

SpeedStar 2000 Plus and SpeedStar SWD Drives

APPLICATIONS

- Electric submersible pump (ESP) operations
- Surface pumping operations

BENEFITS

- Prolonged electrical system life
- Reduced operating costs
- Reduced downtime

FEATURES

- Speed control to maintain constant load or pressure
- Ability to start an ESP while motor is spinning
- Rocking start, used to start wells with stuck pumps
- Programmable automatic load reduction (soft-stall function)
- StarShield* surge protection device (SPD) for protection against lightning strikes and voltage surges
- Load-side, phase-to-phase, short-circuit protection
- Sine wave output filter
- Hall-effect high-frequency response current transformer for current sensing

SpeedStar* variable-speed drives (VSDs) include many standard features to protect and control ESPs and surface pumping systems for variable-speed applications. Two configurations are available: SpeedStar 2000 Plus* VSD and SpeedStar SWD* sine wave drive VSD. The SpeedStar 2000 Plus drive is used typically with surface pumping systems. The SpeedStar SWD sine wave drive, which has an integral output sine wave filter, is typically used with ESPs. The output voltage wave form is similar to that of a true sine wave and thus results in less voltage stress and a longer life for the motor, cable, and other electrical components.

The use of a VSD allows a pumping system to perform across a wider operating range than is possible using a fixed-speed drive (FSD) because of the VSD's ability to vary the speed of the motor. Optimum producing conditions can be preset and maintained by automatically adjusting the speed to a preset drawdown pressure or load. Making this adjustment decreases the need to resize a pump as operating conditions change. It thus reduces downtime and operating costs.

Enhanced operation and protection

Standard features enhance downhole and surface operations. The rocking-start function switches the motor direction back and forth to start units that are stuck, particularly in abrasive environments. The current-pressure mode allows pumps to be set to a target load or pressure and their speed to be adjusted as operating conditions change. This flexibility in speed helps stabilize operations in gassy and viscous environments, and it maximizes uptime.

SpeedStar VSDs use the UniConn* universal site controller as the single user interface for all wellsite control and data acquisition requirements. The UniConn controller's expandable functionality optimizes data gathering, remote monitoring, and controls related to downhole and surface pumping operations.



SpeedStar SWD sine wave drive.

The modular, customizable controller provides

- a single point for all wellsite data gathering, including data from a Phoenix* downhole monitoring system
- ability to start an ESP while motor is spinning
- setting of alarms and parameters for auto restart
- programmable automatic load reduction (soft-stall function)
- user-adjustable long acceleration curve to prevent sand production.

SpeedStar VSDs are provided in NEMA 1– (indoor) and NEMA 3R–rated (indoor or outdoor) enclosures. For outdoor use, the NEMA 3R has all its electronic components located inside a sealed (NEMA 4) section of the drive enclosure with no exchange of outside cooling air. It is suitable for use in subzero and high-temperature submersible pump climates, operating in temperatures ranging from –30 degC to +50 degC [–22 degF to +122 degF].

SpeedStar 2000 Plus and SpeedStar SWD Drives

PROTECTION FEATURES

- Main circuit overcurrent at startup
- Electronic thermal overload
- Load-side phase-to-phase short-circuit protection
- Heat sink and enclosure overtemperature protection
- Open output phase
- Soft-stall: automatic load reduction
- DC bus overvoltage and undervoltage
- Momentary power failure ride-through

STANDARD FEATURES

- Input circuit breaker disconnect with 100-kAIC-rated fuses
- Diode front-end converter
- Insulated-gate bipolar transistor inverter
- Heat-sink-mounted power components
- Hall-effect current transformer sensing device
- UniConn universal site controller
- Weatherproof gasketed door with three-point padlockable latch
- Lifting eyebolts
- StarShield SPD
- Outdoor-rated heat exchanger for forced air cooling
- 1-kVa potential transformer for two 110-V receptacles
- Mounting studs and antenna stand
- Sine wave output filter (SpeedStar SWD VSD)

