedures are documented and implemented with a goal of Total Customer Satisfaction.

PRODUCT

RATINGS

INPUT POWER:
The drive is self adjustable to accept an input voltage range between 380-480VAC, three phase +/-10%. (Configured drive packages will be designed to a single nominal voltage; 230, 460, or 575 VAC)

Displacement power factor shall range between 1.0 and 0.95, lagging, over the entire speed range (0.80 for 0.5-5hp/0.37-3.7kW, 200-480V drives). The efficiency of the drive shall be a minimum of 97% at full load and speed.

ENVIRONMENT:
Storage ambient temperature range: -40 C to 70 C (-40 to 158 F).
Operating ambient temperature range: 0 C to 40 C (0 to 109 F) without derating.
The relative humidity range is 5% to 95% non-condensing.
Operating elevation: up to 1000 Meters (3,300ft) without derating.

OUTPUT POWER:
The output voltage is adjustable from 0 to rated input voltage. The output frequency range is adjustable from 0 to 400Hz. The inverter section will produce a pulse width modulated (PWM) waveform using latest generation IGBTs.

REFLECTED WAVE
Drives less than 60 HP will have software to limit the reflected wave due to long cable lengths to a maximum of 2 time bus voltage. Larger drives will have designs to minimize reflected wave.

DESIGN

HARDWARE:
The drive hardware employs the following power components

- Diode or fully gated bridge on the input.
- DC bus inductor on all ratings 7.5HP (5.5kW) or greater.
- Switching logic power supply operating from the DC bus.
- Phase to phase and phase to ground MOV protection.
- Gold plated plug-in connections on printed circuit boards.
- Microprocessor based inverter logic isolated from power circuits.
- Latest generation IGBT inverter section.
- Inverter section shall not require commutation capacitors.
- Customer Interface common for all horsepower ratings. Interface shall include an LCD digital display, programming keypad and operator keys option.
- Two Main Control Boards
  One common for .5 HP (.37kW) - 20 HP (15kW) and
  One common for 15 HP (11kW) and up.
- Common control connection for all ratings.
- Optimized for 4kHz carrier frequency at 60HP (44kW) or less, and 2kHz at 75HP (55kW) and larger.
- Peripheral Interface to enable attaching common options.

CONTROL LOGIC:
The drive is programmable or self adjusting for operation under the following conditions.

- Operate drive with motor disconnected.
- Controlled shut down, when properly fused, with no component failure in the event of an output phase to phase or phase to ground short circuit and annunciation of the fault condition.
- Adjustable PWM carrier frequency within a range of 2-8kHz.
- Selectable Sensorless Vector or V/Hz mode.
- Selectable for variable or constant torque loads. Selection of variable torque provides 115% of rated VT current for up to one minute. Selection of constant torque provides 150% of rated CT current for up to one minute.

- Multiple programmable stop modes including - Ramp, Coast, DC-Brake, Ramp-to-Hold and S-curve.
- Multiple acceleration and deceleration rates.
- All adjustments to be made with the door closed.
- Adjustable output frequency up to 400Hz.

TERMINAL BLOCKS:
Separate terminal blocks are provided for control and power wiring. Power terminal blocks are rated a minimum of 90 ºC and dual marked for both inputs and outputs (R-L1, S-L2, T-L3 and U-T1, V-T2, W-T3)

POWER CONDITIONING:
This drive will have an 18 – Pulse front end. Details to follow in the section called: " 1336 PLUS II CONFIGURED 18 Pulse PACKAGE Specifications ".

FEATURES

OPERATOR INTERFACE:
See: Human Interface module options, configured drive package section.

CONTROL MODE:
Programming provides the ability to select sensorless vector or v/hz mode. The sensorless vector mode uses motor nameplate data plus motor operating data such as IR drop, nominal flux current and flux up time. The volts per hertz mode can be programmed straight line, pre programmed fixed boost or full custom patterns.

CURRENT LIMIT:
Programmable current limit from 20% to 300% of constant torque rating. Current limit is active for all drive states; accelerating, constant speed and decelerating. The drive employs PI regulation with an adjustable gain for smooth transition in and out of current limit.

ACCELERATION/DECELERATION:
Accel/Decel settings provide separate adjustments to allow either setting to be adjusted from 0 seconds to 3600 seconds. A second set of remotely selectable Accel/Decel settings are accessible with Control Interface option. An adaptive current limit circuit can be disabled in programming for fast acceleration of low inertia loads.

SPEED REGULATION:
The programmable speed regulation modes include the following:
- Open Loop
- Slip Compensation with 0.5% speed regulation
- Droop - Negative Slip Compensation with 0.5% speed regulation
- Traverse Function
- Closed loop encoder feedback with 0.1% speed regulation
- Process PI control
- Phase Lock Loop to lock output phasing to input pulse train frequency command

SPEED PROFILES:
Programming capability allows the user to produce speed profiles with linear acceleration/deceleration or "S-Curve" profiles that provide changing accel/decel rates. S-Curve profiles shall be selectable for fixed or adjustable values.

ADJUSTMENTS:
The digital interface is used for all set-up, operation and adjustment settings. All adjustments are stored in nonvolatile memory (EEPROM). No potentiometer adjustments are used. The drive provides EEPROM memory for factory default values.

PROCESS PI CONTROL:

The internal process PI regulator has both proportional and intergral gain adjustments as well as error inversion and output clamping functions. The feedback can be configured for normal or square root functions. If the feedback indicates that the process is moving away from the setpoint, the regulator will adjust the drive output until the feedback equals the reference. Process control can be enabled or disabled with a hardwire input. Transistioning in and out of process control can be tuned for faster response by preloading the integrator. Protection is provided for a loss of feedback or reference signal. A signal can also be provided to indicate that excess error exists.

FAULT RESET/RUN:
The drive provides up to nine automatic fault reset and restarts following a fault condition before locking out and requiring manual restart. The automatic mode is not applicable to a ground fault, shorted output faults and other internal microprocessor faults. The time between restarts is adjustable from 0.5 seconds to 30.0 seconds.

SKIP FREQUENCIES:
Three adjustable set points that lock out continuous operation at frequencies which may produce mechanical resonance are provided. The set points have a bandwidth adjustable from 0Hz to 15Hz.

