

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.

Foregoing the below details, a rule of thumb is taking 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 bridge rectifier to handle the higher single phase input 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 for single phase) 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: 240V source, 208V motor).

Summary

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

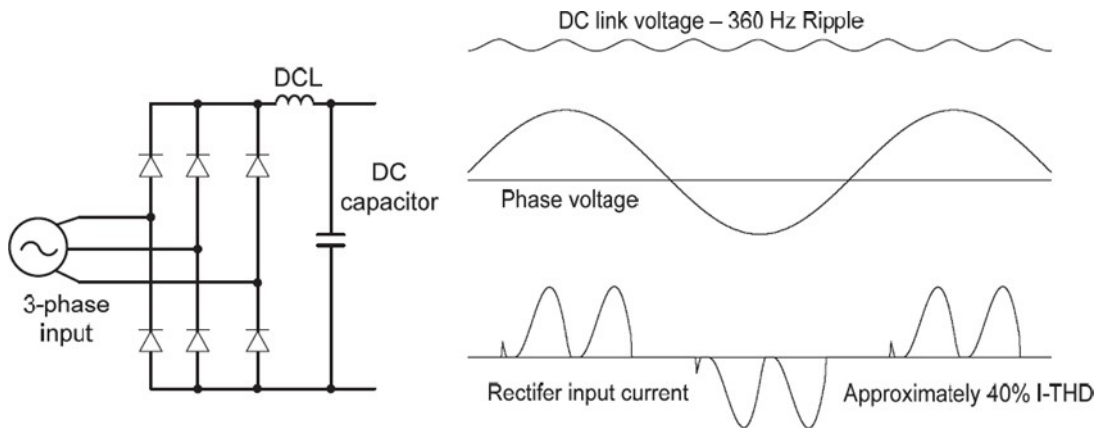


Figure 1. Typical Three Phase Configuration

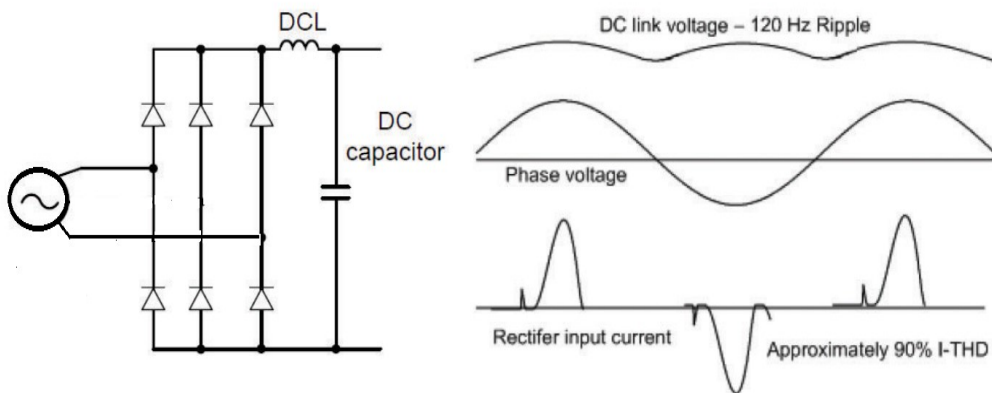


Figure 2. Typical Single-Phase Configuration

Wiring

Another rule of thumb is to connect the Single-phase power source to terminals 1 (R) and L3 (T). The L2 (S) terminal will not be connected. 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

- **IMPORTANT** -The VFD's in the following tables have a built-in EMC filter. This filter must be disconnected when using a single-phase input to the VFD. See Instruction Manual for disconnecting the filter.
- Add a line reactor matched to the VFD rating. A three-phase reactor can be wired as single-phase.
- Connect the single-phase power source to R(L1) and T(L3) terminals of the VFD.
- Output current ratings are valid for 60Hz power source only.
- Verify minimum input voltage.
- *Input Phase Open* fault will occur. Turn off the input phase loss protection with parameter Pr.05, PRT-05.
- Set Motor Data and Protections - Set motor parameters based on motor information and set protection parameters for overload 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	0.75	1	3.1	2.5	2	1.5	0.5	2.2*
RSI-002-GM2-2C	1.5	2	6	5	3.6	2.8	0.75	3.2
RSI-003-GM2-2C	2.2	3	9.6	8	5.9	4.6	1	4.2
RSI-005-GM2-2C	3.7	5	12	11	6.7	6.1	1.5	6
RSI-007-GM2-2C	5.5	7.5	18	17	9.8	9.3	2	6.8*
RSI-010-GM2-2C	7.5	10	30	24	16.3	12.8	3	9.6
RSI-015-GM2-2C	11	15	40	32	22	17.4	5	15.2
							7.5	22