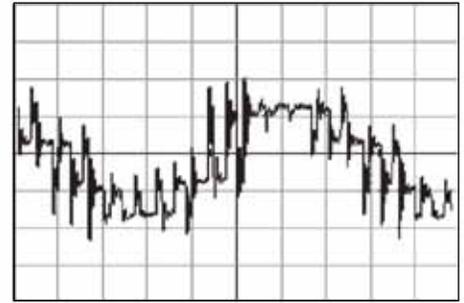
SpeedStar VSDs provide state-of-the-art motor control, incorporating advanced digital pulse-width modulation (PWM) flux-vector control that ensures a constant speed and torque. VSDs also provide higher torque per amp, which results in minimal motor heating and reduced torque pulsation, both of which can prolong the life of the electrical system. Electrical stresses during startup are detrimental to the electrical system, but the capability of reducing the in-rush current to as low as 1.5 times the operating current helps prolong insulation life for all electrical components downstream of the VSD, including connectors, splices, cables, and motor insulation.

SpeedStar SWD VSDs offer an integral sine wave output filter that eliminates problems related to resonance. The patented filter pushes the resonance band of the downhole system below the drive's carrier frequency, eliminating excessive resonance and minimizing voltage overshoots, regardless of variations in cable length, motor type, and transformer taps selected. The output voltage wave form is similar to that of a true sine wave and thus results in less voltage stress and longer life for the motor, cable, and other electrical components.

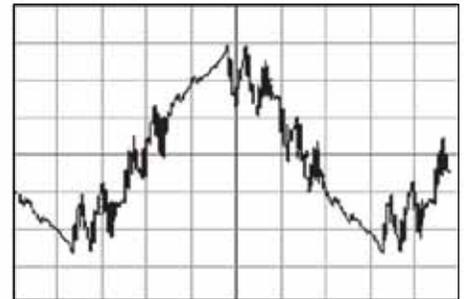
Input harmonics reduction

Higher-level-pulse low-voltage VSDs (12- and 18-pulse) are options to reduce line harmonics. They work by increasing the input phases to six and nine phases, respectively. The 12-pulse VSD will require the use of an external phase shift transformer, while the 18-pulse solution offers a method, subject to types of power systems, of achieving industrial guidelines (such as IEEE 519 or its IEC equivalent), with an all-inclusive package. Eighteen-pulse cancellation is achieved using an integral patented phase shifting autotransformer. This design has a 0.99 constant power factor regardless of speed and is 1% more efficient (which could mean thousands of dollars per year in energy savings) compared with a typical external isolation phase shifting transformer.

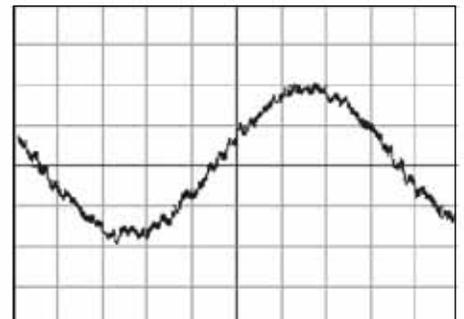
Compared with a basic 6-pulse VSD, a 12-pulse VSD typically reduces the input supply total harmonic distortion level to less



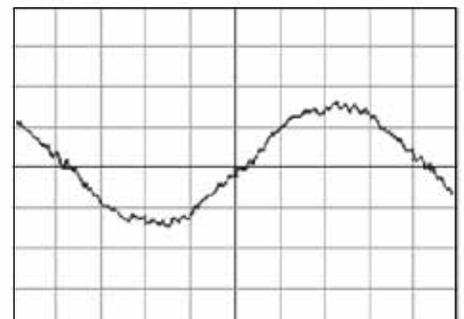
PWM voltage.



PWM current.



SWD voltage.



SWD current.