RUN ON POWER UP:
A user programmable restart function is provided to automatically restart the equipment after restoration of power after an outage. A mintained 2-wire start input is required for this function.

LINE LOSS RESTART:
This programmable function selects the reconnect mode of the drive after recovery from a line loss condition. The reconnect modes are - Last Speed, Speed Search, Track Volts, or Use Encoder. Disabling this feature will force the drive to start from zero hertz.

FAULT MEMORY:
The last four faults as well as operating frequency, drive status and power mode are stored at the time of fault. Information is maintained in the event of a power loss.

OVERLOAD PROTECTION:
The drive will provide Class 10 motor overload protection investigated by UL to comply with N.E.C. Article 430. Overload protection is speed sensitive and adjustable for motors with speed ranges of 2:1, 4:1 and 10:1. A veiwable parameter stores the overload usage in percent. An alarm bit can be used to adjust a process to eliminate an overload trip.

AUTO ECONOMIZER:
This feature automatically reduces the output voltage when the drive is operating in an idle mode (drive output current less than programmmed motor FLA). The voltage is reduced to minimize flux current in a lightly loaded motor thus reducing kW usage. If the load increases, the drive will automatically return to normal operation.

FLYING START:

The drive is capable of determining the speed and direction of a spinning motor and adjusts its output to "pick-up" the motor at the rotating speed. The flying start feature is operable with or without encoder feedback.

RIDE THROUGH:
The control logic is capable of "riding through" a power outage of at least 2 seconds in duration. The inverter section is shut off after a drop in bus voltage to conserve power for the drive logic. The amount of drop required will be adjustable to 50% of nominal.

INERTIA RIDE THROUGH:
The drive can respond to a loss of AC input power by adjusting the output frequency to create a regenerative situation in the motor. This regenerated energy recaptures the mechanical energy and converts it to electrical energy to power the drive logic during the power outage. This allows the drive to retain control of the motor during the power outage. Performance is based on the amount of system inertia and the length of the outage. The amount of voltage drop required to trigger inertia ride through and the level at which regulation occurs shall both be adjustable. Inertia Ride Through can be enabled or disable via programming.

ANALOG OUTPUT:
Two single ended output signals, 0 - 10V DC are available as standard. They are user programmable to be proportional to one of 13 process parameters including output frequency, output current, encoder feedback, output power and others. Programming is available to select either absolute or signed values of these parameters. A programmable offset is provided to allow modification of the analog output to obtain 2 - 10V DC.

Optionally, Up to two isolated outputs, dip switch configurable as 0-10V DC or 0-20mA, are available. These outputs offer full galvanic isolation to 195 V DC (greater than 10M ohm, less than 50 pf) to isolate the signal from drive common or earth ground. Also available is a non isolated pulse train output capable of a 5V DC pulse train at 250 kHZ maximum output rate.

Programmable gain adjustments for standard and optional outputs allow adjustment of both upper and lower settings to allow for system calibration.

ANALOG INPUTS
Three single ended (non isolated) analog inputs, jumper configurable as 0 - 10V DC, 0-20 mA or potentiometer are available as standard. They are user programmable for a variety of uses including frequency command, process loop inputs, and others.

Optionally, isolated inputs, dip switch configurable as 0-10V DC or 0-20mA are available. Also available are bipolar inputs, configurable as ± 10V or ± 20mA, isolated thermister input and isolated pulse train input. The bipolar inputs provide commands for both speed and direction.

Isolated inputs offer full galvanic isolation to 195 V DC (greater than 10M ohm, less than 50 pf) to isolate the signal from drive common or earth ground. Up to three isolated inputs can be supplied (two, if two outputs are required).

The pulse train input is capable of input pulse frequencies of up to 250 kHz. The thermister input monitors a nominal input of 1.8 K ohms for a PTC device. Trip points at 3.3 K ohms for overtemperature and 60 ohms for shorted circuit are provided.

Programmable gain adjustments for standard and optional outputs allow adjustment of both upper and lower settings to allow for system calibration. A programmable offset is also provided to allow modification of the analog input to obtain 2 - 10V DC or 4-20 mA.

REFERENCE SIGNALS:
The drive is capable of the following input reference signals:

- Digital pulse train input
- Digital MOP
- HIM (Program/Control panel)
- Analog Input signals as:
  - Remote potentiometer
  - 0-10V DC
  - 0-20ma

The first analog input is also programmable to be used as a trim signal for the selected speed reference. The analog inputs have programmable gain adjustments for both upper and lower settings allow for system calibration. The analog inputs are programmable for normal, inverted or sqare root operation. The remote potentiometer is also programmable to be used as a trim pot for the 0-10V DC or 4-20ma signals. Programmable gain adjustments for both upper and lower settings allow for system calibration. The analog inputs are programmable for normal, inverted or sqare root operation.

LOSS OF REFERENCE:
The drive is capable of sensing the following reference loss conditions;

- Remote potentiometer wiper loss
- 2-10V DC signals below 2 volts
- 4-20ma signals below 4 ma

In the event of loss of an analog input reference signal, the drive is user programmable to the following:

- Fault and stop
- Alarm and maintain last reference within 10%
- Alarm and go to preset speed
- Alarm and go to minimum speed
- Alarm and go to maximum speed

Signal loss detection is available when the signal being monitored is

- The active Process PI reference or feedback
- The active Frequency reference

DIGITAL I/O:
Digital I/O consists of two Form A and two Form C relay outputs as standard. Contact output ratings are 115V AC/30V DC, 5.0 Amp resistive, 2.0 Amp inductive and nine inputs, accessible through optional input cards

CONTROL INTERFACE OF YOUR CHOICE
All 1336 Plus II Configured Drives come with a 115VAC Control Interface Card (option L6C) as standard unless otherwise specified. We are providing a 24 V AC/DC control with on the drive in this quote. Additionally a Contact Closure Control are also available as options. Encoder feedback is also available as an option with any of the three control methods. Refer to the control interface option selection for information specific to this quotation.

VARIABLE TORQUE
Variable Torque refers to a multi-speed motor used on loads with torque requirements, which vary with speed as with some centrifugal pumps and blowers. The horsepower varies as the square of the speed.