*NEC slightly higher

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	0.75	1	2	1.3	1.3	0.7	0.5	1.1
RSI-002-GM2-4C	1.5	2	3.1	2.5	1.9	1.4	0.75	1.6
RSI-003-GM2-4C	2.2	3	5.1	4	2.8	2.1	1	2.1
RSI-005-GM2-4C	3.7	5	6.9	5.5	3.6	2.8	2	3.4
RSI-007-GM2-4C	5.5	7.5	10	9.5	5.4	4.9	3	4.8
RSI-010-GM2-4C	7.5	10	16	12	8.7	6.4	5	7.6
RSI-015-GM2-4C	11	15	23	16	12.6	8.7	7.5	11

Table 2 - Benshaw 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	
Benshaw	kW	HP (ND)	ND [A]	HD [A]	ND [A]	HD [A]	HP	Amps
RSI-001-SS-2C	0.4	1	3.1	2.5	1.8	1.5		
RSI-002-SS-2C	0.75	2	6	5	3.3	2.8	0.5	2.2
RSI-003-SS-2C	1.5	3	9.6	8	5.7	4.6	1	4.2
RSI-005-SS-2C	2.2	5	12	11	6.6	6.1	1.5	6
RSI-007-SS-2C	4.0	7.5	18	17	9.9	9.3	3	9.6
RSI-010-SS-2C	5.5	10	30	24	16	13	5	15.2
RSI-015-SS-2C	7.5	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	
Benshaw	kW	HP (ND)	ND [A]	HD [A]	ND [A]	HD [A]	HP	Amps
RSI-001-SS-4C	0.4	1	2	1.3	1.3	0.8	0.5	1.1
RSI-002-SS-4C	0.75	2	3.1	2.5	1.9	1.5	0.5	1.1
RSI-003-SS-4C	1.5	3	5.1	4	3	2.3	1	2.1
RSI-005-SS-4C	2.2	5	6.9	5.5	3.9	3.1	2	3.4
RSI-007-SS-4C	4.0	7.5	10	9	5.9	5.4	3	4.8
RSI-010-SS-4C	5.5	10	16	12	9.5	7.1	5	7.6
RSI-015-SS-4C	7.5	15	23	16	14	9.5	7.5	11

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

SW 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 (HD)	HD [A]	ND [A]	HD [A]	ND [A]	HP	Amps
RSI-0F5-SW-2W	0.4	0.5	2.5	-	1.5	-		
RSI-001-SW-2W	0.75	1	5	-	2.8	-	0.5	2.2
RSI-002-SW-2W	1.5	2	8	-	4.6	-	1	4.2
RSI-003-SW-2W	2.2	3	11	-	6.1	-	1.5	6
RSI-005-SW-2W	3.7	5	16	-	8.8	-	2	6.8
RSI-007-SW-2W	5.5	7.5	24	-	13	-	3	9.6
RSI-010-SW-2W	7.5	10	32	-	18	-	5	15.2
RSI-015-SW-2W	11	15	46	-	26	-	7.5	22
RSI-020-SW-2W	15	20	60	-	33	-	10	28

SW 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 (HD)	HD [A]	ND [A]	HD [A]	ND [A]	HP	Amps
RSI-0F5-SW-4W	0.4	0.5	1.3	-	0.8	-		
RSI-001-SW-4W	0.75	1	2.5	-	1.5	-	0.5	1.1
RSI-002-SW-4W	1.5	2	4	-	2.3	-	1	2.1
RSI-003-SW-4W	2.2	3	5.5	-	3.1	-	2	3.4*
RSI-005-SW-4W	3.7	5	8	-	4.8	-	3	4.8
RSI-007-SW-4W	5.5	7.5	12	-	7.1	-	5	7.6*
RSI-010-SW-4W	7.5	10	16	-	9.5	-	7.5	11*
RSI-015-SW-4W	11	15	24	-	15	-	10	14
RSI-020-SW-4W	15	20	30	-	18	-		
RSI-025-SW-4W	18.5	25	39	-	23	-	15	21
RSI-030-SW-4W	22	30	45	-	27	-	20	27

