Electrical Submersible Pump

Low Harmonic Variable Frequency Drive

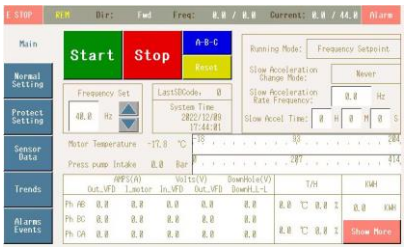
Voltage rating: 380V to 480V, 50/60Hz

DCUS

EVR 3 Series Low Harmonic Variable Frequency Drive

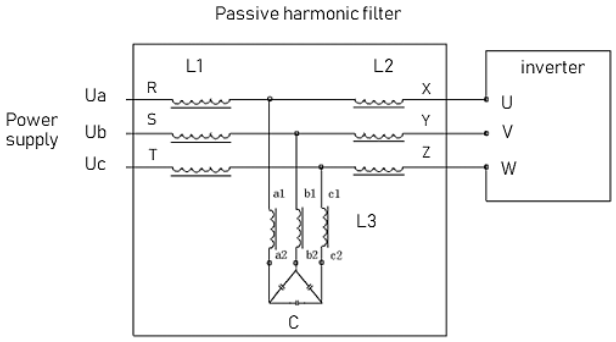
Industry Power & Control for Artificial Lift Application

Modular design, Low Harmonic, Cost effective, Easy-to-use and Easy-to-maintain Variable frequency drive



Input power supply	3 phase 380V to 480V ±10%, 50/60Hz ±5%
Converter type	6 pulse diode
Inverter type	IGBTs
Input current protection	Circuit breaker
Input surge suppression	IEC test classification / EN type: II/T2 Maximum continuous voltage: 350V(L-PE) I_{SCCR}: 50kA (max.200A gG) Voltage protection level: 1500V I_n: 20kA 8/20 µs I_{max}: 40kA 8/20 µs
Input low harmonic	Integrated passive harmonic filter
Output voltage	The same as power supply
Output frequency	0.1Hz to 120Hz
Output waveform	High performance Sinewave
Motor control	Constant or Variable Torque (V/F)
Motor technology	Induction motor (IM) or Permanent Magnet Motor (PMM)
Efficiency	~96.5% at full load
Power factor	0.98 across entire speed range
Overload rating	120% for 1min/5min
Certifications	ISO9001, ISO14001
Enclosure rating	Junction box & main power section: IP66 [equivalent to NEMA4] Magnetics section: IP24 [equivalent to NEMA3R]
Cooling system	IP66: air-conditioning unit, heat sink IP24 : forced air cooling
Altitude	0 to 1000m without derating
Ambient operating Temp.	-30 degC to 55 degC
Relative humidity	20% to 95% maximum(noncondensing)
H_2S protection	Conformal-coated PCBs & bus bars
Material	Carbon steel, the thickness is 2.5mm
Line-side termination	Circuit breaker's lugs in power junction box
Load-side termination	Lugs in power junction box
Control termination	Mounting plate on the dedicated swing door
Safety features	Emergency stop button Electronic interlocks Separated power and control sections Backspin indication LED on the front door Prewired IO junction box
Analog inputs (AI)	Qty 2: 4-20mA, resolution 12 bits
Digital inputs (DI)	Qty 5: DC24V, sink wiring
Digital outputs (DO)	Qty 4: relay output, NO, up to 5A
Serial communication	Qty 1: RS485 Modbus Master (for DHS) Qty 1: RS485 Modbus Slave (for SCADA)

Passive harmonic filter



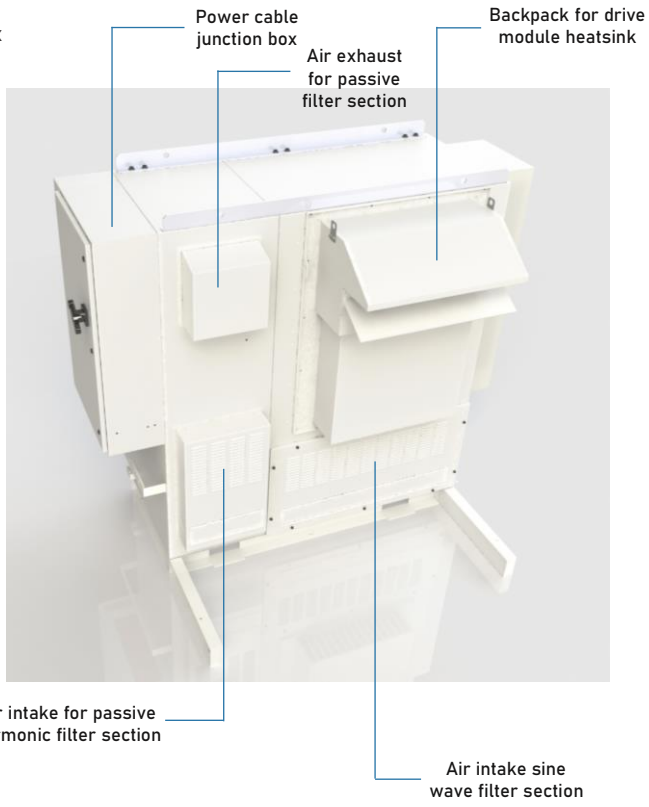
+ The total current harmonic generated by diode bridge rectifier (3 phase, 6 pulse rectifier) on the power grid of the converter can reach 35-40%, mainly 5th , 7th ,11st and13rd, of which 5th harmonics account for 70-80%.
+ The passive harmonic filter we used has been matched with the VFD to adapt to a variety of motor control modes, ensuring the stable operation of the system without any adverse impact on the power grid. And THDI, the total harmonic current generated by the VFD to the power grid, can be suppressed within 5%. The passive harmonic filter is also composed of inductor capacitor matching, but different from the general solution, we add an inductor (L2) in the main loop, so that L1, C, L2 can form LCL filter to achieve better harmonic suppression effect through accurate matching.