1336 PLUS II CONFIGURED PACKAGE Specifications

GENERAL

The heart of every Configured Drive Package is a standard 1336 PLUS II AC drive. This world class product will help to provide you with a single solution for virtually all of your speed control requirements.

The Configured Drives supplies a much larger offering of factory mounted options than what is normally available with a standard drive program. Most options are pre-engineered for consistency of design. This translates to time and money savings in set-up, integration and maintenance of your automation systems.

PACKAGE FEATURES

STANDARD 1336 PLUS II AC DRIVE

(see the preceding "1336 PLUS II Drive Specification" for more information)

DRIVE INPUT FUSES:
Drive input fuses are provided standard with any configured drive package the fuses provide circuit protection for the drive.

ENCLOSURE STYLE OF YOUR CHOICE
The drive proposed is rated NEMA 1 and will have enclosure filters, Gasketing and a FLOOR PLATE to help provide an added degree of protection against dust entering the enclosure. It is up to the customer to provide a regular preventative maintenance program to change these filters regularly based upon how dusty the environment is. Each enclosure type lends itself to a particular type of protection and environment. The enclosures detailed below do not normally protect electrical equipment from condensation, corrosion or contamination which may occur within the enclosure or enter via the conduit or unsealed openings. Users must make adequate provisions to safeguard against such conditions, and satisfy themselves that the equipment is properly protected. Other enclosure types are available by custom quotation. For further information on criteria associated with NEMA enclosure ratings, refer to NEMA standards Publications NO. 250-1991. See enclosure options for specific enclosure style quoted.

DRIVE DISCONNECT SWITCH: (Option DS)
A flange mount or rotary style switch (1494F where possible) is provided on D frame drives and larger. With the exception of the "F" frame the drive input fuses will be resident on the switch allowing it to meet the requirements for branch circuit protection. All disconnect switches are door interlocked and padlockable.

CONTROL AND FEEDBACK OPTIONS

CONFIGURABLE ANALOG INPUTS/OUTPUTS OPTIONS:
Configurable isolated I/O are designed with full galvanic isolation. This results in an isolation withstand capibility of 200VAC from each channel to true earth (TE) ground and between channels. (Only one option is allowed in port A and only one option is allowed in Port B.)
ANALOG INTERFACE – PORT A
Option LA2C - Two Isolated Configurable Inputs

CONTROL INTERFACE OPTIONS:

CONTROL INTERFACE CARDS
All Control Interface cards provide input terminals for access to fixed drive functions that include start, stop, auxiliary fault, line loss,output contact close, speed select, sync, traverse, reset, and enable,. Additional inputs are programmed for functions such as reverse, preset speed access, jog, second accel/decel time access and local control selection. The function of each input is defined through programming. For Configured drives, functions are pre-programmed at the factory for a specific application and configuration and should not require Customer programming.

Operator control devices provided as part of the drive control package will be interfaced to these same input terminals. All control input terminals are optically isolated from the drive internal logic control.

Optional encoder feedback is available for use with single ended or differential type encoders. When using a single ended encoder there is a 12V DC power supply available for Customer use. Differential encoders wil require a user supplied power supply.

Option L5C – Circuits used with the optional L5C interface must be capable of operating with **high = true logic**. DC external circuits in the low state must generate a voltage of no more than 8V DC. Leakage current must be less than 1.5mA into a 2.5k ohm load. AC external circuits in the low state must generate a voltage of no more than 10V AC. Leakage current must be less than 2.5mA into a 2.5k ohm load. Both AC and DC external circuits in the high state must generate a voltage of +20 to +26 volts and source a current of approximately 10mA for each input.

OPERATOR INTERFACE OPTIONS

HUMAN INTERFACE MODULES:
The drive provides a removable Human Interface Module with integral display to show drive operating conditions, adjustments and fault indications. Two physical packages are offered. The first is a snap-in package designed to mount on the drive's main control board. The second is a hand held version that is connected to the drive by means of cable of up to 10 meters (33ft). The hand held version is removable under power without causing a fault. The display consists of 2 lines of 16 character alphanumeric, backlit LCD with the display being configurable for simultaneously displaying two values using customized multi-lingual text and user scaled units. Two basic types of modules are available; one providing only programming information and one providing programming plus an operation keypad with Start, Stop, Speed Reference (analog pot or digital keys), direction control / indication and Jog. This removable Human Interface Module can store up to 2 drive configuration in EEPROM.

Option HA2C – Nema type 1 door mounted HIM program/control with digital speed pot

DOOR-MOUNTED OPERATOR DEVICES

OPTION D13:
This option provides a "Hand/Off/Auto" selector switch for start-stop and speed reference control. The devices are Allen-Bradley 800E style mounted on the enclosure door.

