

VFD Application Note

Sizing VFD's for Use with a Single-Phase Power Source

A Single-phase power source can be safely applied to 3-phase rated VFD's provided that care is taken to properly oversize the VFD.

NOTE: Some VFD's are not designed or tested for operation utilizing a single phase input power source. Verify with the manufacturer that the VFD can be powered with a single phase power source.

NOTE: The output is always three phase.

Single Phase vs. Three Phase

For a given power (kW or HP) and voltage, the ratio of current in a single-phase circuit will be $\sqrt{3}$ (1.732) times higher than that of a three-phase circuit. This means that the input rectifiers of the VFD will see 1.732 times the current compared to the output of the VFD. This higher single phase input current can destroy the input of the drive if the VFD is not sized correctly. An oversized VFD is required.

Without going any further, a rule of thumb is: take the full load amperage (FLA) rating from the three-phase motor's nameplate and double it. Then select a VFD with this doubled continuous output current rating. This will give adequate margin for the input rectifier bridge to handle the higher current.

NOTE: Benschaw VFD's require the single phase source to be 60 Hz.

Details

The following is a summary of operating conditions that occur in a VFD when powered with a single-phase power source compared to a three-phase power source.

- **Frequency** - Refer to Figure 1. Standard Pulse-Width-Modulated (PWM) VFDs use a 6-pulse diode rectifier. The 6-pulse rectification results in 360 Hz DC bus ripple when used with a three-phase 60 Hz power source. However, when a single-phase power source is used (Figure 2.), the DC bus ripple becomes 120 Hz. The result is the DC bus ripple voltage is higher and the DC Bus circuit is subject to higher stress in order for the VFD to deliver equivalent power to the motor.
- **Input Current** - The input current through the two phases on the diode bridge converter will approximately double (1.732 times).
- **Harmonics** - Refer to Figure 2. Input current harmonics increase resulting in current distortion levels of 90% THD_i and greater compared to approximately 40% with a three-phase power source making the overall input power factor lower. Adding a line reactor (required) helps attenuate harmonics. Size the reactor based on VFD rating.
- **Voltage** - A stricter input voltage tolerance of -5% applies to the single phase source, compared to -15% when powering the VFD from a three-phase power source. The average bus voltage will be lower and the maximum output voltage (motor voltage) will also be lower with a single-phase power source. The minimum input voltage must be no less than 228Vac for 240 volt models and 456Vac for 480 volt models. It will be necessary to maintain a rigid incoming line voltage so that adequate motor voltage can be produced. A reduction in applied motor voltage results in a reduction of torque produced by the motor. To minimize the effect of voltage deprivation at the motor, consider operating the motor at reduced speed (reduced power) or using a motor with a base voltage that is lower than the incoming AC power source rating (EX: 480V source, 415V motor).

Summary

The result of all the above is that derating the drive’s output current and horsepower is required to avoid over stressing the rectifier and DC link components within the VFD. Improper selection of the VFD will result in poor performance and premature failure.

