Technical Note 091

580 series drive ratings for 480 Volt single phase

Sizing for single-phase input to three-phase output

Variable frequency drives (VFDs) can convert single-phase input voltage to three-phase output voltage. The standard ABB 580 series VFD is UL listed for 230 V single to three-phase conversion, and sizing can be found in the published 580 series VFD hardware manuals and price lists. However, ABB does not offer a UL listed single-phase input to three-phase output solution for 480 V. This document outlines how ABB recommends sizing VFDs for use in converting single-phase input to three-phase output for 460-480 V power systems for non-UL listed applications. This document is applicable for the 580 series, which comprises the ACH580, ACQ580, and ACS580 drives (collectively referred to as ACx580 drives in Tables 1 and 2).

VFDs, when fed from three-phase input voltage, convert three-phase AC line input voltage to a DC bus voltage, then take the DC voltage and convert it back into an AC waveform for the motor. In the event of a single-phase application, the high-level process is still the same, with the VFD converting AC to DC and then back to AC. However, converting a single-phase AC line input to DC will draw more current and result in more DC bus ripple within the VFD. VFDs must be sized appropriately to handle the increased current across the input diode bridge and the added DC bus voltage ripple within the VFD. Simply doubling the VFD size compared to the motor will cover the added input current but not always be enough to handle the extra DC bus ripple on 480 VAC drives. The VFD must have enough DC bus capacitance to compensate for this extra DC bus ripple. The ABB calculation to determine the amount of minimum capacitance (and, therefore, how much to upsize the VFD) to smooth out the ripple is shown in Figure 1 below:

$$C_{min} = \frac{4.54 * 10^6 * P_{mot}}{V_{LL}^2 * (2 * r - r^2) * eff_{mot}}$$

where:

C_{min} = minimum total capacitance (mircofarads)

P_{mot} = motor power (HP)

V_{LL} = nominal voltage line to line (V)

r = ripple allowed (%)

eff_{mot} = efficiency (%)

Figure 1 – formula to calculate the minimum total capacitance

ABB can take this calculated minimum total capacitance requirement and compare it to the proprietary DC bus capacitance ratings of each 580 VFD. Tables 1 and 2 show the recommended non-UL ABB VFD selection based on this comparison.

Example

A 90% efficient, 3 phase, 60 Hz, 460 Volt 38.3 HP, 51.45 FLA submersible pump motor with an incoming power of single-phase, 60 Hz, 460 Volt has a minimum required DC bus capacitance of:

$$\frac{4.54 * 10^6 * 38.3}{460^2 * (2 * 0.121 - 0.11^2) * 0.9} = 4{,}483\ \mu F$$

Based on the example above, all that is needed is the HP (in this case, we round the 38.3 HP up and assume 40 HP), the motor efficiency (in this case, it is 90%), and the L-L voltage (in this case it is 460 V). The allowed ripple allowance, in this case, is 12.1%. Looking at Table 1 for 460 V and crossing over on the 40 HP row to the middle column for 90% efficiency, the recommended non-UL ABB VFD selection would be the ACX580-01-240A-4.

Motor HP P_{motor}	Motor Eff % eff_{mot}	ABB VFD Selection	Motor Eff % eff_{mot}	ABB VFD Selection	Motor Eff % eff_{mot}	ABB VFD Selection
2	85	ACX580-01-07A6-4	90	ACX580-01-07A6-4	95	ACX580-01-07A6-4
3	85	ACX580-01-014A-4	90	ACX580-01-014A-4	95	ACX580-01-014A-4
5	85	ACX580-01-014A-4	90	ACX580-01-014A-4	95	ACX580-01-014A-4
7.5	85	ACX580-01-034A-4	90	ACX580-01-034A-4	95	ACX580-01-034A-4
10	85	ACX580-01-052A-4	90	ACX580-01-052A-4	95	ACX580-01-052A-4
15	85	ACX580-01-096A-4	90	ACX580-01-096A-4	95	ACX580-01-096A-4
20	85	ACX580-01-096A-4	90	ACX580-01-096A-4	95	ACX580-01-096A-4
25	85	ACX580-01-156A-4	90	ACX580-01-156A-4	95	ACX580-01-156A-4
30	85	ACX580-01-156A-4	90	ACX580-01-156A-4	95	ACX580-01-156A-4
40	85	ACX580-01-240A-4	90	ACX580-01-240A-4	95	ACX580-01-240A-4
50	85	ACX580-01-302A-4	90	ACX580-01-240A-4	95	ACX580-01-240A-4
60	85	ACX580-01-302A-4	90	ACX580-01-302A-4	95	ACX580-01-302A-4
75	85	Consult Factory	90	ACX580-01-302A-4	95	ACX580-01-302A-4
100	85	Consult Factory	90	Consult Factory	95	Consult Factory
125	85	Consult Factory	90	Consult Factory	95	Consult Factory
150	85	Consult Factory	90	Consult Factory	95	Consult Factory
200	85	Consult Factory	80	Consult Factory	95	Consult Factory