ENCLOSURE OPTIONS

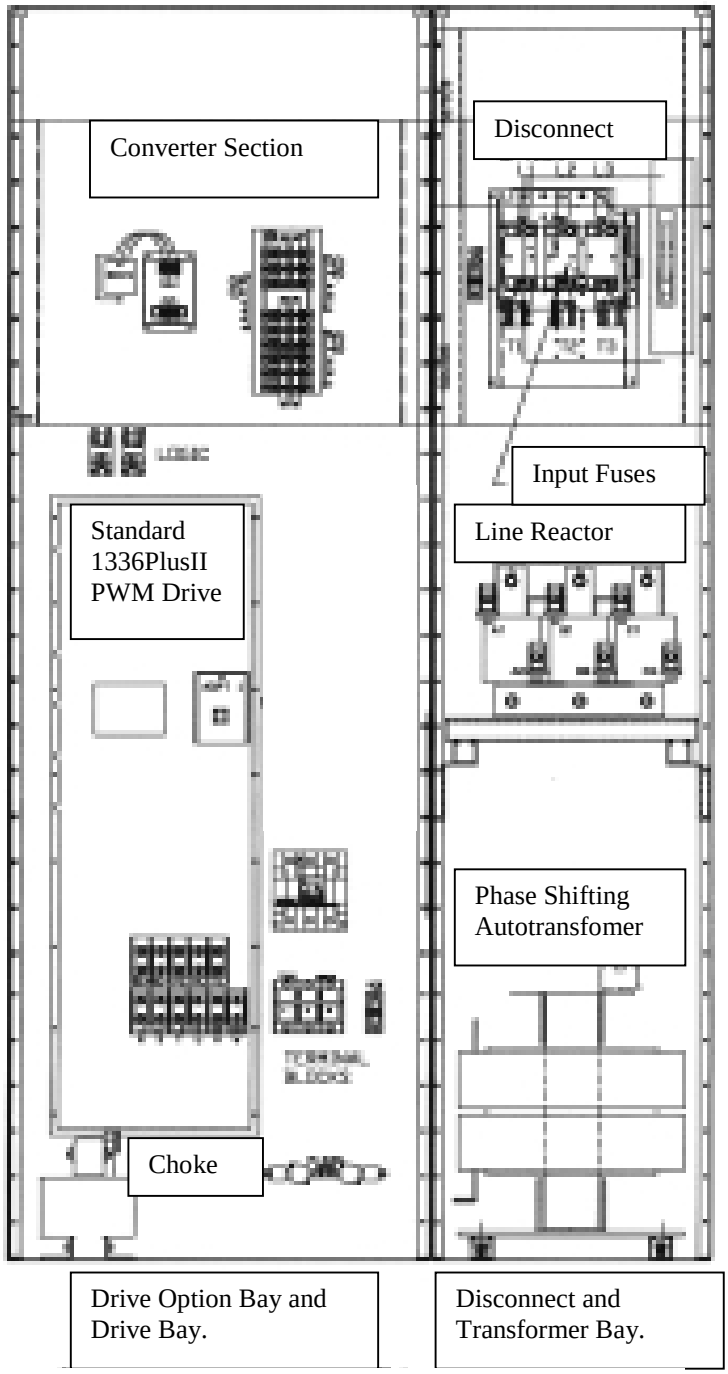
IP20 NEMA TYPE 1: (Option AA)
Type 1 enclosures are intended for indoor use primarily to provide protection against contact with the enclosed equipment in locations where unusual service conditions do not exist. The enclosures are designed to meet the rod entry and rust resistance design test. Slotted openings in the enclosure sides or door(s) allow for free exchange of inside and outside air.

GASKETED WITH FILTERED DOOR OPENINGS: (Option EG)
This option provides washable metal mesh filters on the outside of the enclosure door and over all other vented openings. In addition all doors and wall panels will be gasketed as necessary to prevent unfiltered air from entering the enclosure. This option applies only to Nema 1 enclosures.

CODES AND STANDARDS

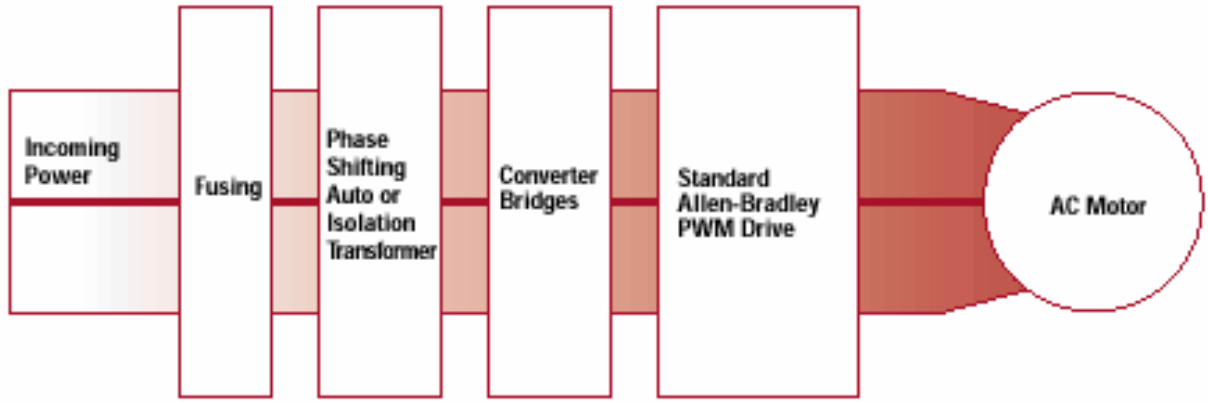
UL, C-UL (CSA) RECOGNITION: (Option UL)
This option provides UL panel recognition from the factory.

General Layout and Dimensional Information:



TYPICAL CONFIGURED PACKAGE CONSTRUCTION

Typical Allen-Bradley Multi-Pulse Topologies



18 Pulse Bridge Design Option "A"

18 Pulse Converter with AutoTransformer to address with IEEE-519 (1992) Power Utility standards @ PCC:

We can guarantee meeting IEEE519-1992 at the drive-input terminals without analysis; provided the input power phases are balanced within 1%. An autotransformer will have a lower cost and smaller physical size (easier to mount in the enclosure line-up) than an isolation transformer.

In order to guarantee meeting the IEEE519-1992 standard at the POINT OF COMMON COUPLING (PCC) (as prescribed in the IEEE519 standard), it would be necessary to know the following:

- ***From a VOLTAGE Harmonic Distortion stand point:***

Total voltage distortion not to exceed 5% in general power systems, which is the typical environment for this type of project. A 10% limit is allowed in dedicated power systems, or a 3% limit if this application is considered a special power system i.e.(hospitals, research labs) Refer to IEEE standard 519-1992 Table 10.2 for more specific information. (Below). With our 18-Pulse solution, and based upon the one-line diagram provided for this customer's site, meeting this part of the IEEE519 standard, is not a problem. Voltage Distortion will be below guidelines at 100% Speed, 75% Speed and all other speeds less than full load. Generally the concern is more involved with compliance with the THD for Current in order to know how to size transformers and generators.

IEEE519-1992 LIMITS
Table 10.2
Low Voltage Systems Classification and Distortion Limits

	Special Applications*	General System	Dedicated System†
Notch Depth	10%	20%	50%
THD (Voltage)	3%	5%	10%
Notch Area (AN)‡	16 400	22 800	36 500

Note: The value AN for other than 480 V systems should be multiplied
* Special applications include hospitals and airports.
† A dedicated system is exclusively dedicated to the converter load.
‡ In volt-microseconds at rated voltage and current.

From a Current Harmonic Distortion stand point: Total current distortion ranging from 5%-20% maximum dependent upon Short Circuit Ratio. Current Distortion on a AutoTransformer parallel bridge design will meet IEEE-519 requirements at full load with balance supply voltage and no pre-existing harmonic content.

