Clean Power VFD

Meeting IEEE 519 harmonics recommendations for VFD

IEEE 519 [1]

IEEE 519 is a standard developed by the Institute of Electrical and Electronics Engineers (IEEE) to establish guidelines for controlling harmonics in electrical systems. The goal of IEEE 519 is to limit harmonic distortion in electrical networks, ensuring reliable operation of equipment and minimizing the adverse effects of harmonics on the electrical grid and connected devices.

IEEE 519 provides guidelines and limits for harmonic distortion at the point of common coupling (PCC), which is the point where the customer's electrical system connects to the utility's system. It's essentially the main connection point between the customer's power system and the utility's grid. The standard specifies maximum allowable THD for voltage and TDD for current, based on the voltage level and the size of the load.

Total Harmonic Distortion (THD)

Bus voltage V at PCC	Individual harmonic (%)	Total harmonic distortion THD (%)
$V \leq 1.0$ kV	5.0	8.0
1 kV < $V \leq$ 69 kV	3.0	5.0
69 kV < $V \leq$ 161 kV	1.5	2.5
161 kV < V	1.0	1.5[a]

IEEE519 - Table 1 - Voltage distortion limits

Total Demand Distortion (TDD)

I_{SC}/I_L	Individual harmonic limits. Harmonics values are in % of maximum demand load												TDD
	2 ≤ h < 6		6 ≤ h < 11		11 ≤ h < 17		17 ≤ h < 23		23 ≤ h < 35		35 ≤ h ≤ 50		
	Odd	Even	Odd	Even	Odd	Even	Odd	Even	Odd	Even	Odd	Even	
<20[c]	4.0	2.0	4.0	4.0	2.0	2.0	1.5	1.5	0.6	0.6	0.3	0.3	5.0
20<50	7.0	3.5	7.0	7.0	3.5	3.5	2.5	2.5	1.0	1.0	0.5	0.5	8.0
50<100	10.0	5.0	10.0	10.0	4.5	4.5	4.0	4.0	1.5	1.5	0.7	0.7	12.0
100<1000	12.0	6.0	12.0	12.0	5.5	5.5	5.0	5.0	2.0	2.0	1.0	1.0	15.0
>1000	15.0	7.5	15.0	15.0	7.0	7.0	6.0	6.0	2.5	2.5	1.4	1.4	20.0

IEEE519 - Table 2 - Current Distortion Limits for

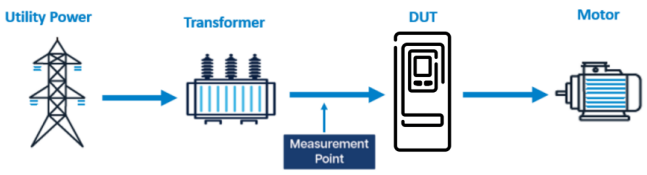
ELIMINATING HARMONICS AT THE SOURCE [2]

The ***Clean Power*** **VFD**'s advanced design effectively eliminates harmonics at both the input and output, ensuring Total Harmonic Distortion (THDi) levels are well within the stringent limits set by IEEE 519. This proactive approach negates the need for external filters and reactors, simplifying installation and reducing overall system complexity.

The ***Clean Power*** **VFD** ensures full compliance with IEEE 519 standards, eliminating the risk of penalties from utility providers and ensuring a smoother operation within regulated environments. This compliance also provides peace of mind to facility operators and managers, knowing their systems meet or exceed industry benchmarks

EXTERNAL LAB TEST SETUP

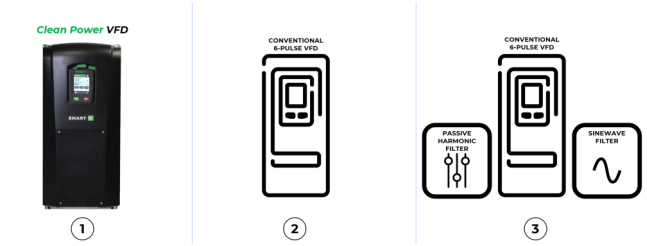
An autotransformer with impedance of less than 2% is used to supply the ***Clean Power*** **VFD** with voltage of 480V. In addition, a 25HP motor is used to load the ***Clean Power*** **VFD**. Moreover, an electrical generator (not shown) is used to provide the mechanical load of the motor. The load was controlled by modifying the generator field current.