Table 1 – L-L Voltage [V_{LL}] = 460 V

Motor HP P_{motor}	Motor Eff % eff_{mot}	ABB VFD Selection	Motor Eff % eff_{mot}	ABB VFD Selection	Motor Eff % eff_{mot}	ABB VFD Selection
2	85	ACX580-01-07A6-4	90	ACX580-01-07A6-4	95	ACX580-01-07A6-4
3	85	ACX580-01-014A-4	90	ACX580-01-014A-4	95	ACX580-01-07A6-4
5	85	ACX580-01-014A-4	90	ACX580-01-014A-4	95	ACX580-01-014A-4
7.5	85	ACX580-01-034A-4	90	ACX580-01-034A-4	95	ACX580-01-034A-4
10	85	ACX580-01-052A-4	90	ACX580-01-052A-4	95	ACX580-01-052A-4
15	85	ACX580-01-096A-4	90	ACX580-01-096A-4	95	ACX580-01-096A-4
20	85	ACX580-01-096A-4	90	ACX580-01-096A-4	95	ACX580-01-096A-4
25	85	ACX580-01-156A-4	90	ACX580-01-156A-4	95	ACX580-01-096A-4
30	85	ACX580-01-156A-4	90	ACX580-01-156A-4	95	ACX580-01-156A-4
40	85	ACX580-01-240A-4	90	ACX580-01-240A-4	95	ACX580-01-240A-4
50	85	ACX580-01-302A-4	90	ACX580-01-240A-4	95	ACX580-01-240A-4
60	85	ACX580-01-302A-4	90	ACX580-01-302A-4	95	ACX580-01-302A-4
75	85	ACX580-01-302A-4	90	ACX580-01-302A-4	95	ACX580-01-302A-4
100	85	Consult Factory	90	Consult Factory	95	Consult Factory
125	85	Consult Factory	90	Consult Factory	95	Consult Factory
150	85	Consult Factory	90	Consult Factory	95	Consult Factory
200	85	Consult Factory	80	Consult Factory	95	Consult Factory

Table 2 – L-L Voltage [V_{LL}] = 480 V

Additional Note

In some applications, single-phase input voltage can increase the likelihood of experiencing DC bus voltage instability, which may result in intermittent over voltage alarms or input phase loss faults. The 580 series has two parameters that can be used to monitor and then tune out instability problems. DC bus ripple is observed by the 580 series parameter 97.135 “UDC ripple.” The ripple trip value for the 580 series is 75 VDC for a 460-480 V line. Parameter 97.48 “UDC Stabilizer” is a setting that tunes and stabilizes the DC bus voltage. Start at the lowest setting of 97.48 while monitoring 97.135, and slowly increase 97.48 until the intermittent alarms or faults no longer occur. The goal is to stabilize the 97.135 value so the value does not have significant swings in magnitude.

Conclusion

Upsizing VFDs for single to three-phase conversion for 480 V drives is not a simple and intuitive rule of thumb. Tables 1 and 2 identify ABBs recommendations for sizing VFDs for converting single-phase input to three-phase output for 460-480 V power systems for non-UL listed applications.