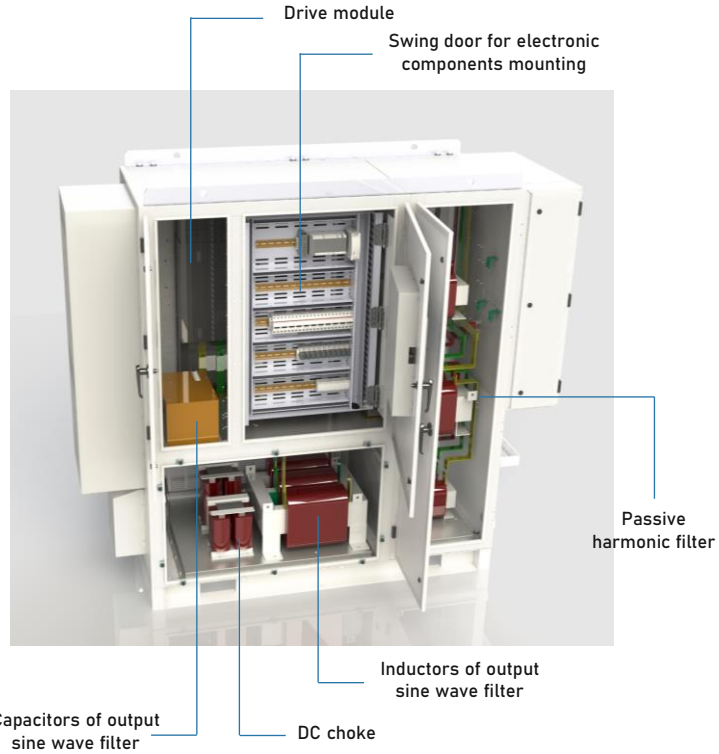
+ For the largest proportion of the 5th harmonic, we use branch single tuned filtering. The 5th harmonic is 250Hz harmonic, which forms a series resonance at 250Hz through the matching of inductor L3 and capacitor C. That is, the 5th harmonic generated by the inverter with the lowest impedance at this frequency will flow into the branch and be absorbed by the inductor capacitor; Total harmonic THDI can be reduced to<12%; (Resonant frequency $f=1/(2 * \pi * \sqrt{LC})$
+ LCL filter composed of inductor L1, L2 and capacitor C can effectively suppress 7th, 11st, 13rd and above higher harmonics. Combining the two filtering effects, the total harmonic THDI of the line can meet the requirement of 5%; LCL $F=[1/(2\pi)]*SQRT[(L1+L2)/(L1*L2*C1)]$

Comparison of harmonics reduction solutions

	6-pulse rectifier without choke	6-pulse rectifier with large choke	6-pulse VFD and passive filter	6-pulse VFD and active filter	Multi-pulse VFD	IGBT supplied VFD/ ultra-low harmonic VFD
Typical THDI% at nominal load	>100%	40%	<10%	<5%	12-pulse: 6 to 10% 24-pulse: <5%	<5%
Drive system efficiency (excluding motor and supply), typical value at rated power	~98%	~97%	~96.5%(1)	~96.5%(1)	~96%(2)	~96.5%(3)
True power factor	~0.7 at nominal load only	~0.98 at nominal load only	~0.98 at nominal load only	~0.99 at nominal load only	~0.98 at nominal load only	1.0 at all load conditions
Simplicity of the installation	One single component	One single component or two separate components	One single component or two separate components	One single component or two separate components	Multiple separate components	One single component
Installation footprint	100%	110%	140%	200%	300%(4)	120%
Equipment cost of all requirement components	100%	120%	160%	250%	200%	300%(5)

+ (1) Both filter and drive efficiency must be considered: Filter efficiency is ~98.5% and standard 6-pulse drive efficiency is ~98%. The total combined efficiency is ~96.5%
+ (2) Transformer and drive efficiency must considered: Typical total combined efficiency is ~96%
+ (3) Increase losses through is inverter supply unit and filter. The total combined efficiency is ~96.5%
+ (4) cost and size comparison includes dedicated multi-winding transformer
+ (5) The IGBT rectifier VFD is not the general products in the market. The heat dissipation is large, the drive module's price is very high and the spare parts are expensive





+ EVR3 series low harmonic VFD is composed of integrated Passive Harmonic Filter and 6 pulse VFD
+ Different rating passive harmonic filter can be matched the exist EVR3 series VFDs to form low harmonic VFDs and drive the induction motor and permanent magnet motor. The output power ratings are the same as the exist EVR3 series VFD's,
+ EVR3 low harmonic VFD is custom designed product

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