*NEC slightly higher

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

H2 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]	ND [A]	HP	Amps
RSI-007-H2-2C	5.5	7.5	22	11	3	9.6
RSI-010-H2-2C	7.5	10	30	16	5	15.2
RSI-015-H2-2C	11	15	42	23	7.5	22
RSI-020-H2-2C	15	20	56	30	10	28
RSI-025-H2-2C	18.5	25	69	37	10	28
RSI-030-H2-2C	22	30	82	45	15	42
RSI-040-H2-2C	30	40	110	58	20	54
RSI-050-H2-2C	37	50	142	78	25	68
RSI-060-H2-2C	45	60	169	92	30	80
RSI-075-H2-2C	55	75	223	122	40	104
RSI-100-H2-2C	75	100	264	145	50	130
RSI-125-H2-2C	90	125	325	178	60	154

H2 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]	ND [A]	HP	Amps
RSI-007-H2-4C	5.5	7.5	12	6.8	3	4.8
RSI-010-H2-4C	7.5	10	16	9.2	5	7.6
RSI-015-H2-4C	11	15	24	14	7.5	11
RSI-020-H2-4C	15	20	30	17	10	14
RSI-025-H2-4C	18.5	25	38	22	15	21
RSI-030-H2-4C	22	30	45	26	15	21
RSI-040-H2-4C	30	40	61	36	20	27
RSI-050-H2-4C	37	50	75	39	25	34
RSI-060-H2-4C	45	60	91	47	30	40
RSI-075-H2-4C	55	75	107	55	40	52
RSI-100-H2-4C	75	100	142	73	50	65
RSI-125-H2-4C	90	125	169	86	60	77
RSI-150-H2-4C	110	150	223	93	60	77
RSI-200-H2-4C	132	200	264	101	75	96
RSI-250-H2-4C	160	250	325	137	75	96
RSI-300-H2-4C	185	300	370	137	100	124
RSI-400-H2-4C	250	400	481	218	150	180
RSI-500-H2-4C	315	500	613	232	150	180
RSI-650-H2-4C	400	650	770	280	200	240
RSI-800-H2-4C	500	500	962	361	300	361

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

SG Series							For Reference	
240V 3-Phase Rating					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	5.5	7.5	24	17	12	8.5	3	9.6
RSI-010-SG-2B	7.5	10	32	23	16	12	5	15.2
RSI-015-SG-2B	11	15	46	33	24	17	7.5	22
RSI-020-SG-2B	15	20	60	44	31	23	10	28
RSI-025-SG-2B	18.5	25	74	54	38	28		
RSI-030-SG-2B	22	30	88	68	46	35	15	42
RSI-040-SG-2B	30	40	115	84	59	43	20	54

SG Series							For Reference	
480V 3-Phase Rating					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	5.5	7.5	12	8.8	6.6	4.8	3	4.8
RSI-010-SG-4B	7.5	10	16	12	8.9	6.7	5	7.6
RSI-015-SG-4B	11	15	24	16	14	9.1	7.5	11
RSI-020-SG-4B	15	20	30	22	16	12	10	14
RSI-025-SG-4B	18.5	25	39	28	20	15		
RSI-030-SG-4B	22	30	45	34	23	20	15	21
RSI-040-SG-4B	30	40	61	44	32	23	20	27
RSI-050-SG-4B	37	50	75	55	39	31	25	34
RSI-060-SG-4B	45	60	91	66	47	39	30	40
RSI-075-SG-4B	55	75	110	80	57	47	40	52
RSI-100-SG-4B	75	100	152	111	78	57	50	65
RSI-125-SG-4	90	125	183	134	95	79	60	77
RSI-150-SG-4	110	150	223	164	116		75	96
RSI-200-SG-4	132	200	264	194	134		100	124
RSI-250-SG-4	160	250	325	240	166		125	156