-

Refer to IEEE standard 519-1992 Table 10.3 for more specific information.

Table 10.3

CURRENT DISTORTION LIMITS FOR GENERAL DISTRIBUTION SYSTEMS
(120V THROUGH 69,000V) [1]

Maximum Harmonic Current Distortion in Percent of I_L						
Individual Harmonic Order (Odd Harmonics)						
I_{sc}/I_L	<11	11 h<17	17 h<23	23 h<35	35 h	TDD
<20	4.0	2.0	1.5	0.6	0.3	5.0
20<50	7.0	3.5	2.5	1.0	0.5	8.0
50<100	100.0	4.5	4.0	1.5	0.7	12.0
100<1000	12.0	5.5	5.0	2.0	1.0	15.0
>1000	15.0	7.0	6.0	2.5	1.4	20.0
Even harmonics are limited to 25% of the harmonic limits above.						
Where I_{sc} = maximum short circuit current at PCC I_L = maximum demand load current (fundamental frequency component) at PCC						

1 Reprinted from IEEE standard 519-1992. Please refer to the actual IEEE Standard for current tables and usage instructions.

Actual Measurement of Total Harmonic Distortion (THD):
• Is dependent upon utility power capacity referred to as **Short Circuit Current (Isc)**, measured at the PCC. For calculation purposes the **Isc** number must be supplied by the utility.
• Is dependent upon existing or planned linear and non-linear loads also called **Maximum Demand Load Current (IL),** as required by the user's system.
• The **ratio** of the two quantities above **(Isc /IL)** is referred to as **Short Circuit Ratio.**

Based on the above, our 18 pulse Adjustable Speed Drives will meet the limits set forth within IEEE-519, without further analysis when PCC is defined as the standard intends at the utility metering point.
If PCC is defined at the ASD input terminals, than Short Circuit Ratio, percent existing voltage imbalance, and impedance of the utility transformer will need to be defined.
While almost all applications will meet IEEE-519 when applied to the ASD input terminals, the risk of pre-existing voltage imbalance, and distortion could skew the results, and may not meet the IEEE519-1992 at the ASD input terminals. If IEEE-519 is to be applied at the ASD input terminals, an 18 Pulse "Series Bridge" Autotransformer design should be specified. {See next section for specification details}

18 Pulse Bridge Design Option "B"

18 Pulse "Series Bridge" Converter with Isolation Transformer to address with IEEE-519 (1992) Power Utility standards when applied @ ASD Input Terminals:

We can guarantee meeting IEEE519-1992 at the drive-input terminals without analysis. An "Series Bridge" and Isolation transformer will have a slightly higher cost but allow meeting the IEEE-519 specification at less than full load, and in the presence of typical "real-world" levels of pre-existing levels of voltage distortion and voltage imbalance.

National levels of pre-existing voltage distortion in the United States and Canada are typically 1.2% or less, and in these applications IEEE-519 will be met with this solution.

- ***From a VOLTAGE Harmonic Distortion stand point:***

Total voltage distortion not to exceed 5% in general power systems, which is the typical environment for this type of project. A 10% limit is allowed in dedicated power systems, or a 3% limit if this application is considered a special power system i.e.(hospitals, research labs) Refer to IEEE standard 519-1992 Table 10.2 for more specific information. (Below). Voltage Distortion will be below guidelines at 100% Speed, and all other speeds less than full load. Generally the concern is more involved with compliance with the THD for Current in order to know how to size transformers and generators.

IEEE519-1992 LIMITS
Table 10.2
Low Voltage Systems Classification and Distortion Limits

	Special Applications*	General System	Dedicated System†
Notch Depth	10%	20%	50%
THD (Voltage)	3%	5%	10%
Notch Area (AN)‡	16 400	22 800	36 500

Note: The value AN for other than 480 V systems should be multiplied
* Special applications include hospitals and airports.
† A dedicated system is exclusively dedicated to the converter load.
‡ In volt-microseconds at rated voltage and current.

From a Current Harmonic Distortion stand point: Total current distortion is dependent upon Short Circuit Ratio and will be within IEEE-519 guidlenes for current. This “Series Bridge” Isolation Transformer design will meet IEEE-519 requirements at full speed and any reduced speed and load on any installation with typical levels of pre-existing harmonics and voltage distortion. To determine if this application falls in typical application criteria, a pre-installation harmonic analysis shall be provided based on the following information:

Table 10.3

CURRENT DISTORTION LIMITS FOR GENERAL DISTRIBUTION SYSTEMS (120V THROUGH 69,000V) [1]

Maximum Harmonic Current Distortion in Percent of I_L						
Individual Harmonic Order (Odd Harmonics)						
I_{sc}/I_L	<11	11 h<17	17 h<23	23 h<35	35 h	TDD
<20	4.0	2.0	1.5	0.6	0.3	5.0
20<50	7.0	3.5	2.5	1.0	0.5	8.0
50<100	100.0	4.5	4.0	1.5	0.7	12.0
100<1000	12.0	5.5	5.0	2.0	1.0	15.0
>1000	15.0	7.0	6.0	2.5	1.4	20.0
Even harmonics are limited to 25% of the harmonic limits above.						
Where I_{sc} = maximum short circuit current at PCC I_L = maximum demand load current (fundamental frequency component) at PCC						

1 Reprinted from IEEE standard 519-1992. Please refer to the actual IEEE Standard for current tables and usage instructions.