Drive Systems Under Test (DUT)

The same tests were performed on three (3) drive systems:

1. Clean Power VFD
2. Conventional 6-pulse VFD without filters
3. Conventional 6-pulse VFD with a passive harmonic filter and a sinewave filter



(1) IEEE 519-2022: https://standards.ieee.org/ieee/519/10677/
(2) Whitepaper: Solving Harmonics with SmartD's Clean Power VFD

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Performance Comparison Results

Current Total Harmonic Distortion (TDHi in %)

The Figure 1 below shows the current total harmonic distortion (THDi) for the tested cases. The **Clean Power VFD** has good THDi performance with about 20% THD at no load and less than 5% THD for load greater than 75%. The conventional VFD has relatively poor current THD performance due to the 6-pulse rectifier at its input stage. The input current THD in this case is between 33% to 27% depending on the load condition. By adding a passive harmonic filter to the conventional VFD, the input current THD is reduced significantly. For motor loads more than 75%, the combination of conventional VFD and the passive harmonic filter and the **Clean Power VFD** offer similar performance.

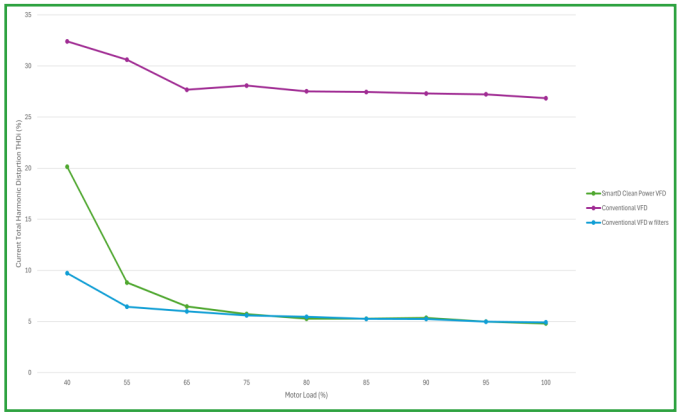

Figure 1: Current total harmonic distortion comparison

Voltage Total Harmonic Distortion (THDv in %)

The Figure 2 shows the voltage total harmonic distortion for the three test setups. The **Clean Power VFD** has the least effect on the voltage THD as shown in green curve. Moreover, this voltage THD remains relatively constant for the entire range of operation with 2.3% at full load.

On the other hand, the conventional VFD slightly disturbs the line voltage as the loading increases as shown in the violet curve. For instance, the voltage THD is about 2.8% at no load and about 3.4% at full load. Nonetheless, the voltage THD is kept below 5% for the entire operating range.

Adding a passive harmonic filter to the conventional VFD results in an improved voltage THD as shown in the blue curve. The voltage THD is about 2.4% at full load in this case.

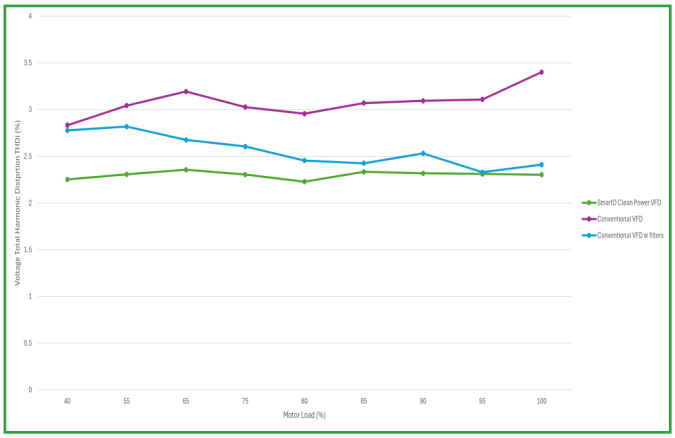

Figure 2: Voltage total harmonic distortion comparison

Conclusion

The test report presents input side test results for the comparison of **Clean Power VFD** performance with a conventional VFD and the combination of a conventional VFD and a passive harmonic filter.

The combination of the conventional VFD and the passive harmonic filter has better performance in terms of line current THD at low loading as compared to the **Clean Power VFD**. However, they have similar performance in terms of the line current THD otherwise.

In terms of affecting the line voltage THD, the **Clean Power VFD** outperforms both other cases.

The results show that the **Clean Power VFD** provides low harmonics both on the line current THD and the line voltage THD.

CLEAN SIGNAL

EMBEDDED FILTERS

OPTIMAL SYSTEM COST