AC Kinetics Variable Frequency Drive Comparative Transient Inertial Testing

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Introduction

In June of this year, AC Kinetics contacted Advanced Energy in regards to testing their newly developed Variable Frequency Drive (VFD) technology. In October of 2014 Advanced Energy performed comparative steady state efficiency tests using AC Kinetics VFD technology and two commercially available VFD's. Those comparative tests were conducted using a 5Hp and 50Hp motor. AC Kinetics has expanded the scope of their test plan to include energy consumption under inertial loading conditions. Comparative inertial tests were conducted on the same 5Hp and 50Hp motor and commercial VFD's used in October.

The 5Hp motor was purchased by AC Kinetics and an appropriately sized VFD was chosen from Advanced Energy's inventory. The 50Hp motor was chosen from Advanced Energy's inventory and an appropriately sized VFD was purchased by AC Kinetics. The VFD's used with the 5Hp and 50Hp motors will be referenced as VFD-5 and VFD-50 respectively. Each of the VFD's used for this testing is the most recent model sold by its manufacturer. Due to confidentiality reasons the manufacturers of the motors and competitor VFD's will not be included in this report. Nameplate data for each piece of equipment is shown in Appendix A. Nameplate data for the AC Kinetics drive is not included.

For both commercially available VFD's the settings used were recommended by the manufacturer either through advice from their respective technical support or by following the provided programming manual. The commercial VFD's were operated in Vector Mode using an encoder (supplied by AC Kinetics).

Test Procedure

Test Set Up

Inertial load tests using the 5Hp and 50Hp motors were performed on one of Advanced Energy's AC dynamometers. In each case the loading motor was replaced with a flywheel having approximately 10 times the inertia of the rotor in each respective motor. A rotary torque transducer connected each motor to the flywheel. The torque transducer was used for speed feedback only and no torque measurements were recorded. A diagram of the transient test setup is shown in Figure 1.

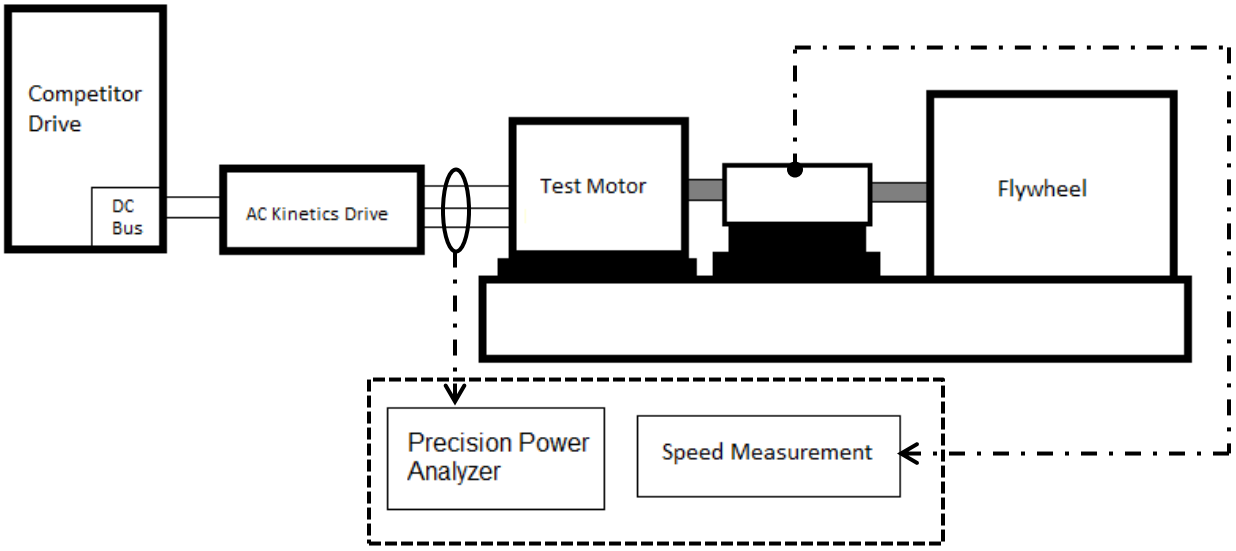

Figure 1: Transient test diagram

In the setup for the 5Hp motor the flywheel was configured to have an inertia of approximately 4.96lb-ft^2. An inertia of approximately 65.80 lb-ft^2 was configured in the flywheel for use with the 50Hp motor. Any regenerative energy created during testing was diverted through a braking transistor and into a load bank of adequate size. Advanced Energy provided the braking transistor and load bank.