BELOW IS SYSTEM DATA THAT MUST BE SUPPLIED IF HARMONIC ANALYSIS IS REQUIRED

Source

60 Hz

PCC1
PCC at distribution xfmr

PCC2
PCC at drive xfmr

PCC3
PCC at distribution panel

Distribution Transformer or Generator

0 feet between distribution xfmr and drive xfmr

kVA 1
%Z 1
Vsec 1

Drive Transformer

0 feet between drive xfmr and distribution panel

kVA 2
%Z 2
Vsec 2

Distribution Panel

Linear Load on distribution xfmr (hp+kW)

0 total hp motor load
\+ 0 total kW resistive load

Linear Load on drive xfmr (hp+kW)

0 total hp motor load
+ 0 total kW resistive load

6 pulse unbuffered drive without line reactor

0 total hp
0 feet to panel

6 pulse buffered drive without line reactor

0 total hp
0 feet to panel

6 pulse buffered drive with 3% line reactor

0 total hp
0 feet to panel

6 pulse buffered drive with 5% line reactor

0 total hp
0 feet to panel

6 pulse buffered drive with basic harmonic filter

0 total hp
0 feet to panel

12 pulse buffered drive with auto xfmr, parallel bridges

0 total hp
0 feet to panel

12 pulse buffered drive with iso xfmr, series bridges

0 total hp
0 feet to panel

18 pulse buffered drive with auto xfmr, parallel bridges

0 total hp
0 feet to panel

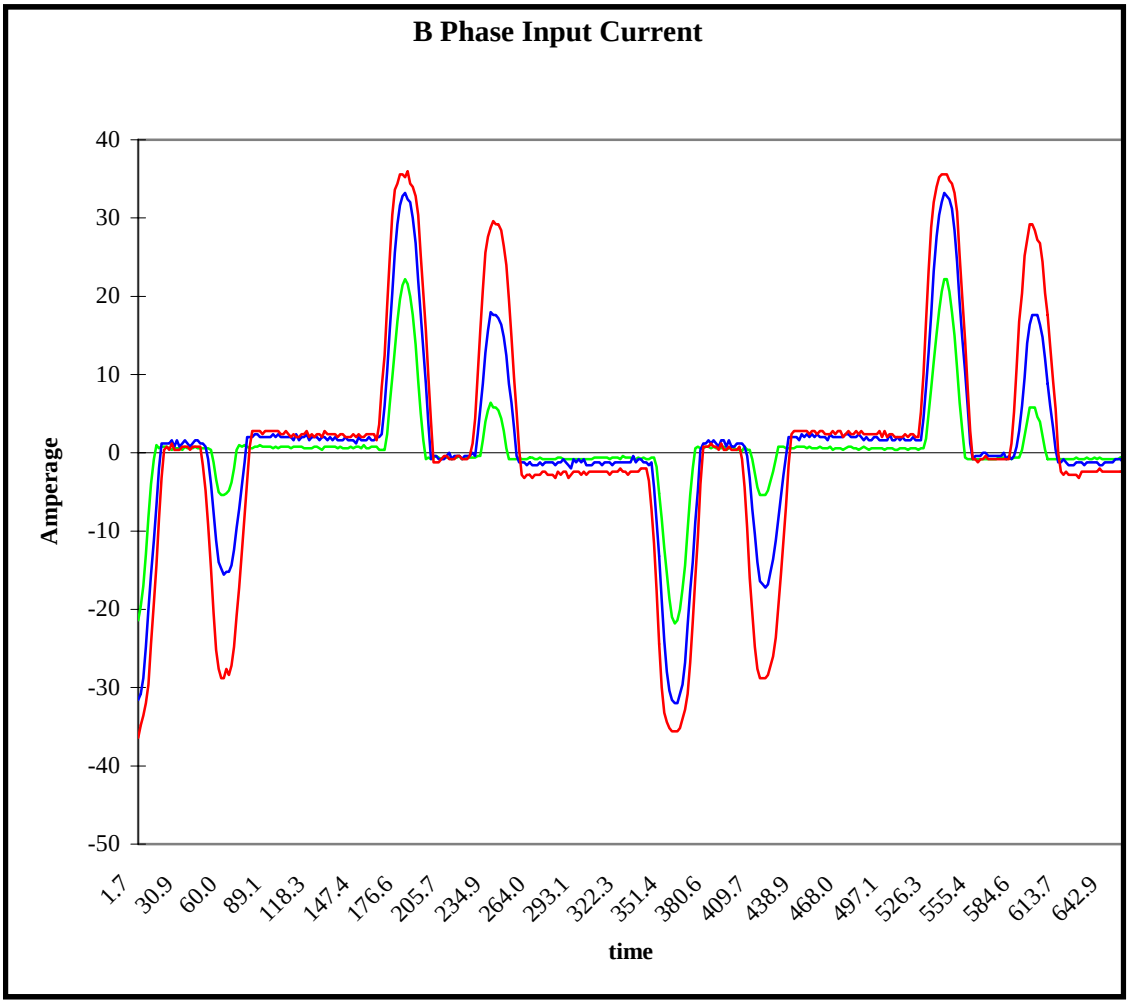
18 pulse buffered drive with iso xfmr, series bridges

0 total hp
0 feet to panel

APPENDIX "A" PARALLEL BRIDGE DESIGN

Rectifier Bridge operation discussions at less than full speed and load, or with pre-existing voltage imbalance or distortion.

