Smart Harmonics™ Technology
vs
18 and 24 Pulse Specifications

The issue:

The electric power distribution system operates most efficiently when the sinusoidal waveform generated by the power plants is not distorted. Large electronic loads, such as Variable Frequency Drives (VFDs) can cause significant harmonic distortion to the waveform.

The Total Harmonic Distortion (THD) created reduces system efficiency, stresses components, and can adversely affect other users on the grid. Strict THD limits are often placed on new equipment installations to minimize this issue.

The solution:

Yaskawa Electric has designed the MV1000 Medium Voltage drive to meet and exceed all current and future anticipated power supply THD requirements. This is part of Yaskawa Electric Corporation's ongoing commitment to green energy and harmony with the electric power distribution system.

MV1000 Smart Harmonics™ Technology:

The MV1000 Medium Voltage drive is designed with a standard feature called Smart Harmonics™ Technology that provides very low input harmonic distortion to the Medium Voltage input power source. The design allows the MV1000 to meet or exceed all present and future requirements including IEEE 519 guidelines. This is accomplished without any additional equipment such as expensive harmonic filters, extra multi-pulse input power conversion bridges, or active power conversion equipment. The result is, Yaskawa Electric superior quality is maintained, customer costs are minimized, strict power quality specifications are exceeded, and delivery of the MV1000 is not impacted.

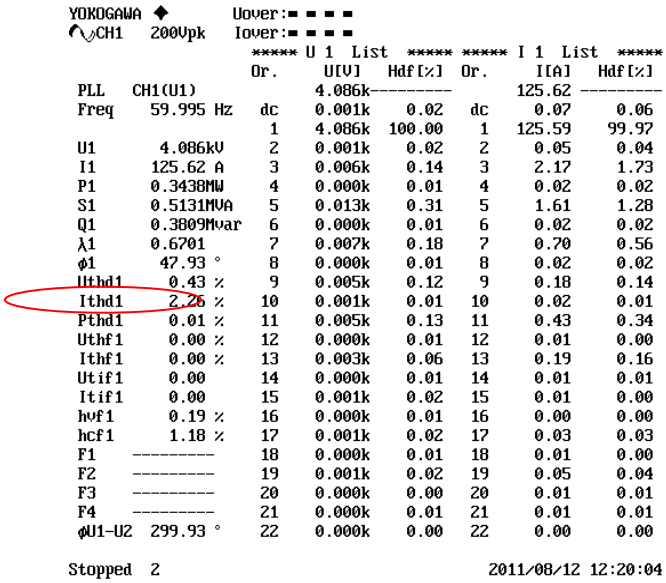
MV1000 Smart Harmonics™ vs. 18 and 24 Pulse Configurations:

To meet IEEE guidelines and customer input power harmonic specifications, a common accepted practice is to utilize an 18, 24, or even 36 pulse input converter scheme. Simply speaking, the higher the pulse configuration input, the lower the THD that the drive will impress on the power supply; i.e. a 36 pulse scheme is superior to a 24 pulse scheme, etc.

However, these higher pulse configurations make the drive more complicated. Typical higher pulse drives have additional converter modules that could increase the drive physical size and increase the drive component count which will reduce drive reliability. Additionally, some manufacturers have to have a separate converter assembly for this capability. The MV1000 Smart Harmonics™ Technology performs to the same levels and exhibits the same characteristics as a classic 36 pulse scheme *without any additional converter modules*.

The performance of the MV1000 with Smart Harmonics™ Technology clearly exceeds IEEE 519 guidelines and the capabilities of 18 and 24 pulse schemes. Therefore, additional equipment is not needed to meet these specifications.

Below is the actual measurement of an MV1000 drive operating at rated output current.



YOKOGAWA ◆ Uover:▪ ▪ ▪ ▪
CH1 200Vpk Iover:▪ ▪ ▪ ▪

		***** U 1 List *****			***** I 1 List *****		
		Or.	U[V]	Hdf[%]	Or.	I[A]	Hdf[%]
PLL	CH1(U1)		4.086k---------			125.62 ---------	
Freq	59.995 Hz	dc	0.001k	0.02	dc	0.07	0.06
		1	4.086k	100.00	1	125.59	99.97
U1	4.086kV	2	0.001k	0.02	2	0.05	0.04
I1	125.62 A	3	0.006k	0.14	3	2.17	1.73
P1	0.3438MW	4	0.000k	0.01	4	0.02	0.02
S1	0.5131MVA	5	0.013k	0.31	5	1.61	1.28
Q1	0.3809Mvar	6	0.000k	0.01	6	0.02	0.02
λ1	0.6701	7	0.007k	0.18	7	0.70	0.56
φ1	47.93 °	8	0.000k	0.01	8	0.02	0.02
Uthd1	0.43 %	9	0.005k	0.12	9	0.18	0.14
Ithd1	2.26 %	10	0.001k	0.01	10	0.02	0.01
Pthd1	0.01 %	11	0.005k	0.13	11	0.43	0.34
Uthf1	0.00 %	12	0.000k	0.01	12	0.01	0.00
Ithf1	0.00 %	13	0.003k	0.06	13	0.19	0.16
Utif1	0.00	14	0.000k	0.01	14	0.01	0.01
Itif1	0.00	15	0.001k	0.02	15	0.01	0.00
hvf1	0.19 %	16	0.000k	0.01	16	0.00	0.00
hcf1	1.18 %	17	0.001k	0.02	17	0.03	0.03
F1	---------	18	0.000k	0.01	18	0.01	0.00
F2	---------	19	0.001k	0.02	19	0.05	0.04
F3	---------	20	0.000k	0.00	20	0.01	0.01
F4	---------	21	0.000k	0.01	21	0.01	0.01
φU1-U2	299.93 °	22	0.000k	0.00	22	0.00	0.00

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Input Harmonic Measurement results of 1000 HP 4160V MV1000 @ 100% Output

Note: I_{thd1} as noted above is the MV1000 drive input current distortion of drive input terminals R, S, T (L1, L2, L3)

The table below summarizes the harmonic content of the MV1000 1000 HP 4.16kV drive compared to a 24 pulse system and IEEE guidelines. It is clear that the MV1000 performs better than a 24 pulse system and is significantly below IEEE guideline values.

Harmonic	5th	7th	11th	13th	17th	19th	23rd	25th	THD %
IEEE 519 Limits	4.00%	4.00%	2.00%	2.00%	1.50%	1.50%	0.60%	0.60%	5%
MV1000 1000 HP 4.16 kV	1.28%	0.56%	0.34%	0.16%	0.03%	0.04%	0.01%	0.01%	2.26%
Typical 24 Pulse Scheme	2.60%	1.60%	0.70%	0.40%	0.20%	0.10%	1.90%	0.80%	3.80%

Summary:

Since the MV1000 Medium Voltage drive outperforms a typical 24 pulse system as standard, there is no need to consider a 24 pulse configuration to meet strict input harmonic specifications. With regard to specifications calling for 18 or 24 pulse solutions, a better choice is the MV1000 with Smart Harmonics™ as it has better performance and thus provides added safety margin for any real world applications, being equivalent to a 36 pulse solution, without any additional hardware.