SpeedStar 2000 Plus and SpeedStar SWD Drives

OPTIONAL FEATURES

- Space heater with thermostat to prevent condensation
- Three-phase current transformer modules for motor current monitoring
- Potential transformers for three-phase input/output voltage monitoring
- UniConn expansion cards
- Internal transceiver
- External junction box
- DC link or AC line reactor
- Door-mounted ammeter, voltmeters, push buttons, and switches



StarShield TVSS surge suppressor, a standard feature, provides excellent protection from power surges and lightning strikes.

than 50%, and the 18-pulse typically reduces the distortion level by a dramatic 80%. This greatly decreases the heating and electrical stresses on other systems connected to the power supply.

Control functionalities and parameters

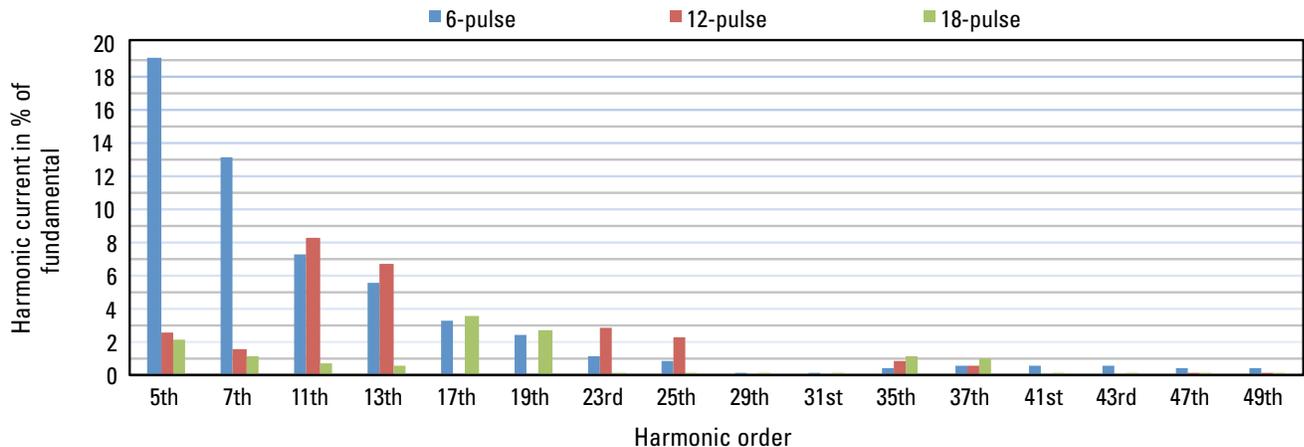
- Speed: target, maximum and minimum, base
- Three jump frequencies and bandwidths, individually settable
- V/Hz pattern, startup boost
- Acceleration and deceleration rates, including start to minimum speed and minimum to target speed; also maintains constant pressure or load (from 0.01 Hz/10,000 s to 1 Hz/s)
- Speed control in frequency, current, or pressure mode
- Ability to catch a spinning motor or change rotation direction without stopping the VSD
- Speed follower: speed control to follow analog input
- Speed force: based on specified digital input
- Soft stall: automatic speed reduction
- Base speed voltage selection
- Rocking start frequency, cycle, and pattern

Monitored parameters

- Current: drive-measured, motor-calculated (optional three-phase measured)
- Voltage: drive input and output (optional three-phase measured)
- Supply voltage
- Power: drive input and output, running frequency
- Spin frequency, leg ground (optional)

Protection set points

- Overload (with 14-point time-response curve), underload, tracking underload, imbalance (optional)
- Overvoltage (optional), undervoltage (optional, with six-point time-response curve), imbalance (optional)
- High and low supply voltage (with six-point time-response curve)
- Pressure or load high and low feedback set points
- Backspin, leg ground (optional)



Input current harmonic order—6-pulse, 12-pulse, and 18-pulse.