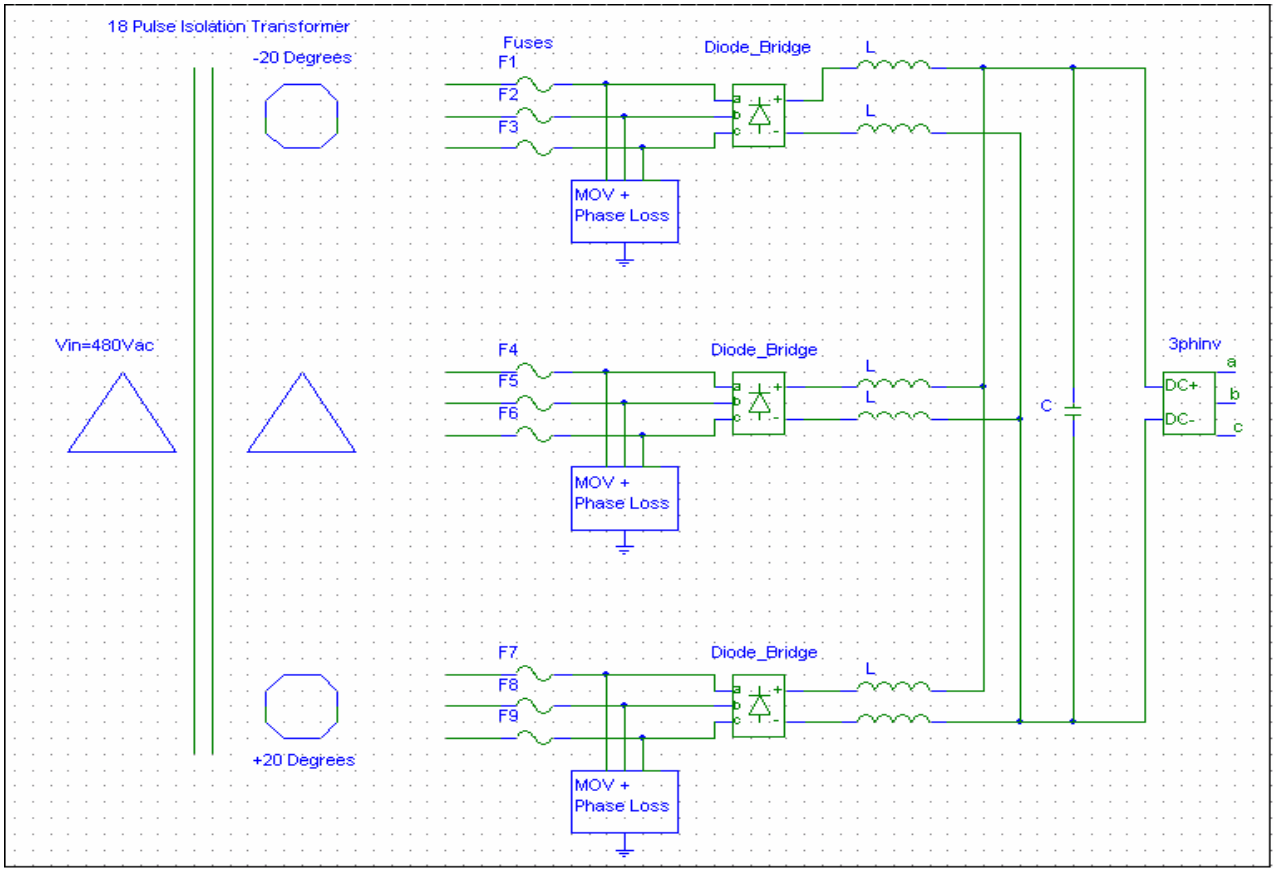
The graphic below displays typical current flow through a standard 6 pulse bridge design at no motor load, rated motor load, and 150% rated motor load.

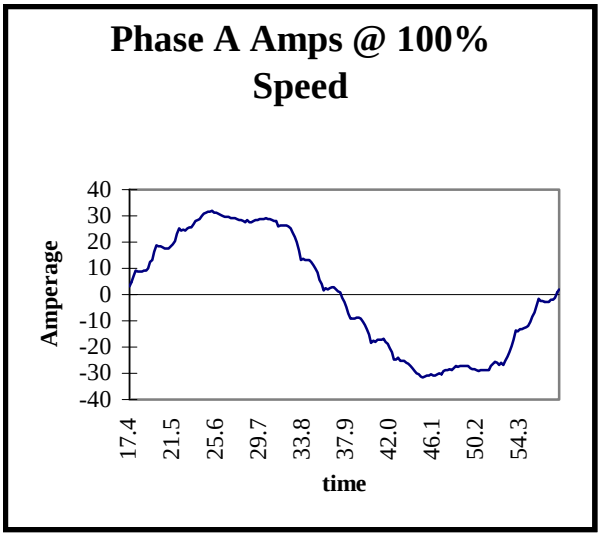


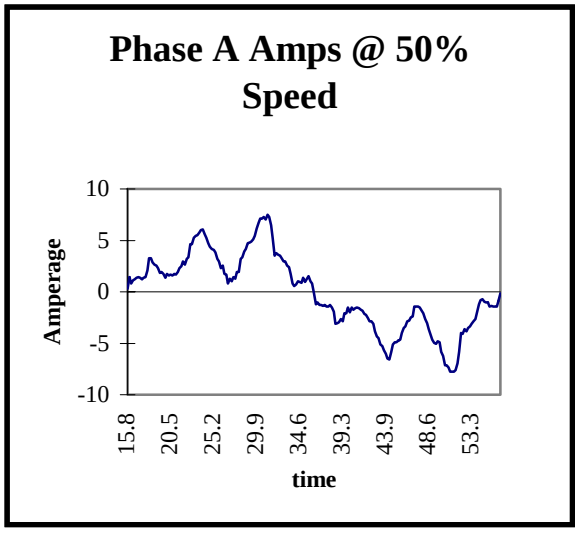
The item of interest to note in these waveforms is that at less than full motor load, the demands for power from the AC line are mostly satisfied with current flow on the A-C transition. This puts a decreased demand on the power system, although mathematically will have a higher percent current distortion, yet a lower percent voltage distortion

This same phenomenon will occur when a manufacturer builds a converter section with two or three parallel bridge sections. They will suffer the same fate at less than full speed operation. Although typically not an application issue, mathematical current limits will not generally be met at the drive input at less than full load.