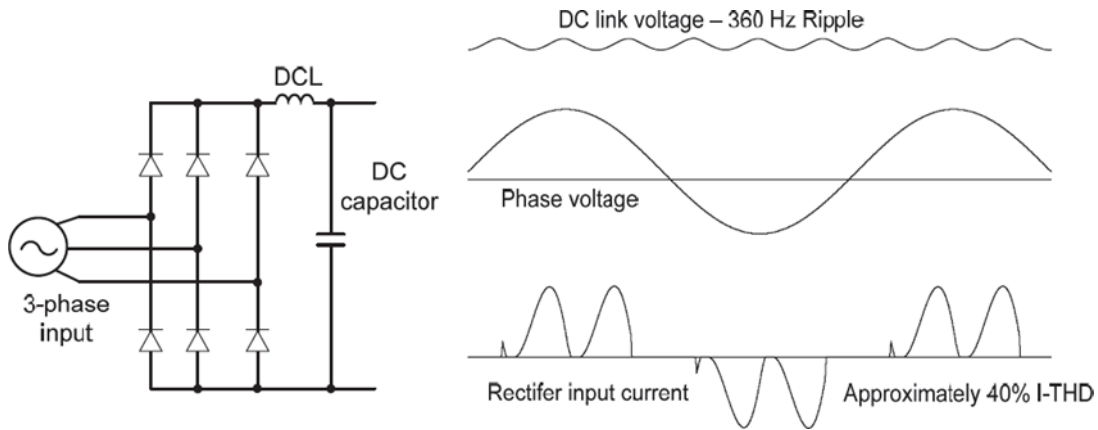


Figure 1. Typical Three Phase Configuration

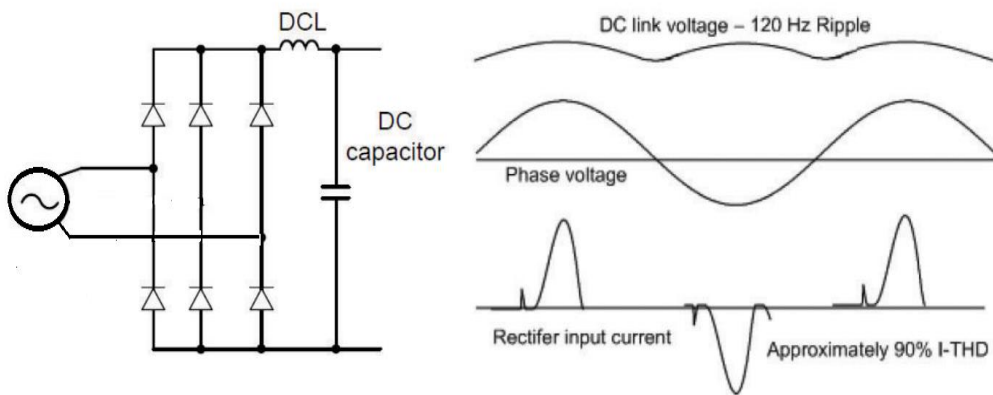


Figure 2. Typical Single Phase Configuration

Wiring

Another rule of thumb is to connect the Single-phase power source to the L1 (R) and L3 (T) terminals. The L2 (S) terminal should remain unconnected. Verify with the manufacturer.

Beyond the VFD, consideration should be given when sizing the components upstream of the VFD. These should be sized based on the higher single phase input current. This includes items such as wiring, reactor, fusing, circuit breakers, contactors, etc. These upstream components will see the higher single phase current.

Precautions

- Add a line reactor matched to VFD rating. A three phase reactor can be wired as single phase.
- Connect single-phase power source to R(L1) and T(L3).
- Output current ratings are valid for 60Hz power source only.
- Verify minimum input voltage.
- If input phase open fault occurs, turn off the input phase open protection.
- Set Motor Data and Protections - Set the parameters that are related to motor information, overload trip and E-thermal.

The following tables list the Benshaw drive ratings (Output Current with 1-Phase Input) when powered by a single phase power source. To select the drive, identify your motor voltage, horse power and amps in the far right columns (NEC). To the left, verify the drive amps (Output Current with 1-Phase Input) are equal to or greater than the motor amps. Track to the first column "Benshaw" for the drive model.

Table 1. Benshaw Model GM2 VFD – Output Ratings with Single Phase Power Source

GM2 Series							For Reference	
240V 3-Phase Rating			Output Current with 3-Phase Input		Output Current with 1-Phase Input		230V Motor Data NEC Table 430.250	
Benshaw	kW	HP (ND)	ND [A]	HD [A]	ND [A]	HD [A]	HP	Amps
RSI-001-GM2-2C	0.75kW-2	1	3.1	2.5	2	1.5	0.5	2.2
RSI-002-GM2-2C	1.5kW-2	2	6	5	3.6	2.8	0.75	3.2
RSI-003-GM2-2C	2.2kW-2	3	9.6	8	5.9	4.6	1	4.2
RSI-005-GM2-2C	3.7kW-2	5	12	11	6.7	6.1	1.5	6
RSI-007-GM2-2C	5.5kW-2	7.5	18	17	9.8	9.3	2	6.8
RSI-010-GM2-2C	7.5kW-2	10	30	24	16.3	12.8	3	9.6
RSI-015-GM2-2C	11kW-2	15	40	32	22	17.4	5	15.2
							7.5	22

GM2 Series							For Reference	
480V 3-Phase Rating			Output Current with 3-Phase Input		Output Current with 1-Phase Input		460V Motor Data NEC Table 430.250	
Benshaw	kW	HP (ND)	ND [A]	HD [A]	ND [A]	HD [A]	HP	Amps
RSI-001-GM2-4C	0.75kW-4	1	2	1.3	1.3	0.7	0.5	1.1
RSI-002-GM2-4C	1.5kW-4	2	3.1	2.5	1.9	1.4	0.75	1.6
RSI-003-GM2-4C	2.2kW-4	3	5.1	4	2.8	2.1	1	2.1
RSI-005-GM2-4C	3.7kW-4	5	6.9	5.5	3.6	2.8	2	3.4
RSI-007-GM2-4C	5.5kW-4	7.5	10	9.5	5.4	4.9	3	4.8
RSI-010-GM2-4C	7.5kW-4	10	16	12	8.7	6.4	5	7.6
RSI-015-GM2-4C	11kW-4	15	23	16	12.6	8.7	7.5	11