SpeedStar 2000 Plus and SpeedStar SWD Drives

SpeedStar 2000 Plus and SWD VSD Specifications

Control system	Flux-vector PWM, V/Hz control
Input supply	380 to 480 V $\pm 10\%$, 50 or 60 Hz $\pm 5\%$
Output voltage regulation	Same as power supply
Frequency setting	0.01 to 120 Hz, 0.1-Hz resolution
PWM carrier frequency (user-adjustable)	SpeedStar 2000 Plus VSD: 0.5 to 3.0 kHz SpeedStar SWD VSD: 2.2 kHz
Input configuration	Diode, 6- or 12-pulse
Efficiency	98% at all loads and speeds
Power factor	96% at all loads and speeds
Overload rating	120% for 120 s, 100% continuous
Certification and standards compliance	UL-508, CE (with addition of electromagnetic interference filter at drive input)

SpeedStar 519 SWD* VSD Specifications

Control system	Flux-vector PWM, V/Hz control
Input supply	380/415/480 V $\pm 10\%$, 50/60 Hz ± 2 Hz
Output voltage regulation	Same as power supply
Frequency setting	0.01 to 90 Hz, 0.01-Hz resolution
Non-SWD (PWM)	0.5 to 3.0 kHz (user-adjustable) carrier frequency
Sine wave drive VSD	2.2-kHz carrier frequency fixed
Input configuration	18-pulse integral phase shift transformer with diode front end
Inverter efficiency	98% at all loads and speeds
Power factor	0.99 at all loads and speeds
Overload rating	120% for 120 s; 100% continuous
Certification and standards	UL-508 pending

SpeedStar 2000 Plus, SWD, and 519 SWD Enclosure and Environmental Ratings

Enclosure rating	NEMA 1 (indoor) or NEMA 3R (outdoor) and IP 56 (option for SpeedStar 519 SWD drive)
Cooling method	Electronic section: sealed from outside air (NEMA 4 section) and cooled by heat exchanger Transformers section: forced air-cooled (automatic internal and external fans)
Max. altitude	1,000 m [3,280 ft] above sea level; output rating derated above upper temperature
Ambient operating temperature	-30 to 50 degC [-22 to 122 degF]; output rating derated above upper temperature
Ambient storage temperature	-40 to 60 degC [-40 to 140 degF]
Relative humidity	20% to 95% maximum (noncondensing)
H ₂ S protection	Conformal-coated circuit boards and tin-plated bus bars
Material	12-gauge carbon steel enclosure [†]

[†]Stainless steel available on request

SpeedStar SWD—NEMA 3R, 18-Pulse, 122 degF [50 degC] Ambient Temperature-Rated

Rating at 480 V, kVa	Rating at 380 V, kVa	Rated Output, A	Weight, lbm [kg]	Dimensions (W x H x D), in [m]
200	158	241	2,550 [1,157]	81.5 x 70.0 x 39.0 [1.98 x 1.78 x 0.99]
260	205	313	3,425 [1,554]	81.5 x 93.5 x 48.0 [1.98 x 2.37 x 1.22]
390	308	469	3,650 [1,656]	81.5 x 93.5 x 48.0 [1.98 x 2.37 x 1.22]
454	359	546	3,800 [1,724]	81.5 x 93.5 x 48.0 [1.98 x 2.37 x 1.22]
518	410	623	3,900 [1,769]	81.5 x 93.5 x 48.0 [1.98 x 2.37 x 1.22]
518	410	623	5,600 [2,540]	81.5 x 130.0 x 50.5 [1.98 x 3.31 x 1.28]
600	475	722	5,600 [2,540]	81.5 x 130.0 x 50.5 [1.98 x 3.31 x 1.28]
700	554	842	5,600 [2,540]	81.5 x 130.0 x 50.5 [1.98 x 3.31 x 1.28]

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SpeedStar 2000 Plus VSD Specifications, Non-Sine-Wave, 6- and 12-Pulse