PARALLEL BRIDGE CONVERTER CONSTRUCTION

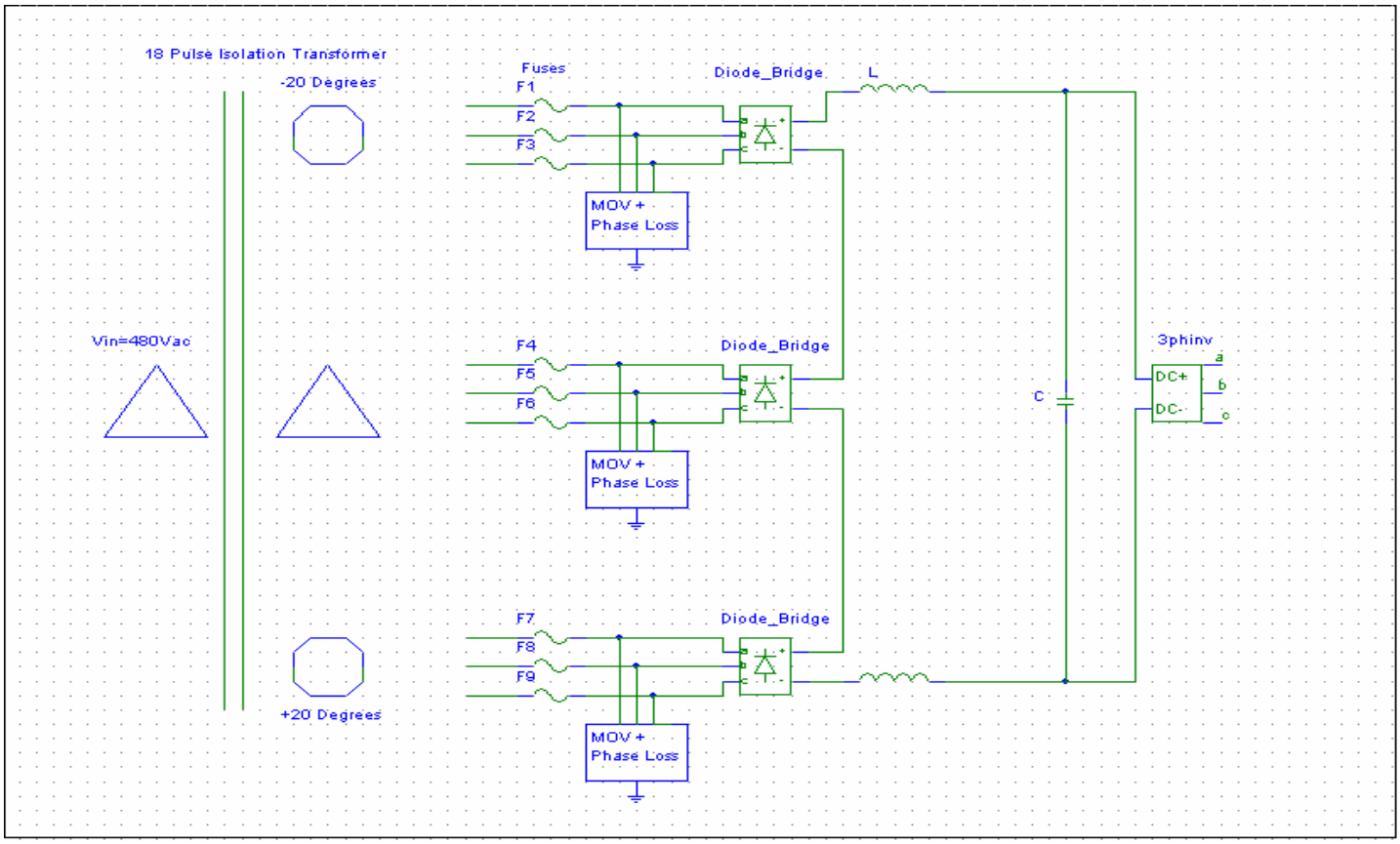






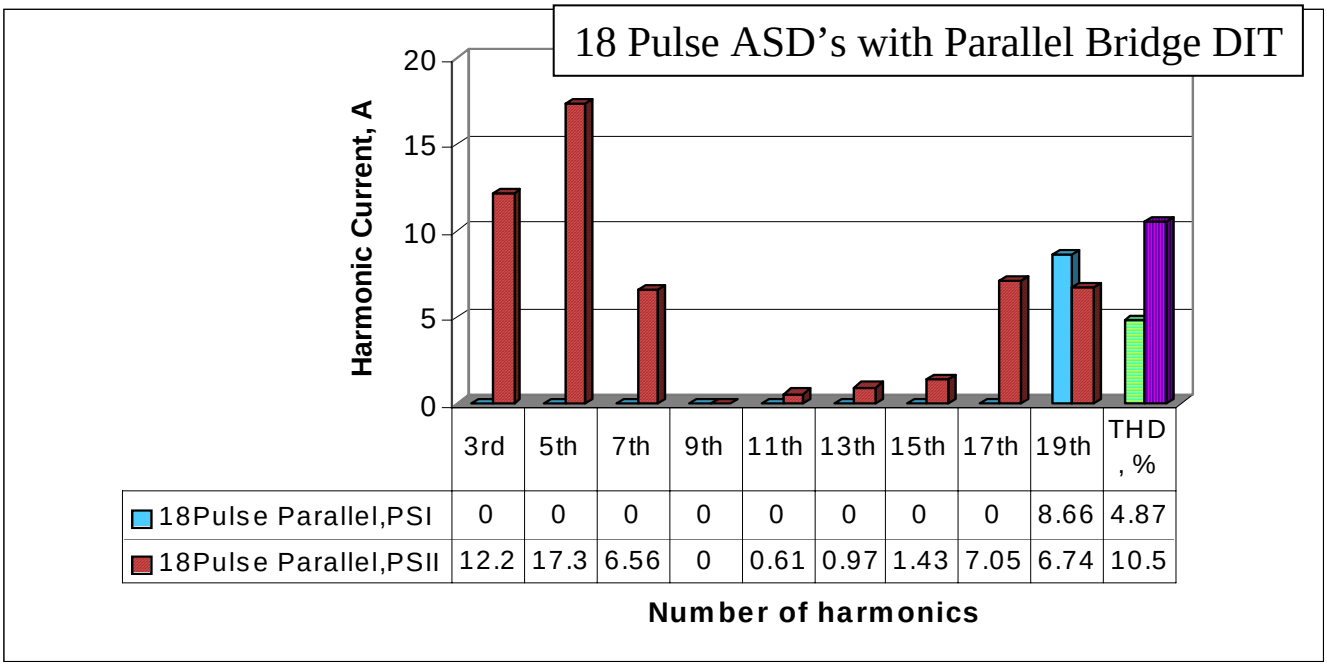
APPENDIX "B" SERIES BRIDGE DESIGN

SERIES BRIDGE CONVERTER CONSTRUCTION



The Series Bridge design solves the light load phenomenon described above with multiple parallel bridges. All current is forced through all bridges, resulting in a 400% improvement in current distortion at less than full speed in sitiuations where there is existing voltage imbalance or distortion. This solution requires an isolation transformer which adds to the package cost

APPENDIX "C" PARALLEL VS SERIES BRIDGE PERFORMANCE



Note the extreme difference between PS1 which is a power supply with zero voltage imbalance and no pre-existing levels of harmonic voltages. This condition is lab theoretical and very seldom seen in actual practice. The PS1 calculations would lead one to believe no current distortion will occur, while PS2 highlights a realistic spectrum

Shown below are the results of the same drive with a Series Bridge design, again there is a difference between lab theoretical, and real world measurements, but in this case the IEEE-519 distortion limits for current can actually be met at the drive input terminals under real-world conditions.