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HR1018

Harmonic Reduction Technology

An overview of 6, 12 and 18 pulse inverter topologies

TECHNICAL NOTE

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A Harmonic Comparison of Different VFD Multi-Pulse Configurations

This paper is intended to document and compare the harmonic content of a given Variable Frequency Drive (VFD) used in 6, 12, and 18-pulse environments. In addition, the drives will be benchmarked against the IEEE Std. 519-1992 specification for Harmonic Control in Electrical Power Systems.

The VFD used in this test is a 75 HP Saftronics GP10 AC Vector Drive. The drive was configured for standard 6-pulse power conversion as well as 12 and 18-pulse. The test was conducted at Saftronics' facility in Fort Myers, Florida. It illustrates the differences between the 6, 12 and 18 pulse technologies. The transformer feeding the drive was rated at 220kva, 480v primary, 480v secondary, and 4.5% impedance. The 75HP drive was run fully loaded at maximum operating speed of 1800 rpm (60hz). Maximum short circuit amps (I_{SC}) was calculated as 5,880 Amps and maximum circuit full load amps (I_L) was 112 amps giving an I_{SC}/I_L of 52.5.

The tables below give power system data and IEEE limits:

Transformer Data		
KVA	220	KVA
%Z	4.5	%
PRI	480	Volts
SEC	480	Volts
Freq.	60	Hz
FLA	264	Amps
SC Amps	5880	Amps

Load Data	
100% load	112

Load Ratio	
I_{SC}/I_L=	52.5

IEEE-519 Limits	
I_{SC}/I_L	Limit
<20	5%
20<50	8%
50<100	12%
100<1000	15%
>1000	20%

The figure below reflects the harmonic current limits established in table 10.3 of IEEE 519-1992.

Table 10.3, p78
Current Distortion Limits for General Distribution Systems
(120 V Through 69,000 V)

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	10.0	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

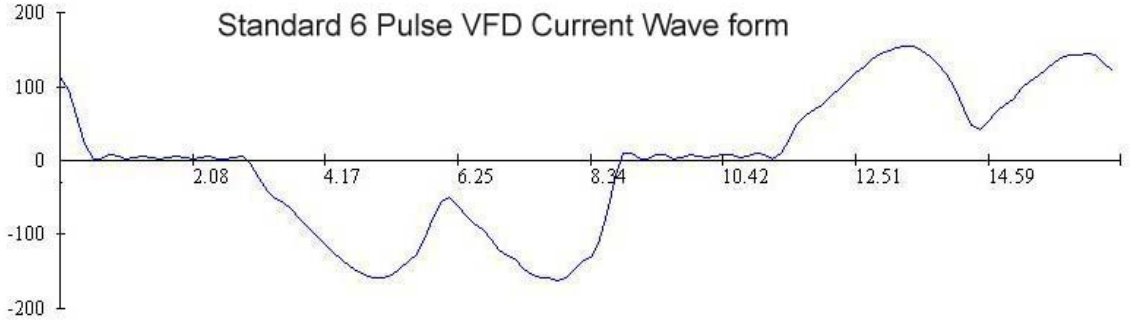
Where:

I_{SC} = maximum short-circuit current at PCC.
I_L = maximum **demand load** current (fundamental frequency component) at PCC.

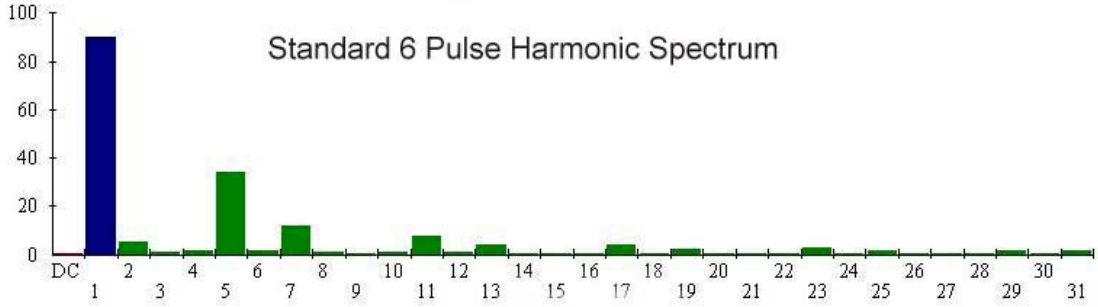
Notes:

1. Even harmonics are limited to 25% of the odd harmonic limits above.
2. Current distortions that result in a dc offset, e.g., half-wave converters, are not allowed.
*All power generation equipment is limited to these values of current distortion, regardless of actual I_{SC}/I_L.

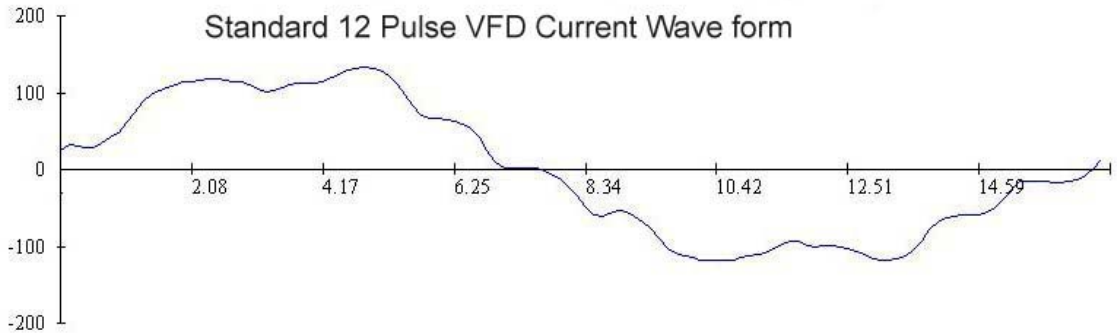
The first test was performed on a standard GP10 drive 6 pulse, rectifier input. A standard DC link choke was incorporated into the design giving the unit 3% input impedance. The current waveform shows the non-linear nature of an uncorrected, standard drive. The total harmonic distortion (THD) created by this type drive usually resides in the 35% to 40% range. The waveform was captured from the 75HP drive, fully loaded.



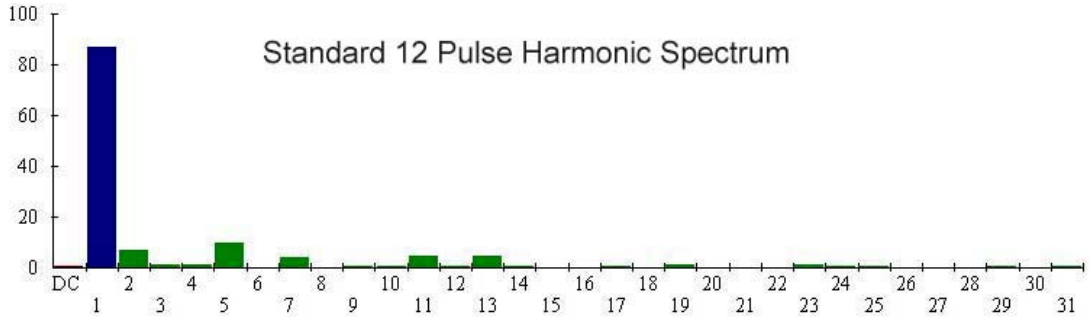
The graph below represents the distortion through the harmonic spectrum. The 5th, 7th and 11th harmonics are the most pronounced. The 5th equals almost 34.9% HD alone. The 11th equals 7.7% HD, total harmonic distortion for this drive is 38.9%.