A	Output Rating		Ambient Temperature Rating, degC	Dimensions (H x W x D), in		Approximate Weight, lbm
	kVA at 480 V	kVA at 380 V		NEMA 3R	NEMA 1	
79	66	52	50	81.50 x 25.06 x 35.00	81.50 x 25.06 x 33.00	1,000
100	83	66	50	81.50 x 25.06 x 35.00	81.50 x 25.06 x 33.00	1,000
132	110	87	50	81.50 x 25.06 x 35.00	81.50 x 25.06 x 33.00	1,000
156	130	103	50	81.50 x 31.50 x 35.00	81.50 x 25.06 x 33.00	1,000
196	163	129	50	81.50 x 31.50 x 35.00	81.50 x 25.06 x 33.00	1,000
241	200	158	50	81.50 x 31.50 x 35.00	81.50 x 25.06 x 33.00	1,000
313	260	206	50	81.50 x 46.00 x 42.00	81.50 x 37.06 x 40.00	1,200
469	390	309	50	81.50 x 46.00 x 42.00	81.50 x 37.06 x 40.00	1,200
546	454	359	50	81.50 x 46.00 x 42.00	81.50 x 37.06 x 40.00	1,200
623	518	410	40	81.50 x 46.00 x 42.00	81.50 x 37.06 x 40.00	1,200
623	518	410	50	81.50 x 90.00 x 48.00	81.50 x 72.00 x 46.00	2,000
722	600	475	50	81.50 x 90.00 x 48.00	81.50 x 72.00 x 46.00	2,000
842	700	554	50	81.50 x 90.00 x 48.00	81.50 x 72.00 x 46.00	2,000
980	815	645	50	81.50 x 90.00 x 48.00	81.50 x 72.00 x 46.00	2,000
1,121	932	738	50	81.50 x 90.00 x 48.00	81.50 x 72.00 x 46.00	2,000
1,203	1,000	792	50	81.50 x 90.00 x 48.00	81.50 x 72.00 x 46.00	2,000
1,443	1,200	950	50	81.50 x 110.00 x 48.00	81.50 x 84.00 x 46.00	3,500
1,684	1,400	1,108	40	81.50 x 110.00 x 48.00	81.50 x 84.00 x 46.00	3,500
1,804	1,500	1,188	40	81.50 x 110.00 x 48.00	81.50 x 84.00 x 46.00	3,500

SpeedStar SWD Specifications, 6- and 12-Pulse

A	Output Rating		Ambient Temperature Rating, degC	Dimensions (H x W x D), in		Approximate Weight, lbm
	kVA at 480 V	kVA at 380 V		NEMA 3R	NEMA 1	
241	200	158	50	99.50 x 31.50 x 35.00	99.50 x 25.00 x 33.00	1,500
313	260	206	50	99.50 x 46.00 x 42.00	99.50 x 37.00 x 40.00	2,000
469	390	309	50	99.50 x 46.00 x 42.00	99.50 x 37.00 x 40.00	2,000
546	454	359	50	99.50 x 46.00 x 42.00	99.50 x 37.00 x 40.00	2,000
623	518	410	40	99.50 x 46.00 x 42.00	99.50 x 37.00 x 40.00	2,000
623	518	410	50	99.50 x 90.00 x 48.00	99.50 x 72.00 x 46.00	3,100
722	600	475	50	99.50 x 90.00 x 48.00	99.50 x 72.00 x 46.00	3,100
842	700	554	50	99.50 x 90.00 x 48.00	99.50 x 72.00 x 46.00	3,100
980	815	645	50	99.50 x 90.00 x 48.00	99.50 x 72.00 x 46.00	3,100
1,121	932	738	40	99.50 x 90.00 x 48.00	99.50 x 72.00 x 46.00	3,100
1,203	1000	792	40	99.50 x 90.00 x 48.00	99.50 x 72.00 x 46.00	3,100
1,121	932	738	50	99.50 x 110.00 x 48.00	99.50 x 84.00 x 46.00	5,000
1,203	1,000	792	50	99.50 x 110.00 x 48.00	99.50 x 84.00 x 46.00	5,000
1,443	1,200	950	50	99.50 x 110.00 x 48.00	99.50 x 84.00 x 46.00	5,000
1,684	1,400	1,108	40	99.50 x 110.00 x 48.00	99.50 x 84.00 x 46.00	5,000
1,804	1,500	1,188	40	99.50 x 110.00 x 48.00	99.50 x 84.00 x 46.00	5,000

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