NEC slightly higher

Table 2 - Benschaw Model S Series VFD – Output Ratings with Single Phase Input

S Series							For Reference	
240V 3-Phase Rating			Output Current with 3-Phase Input		Output Current with 1-Phase Input		230V Motor Data NEC Table 430.250	
Benschaw	kW	HP (ND)	ND [A]	HD [A]	ND [A]	HD [A]	HP	Amps
RSI-001-SS-2C	0.4kW-2	1	3.1	2.5	1.8	1.5		
RSI-002-SS-2C	0.75kW-2	2	6	5	3.3	2.8	0.5	2.2
RSI-003-SS-2C	1.5kW-2	3	9.6	8	5.7	4.6	1	4.2
RSI-005-SS-2C	2.2kW-2	5	12	11	6.6	6.1	1.5	6
RSI-007-SS-2C	4.0kW-2	7.5	18	17	9.9	9.3	3	9.6
RSI-010-SS-2C	5.5kW-2	10	30	24	16	13	5	15.2
RSI-015-SS-2C	7.5kW-2	15	40	32	22	18	7.5	22

S Series							For Reference	
480V 3-Phase Rating			Output Current with 3-Phase Input		Output Current with 1-Phase Input		460V Motor Data NEC Table 430.250	
Benschaw	kW	HP (ND)	ND [A]	HD [A]	ND [A]	HD [A]	HP	Amps
RSI-001-SS-4C	0.4kW-4		2	1.3	1.3	0.8	0.5	1.1
RSI-002-SS-4C	0.75kW-4		3.1	2.5	1.9	1.5	0.5	1.1
RSI-003-SS-4C	1.5kW-4		5.1	4	3	2.3	1	2.1
RSI-005-SS-4C	2.2kW-4		6.9	5.5	3.9	3.1	2	3.4
RSI-007-SS-4C	4.0kW-4		10	9	5.9	5.4	3	4.8
RSI-010-SS-4C	5.5kW-4		16	12	9.5	7.1	5	7.6
RSI-015-SS-4C	7.5kW-4		23	16	14	9.5	7.5	11

Table 3 - Benshaw Model SW Series VFD – Output Ratings with Single Phase Input

SW							For Reference	
240V 3-Phase Rating			Output Current with 3-Phase Input		Output Current with 1-Phase Input		230V Motor Data NEC Table 430.250	
Benshaw	kW	HP (HD)	HD [A]	ND [A]	HD [A]	ND [A]	HP	Amps
RSI-0F5-SW-2W	0.4kW-2	0.5	2.5	-	1.5	-		
RSI-001-SW-2W	0.75kW-2	1	5	-	2.8	-	0.5	2.2
RSI-002-SW-2W	1.5kW-2	2	8	-	4.6	-	1	4.2
RSI-003-SW-2W	2.2kW-2	3	11	-	6.1	-	1.5	6
RSI-005-SW-2W	3.7kW-2	5	16	-	8.8	-	2	6.8
RSI-007-SW-2W	5.5kW-2	7.5	24	-	13	-	3	9.6
RSI-010-SW-2W	7.5kW-2	10	32	-	18	-	5	15.2
RSI-015-SW-2W	11kW-2	15	46	-	26	-	7.5	22
RSI-020-SW-2W	15kW-2	20	60	-	33	-	10	28

SW							For Reference	
480V 3-Phase Rating			Output Current with 3-Phase Input		Output Current with 1-Phase Input		460V Motor Data NEC Table 430.250	
Benshaw	kW	HP (HD)	HD [A]	ND [A]	HD [A]	ND [A]	HP	Amps
RSI-0F5-SW-4W	0.4kW-4	0.5	1.3	-	0.8	-		
RSI-001-SW-4W	0.75kW-4	1	2.5	-	1.5	-	0.5	1.1
RSI-002-SW-4W	1.5kW-4	2	4	-	2.3	-	1	2.1
RSI-003-SW-4W	2.2kW-4	3	5.5	-	3.1	-	2	3.4
RSI-005-SW-4W	3.7kW-4	5	8	-	4.8	-	3	4.8
RSI-007-SW-4W	5.5kW-4	7.5	12	-	7.1	-	5	7.6
RSI-010-SW-4W	7.5kW-4	10	16	-	9.5	-	7.5	11
RSI-015-SW-4W	11kW-4	15	24	-	15	-	10	14
RSI-020-SW-4W	15kW-4	20	30	-	18	-		
RSI-025-SW-4W	18.5kW-4	25	39	-	23	-	15	21
RSI-030-SW-4W	22kW-4	30	45	-	27	-	20	27