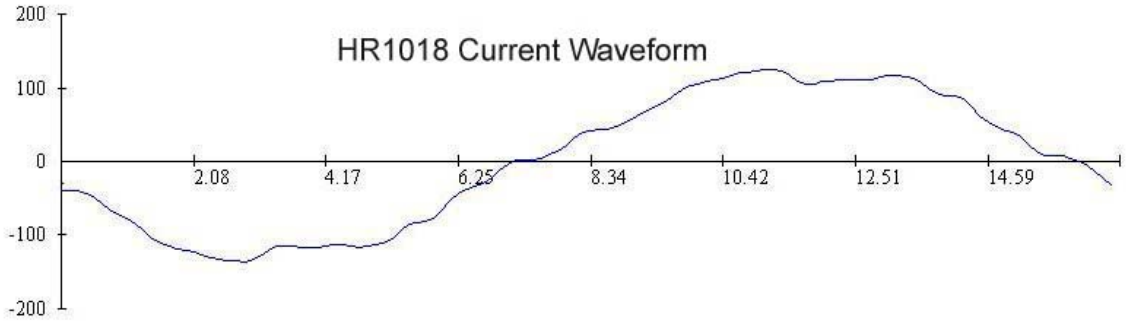
This second test was performed on an identical drive as the first test, but incorporating a 12 pulse input rectifier section. The two rectifier bridges are supplied from a separately mounted isolation transformer connected with a WYE primary and two secondary connections, one WYE and one DELTA. The isolation transformer secondary voltages are thus separated by 30 electrical degrees. Note that the deep current notches have been reduced considerably. The considerable improvement in the current waveform results in less harmonic distortion and a better power factor than the 6-pulse configuration.



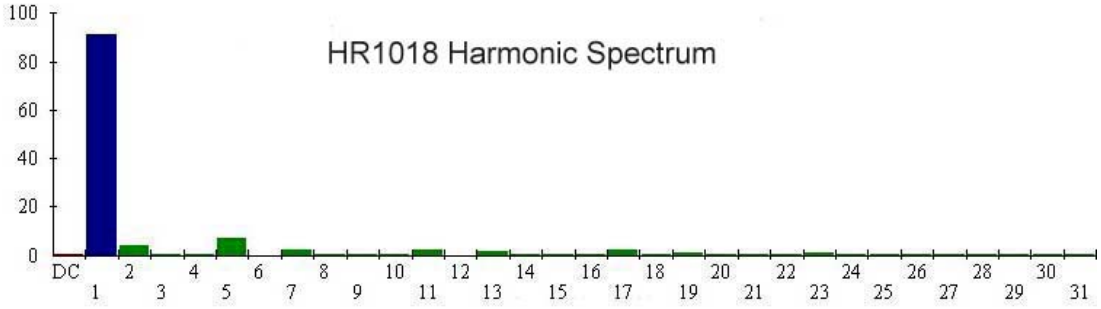
This graph shows the improvement in harmonic correction, the 5th harmonic now represents only 10.7% distortion, 1/3 of the 6-pulse drive. The Total Harmonic Current Distortion this 12 Pulse configuration produces is 16.3%.



The final test was conducted using a Saftronics HR1018 “Harmonic Reduction Technology” drive. An HR1018 is a package VFD utilizing a GP10 drive with additional rectifiers and input transformers necessary for an 18 pulse connection. The 75HP drive was fully loaded as in the previous two tests. The waveform produced was very nearly sinusoidal. The HR1018 VFD meets the recommendations of IEEE-519, 1992.



As demonstrated in this test, the harmonic production of a fully loaded 75 horsepower drive has been dramatically reduced. As tested, the Total Harmonic Current Distortion for the 18 Pulse configuration has been reduced to approximately 6%. The 5th harmonic measured 3.7%, the 7th equaled 1.6% and the 11th equaled 1.2%. THID was 1/6th of the standard 6 Pulse drive described previously. These results can be replicated throughout the range of drives in the HR1018 line.



In all three configurations, the “Total Harmonic Voltage Distortion” (THVD) was never an IEEE-519 issue. Within our system, The THVD level, even with the 6-pulse drive never exceeded 4.3%, with a low of 4% THVD in the 18-pulse configuration.