The AC Kinetics VFD currently lacks the AC rectification components necessary to create a DC bus, so the DC bus from each respective VFD was used to power the AC Kinetics VFD. The DC bus off of VFD-5 was used to power the AC Kinetics VFD when testing the 5Hp motor and the DC Bus off of VFD-50 was used when testing the 50Hp motor. All electrical measurements were recorded at the motor terminals using Advanced Energy's Yokogawa WT-3000 Precision Power Analyzer.

Test Data Points

AC Kinetics provided Advanced Energy with a speed profile that consisted of a series of controlled transitions ranging from 0RPM to 1200RPM over a 6½ minute period. The speed profile was converted into a series of 1,950 discrete points that best approximated the supplied speed profile. The profile was then appropriately scaled into a 0-10V analog signal. Advanced Energy's data acquisition system supplied the scaled analog signal to VFD-5 and VFD-50 which were each configured to accept an external speed control reference. AC Kinetics was responsible for applying the speed profile to their drive. A plot of the applied speed profile is shown in Figure 2.

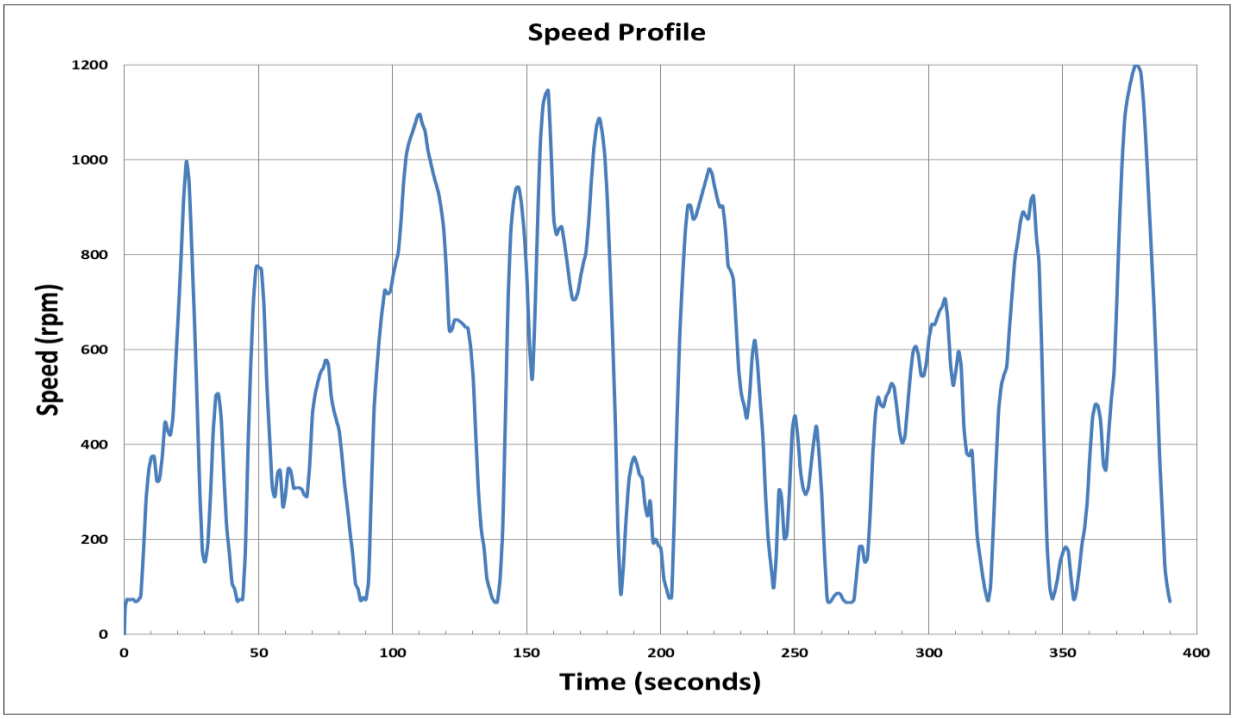

Figure 2: AC Kinetics supplied speed profile

During each speed profile run, energy input to the motor was recorded using the built in watt-hour register functionality of the WT-3000. The speed profile was applied to each motor/VFD combination multiple times clearing the watt-hour register on the WT-3000 before each run.