NEC slightly higher

Table 4 - Benschaw Model H2 Series VFD – Output Ratings with Single Phase Input

H2					For Reference	
240V 3-Phase Rating			Output Current with 3-Phase Input	Output Current with 1-Phase Input	230V Motor Data NEC Table 430.250	
Benschaw	kW	HP (ND)	ND [A]	ND [A]	HP	Amps
RSI-001-H2-2C	0.75kW-2	1	5	2.9	0.5	2.2
RSI-002-H2-2C	1.5kW-2	2	8	4.4	1	4.2
RSI-003-H2-2C	2.2kW-2	3	12	6.4	2	6.8
RSI-005-H2-2C	3.7kW-2	5	16	8.4	2	6.8
RSI-007-H2-2C	5.5kW-2	7.5	22	11	3	9.6
RSI-010-H2-2C	7.5kW-2	10	30	16	5	15.2
RSI-015-H2-2C	11kW-2	15	42	23	7.5	22
RSI-020-H2-2C	15kW-2	20	56	30	10	28
RSI-025-H2-2C	18.5kW-2	25	69	37	15	42

H2					For Reference	
480V 3-Phase Rating			Output Current with 3-Phase Input	Output Current with 1-Phase Input	460V Motor Data NEC Table 430.250	
Benschaw	kW	HP (ND)	ND [A]	ND [A]	HP	Amps
RSI-001-H2-4C	0.75kW-4	1	2.5	1.6	0.5	1.1
RSI-002-H2-4C	1.5kW-4	2	4	2.4	1	2.1
RSI-003-H2-4C	2.2kW-4	3	6	3.5	2	3.4
RSI-005-H2-4C	3.7kW-4	5	8	4.6	3	4.8
RSI-007-H2-4C	5.5kW-4	7.5	12	6.8	5	7.6
RSI-010-H2-4C	7.5kW-4	10	16	9.2	7.5	11
RSI-015-H2-4C	11kW-4	15	24	14	10	14
RSI-020-H2-4C	15kW-4	20	30	17		
RSI-025-H2-4C	18.5kW-4	25	38	22	15	21
RSI-030-H2-4C	22kW-4	30	45	26	20	27
RSI-040-H2-4C	30kW-4	40	61	36	25	34
RSI-050-H2-4C	37kW-4	50	75	39	30	40
RSI-060-H2-4C	45kW-4	60	91	47	40	52
RSI-075-H2-4C	55kW-4	75	107	55	50	65
RSI-100-H2-4C	75kW-4	100	142	73	60	77
RSI-125-H2-4C	90kW-4	125	169	86	75	96

NEC slightly higher

Table 5 - Benshaw Model SG Series VFD – Output Ratings with Single Phase Input

SG							For Reference	
240V 3-Phase Rating			Output Current with 3-Phase Input		Output Current with 1-Phase Input		230V Motor Data NEC Table 430.250	
Benshaw	kW	HP (ND)	ND [A]	HD [A]	ND [A]	HD [A]	HP	Amps
RSI-007-SG-2B	5.5kW-2	7.5	24	17	12	8.5	3	9.6
RSI-010-SG-2B	7.5kW-2	10	32	23	16	12	5	15.2
RSI-015-SG-2B	11kW-2	15	46	33	24	17	7.5	22
RSI-020-SG-2B	15kW-2	20	60	44	31	23	10	28
RSI-025-SG-2B	18.5kW-2	25	74	54	38	28		
RSI-030-SG-2B	22kW-2	30	88	68	46	35	15	42
RSI-040-SG-2B	30kW-2	40	115	84	59	43	20	54

SG							For Reference	
480V 3-Phase Rating			Output Current with 3-Phase Input		Output Current with 1-Phase Input		460V Motor Data NEC Table 430.250	
Benshaw	kW	HP (ND)	ND [A]	HD [A]	ND [A]	HD [A]	HP	Amps
RSI-007-SG-4B	5.5kW-4	7.5	12	8.8	6.6	4.8	3	4.8
RSI-010-SG-4B	7.5kW-4	10	16	12	8.9	6.7	5	7.6
RSI-015-SG-4B	11kW-4	15	24	16	14	9.1	7.5	11
RSI-020-SG-4B	15kW-4	20	30	22	16	12	10	14
RSI-025-SG-4B	18.5kW-4	25	39	28	20	15		
RSI-030-SG-4B	22kW-4	30	45	34	23	20	15	21
RSI-040-SG-4B	30kW-4	40	61	44	32	23	20	27
RSI-050-SG-4B	37kW-4	50	75	55	39	31	25	34
RSI-060-SG-4B	45kW-4	60	91	66	47	39	30	40
RSI-075-SG-4B	55kW-4	75	110	80	57	47	40	52
RSI-100-SG-4B	75kW-4	100	152	111	78	57	50	65
RSI-125-SG-4	90kW-4	125	183	134	95	79	60	77
RSI-150-SG-4	110kW-4	150	223	164	116		75	96
RSI-200-SG-4	132kW-4	200	264	194	134		100	124
RSI-250-SG-4	160kW-4	250	325	240	166		125	156