Test Results

A performance comparison was carried out on the basis of total energy (watt-hours) into a 5Hp and 50Hp motor as measured at their input terminals. The best three runs through the speed profile from each motor/VFD combination were compiled and used in the comparative analysis between the two competitor VFD's and AC Kinetics' proprietary VFD technology. Results from the inertia testing conducted on each 5Hp and 50Hp motor/VFD combination are provided in Table 1 and Table 2 respectively.

Table 1: VFD-5 & AC Kinetics VFD Comparison

5Hp Motor		
	VFD-5	AC Kinetics VFD
Trial	Watt-hours	
1	38.03	12.78
2	38.02	12.71
3	38.00	12.68
Average	38.02	12.72
Average Percent Energy Reduction		66.5%

Table 2: VFD-50 & AC Kinetics VFD Comparison

50Hp Motor		
	VFD-50	AC Kinetics VFD
Trial	Watt-hours	
1	293.94	186.65
2	297.94	186.58
3	297.98	186.97
Average	296.62	186.73
Average Percent Energy Reduction		37.0%

Conclusion

Comparative inertial testing was carried out between commercially available VFD's and AC Kinetics' proprietary VFD technology. This report covers the findings of the comparative inertial testing performed on a 5Hp and 50Hp VFD.

Inertial test results using 5Hp and 50Hp VFD's show that the AC Kinetics VFD has significant energy saving potential under transient loading conditions.

Appendix A:

Nameplate information of motor and commercially available VFD used.

Table A1: 5Hp Motor Nameplate

5Hp Motor Nameplate			
Sample Number:	2733	Phases:	3
Rated Voltage (V):	230/460	Frequency (Hz):	60
Rated Output:	5Hp	Rated Speed (RPM):	1760
Rated Current (A):	13.2/6.6	Sync. RPM:	1800
Magnetizing Current (A):	7.2/3.6	SL Hz:	1.6
Frame:	184TC	Type:	Inverter Duty
NEMA Design:	B	Encl.:	TE
Nameplate Eff.(Nom):	89.5%	Ins. Class:	H
Nameplate Eff.(Min):	-	SF:	1.00
Power Factor:	-	Code:	-

Table A2: VFD-5 Nameplate

VFD – 5 Nameplate			
Sample Number:	2734	Output Voltage (V):	0-480
Input Voltage (V):	380-480	Output Current (A):	10
Input Current (A):	10	Output Frequency (Hz):	0-300
Input Frequency (Hz):	50/60	Output Phases:	3
Input Phases:	3	Power (Hp):	-

Table A3: 50Hp Motor Nameplate

50Hp Motor Nameplate			
Sample Number:	1009	Phases:	3
Rated Voltage (V):	230/460	Frequency (Hz):	60
Rated Output:	37kW	Rated Speed (RPM):	1775
Rated Current (A):	110/55	Sync. RPM:	1800
Frame:	200L	Type:	-
NEMA Design:	-	Encl.:	TEFC
Nameplate Eff.(Nom):	93.0%	Ins. Class:	F
Nameplate Eff.(Min):	-	SF:	-
Power Factor:	-	Code:	-

Table A4: VFD-50 Nameplate

VFD – 50 Nameplate			
Sample Number:	2735	Output Voltage (V):	0-460
Input Voltage (V):	432-528	Output Current (A):	65
Input Current (A):	59.6	Output Frequency (Hz):	0-400
Input Frequency (Hz):	47-63	Output Phases:	3
Input Phases:	3	Power (Hp):	50

Appendix B:

Reported Data and Republication

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