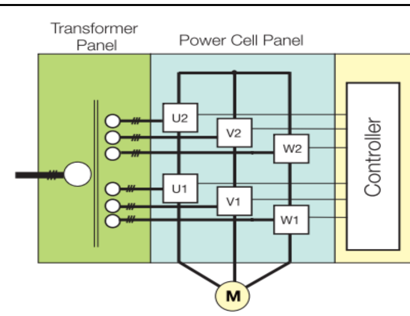
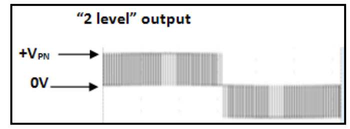
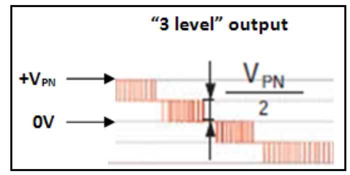
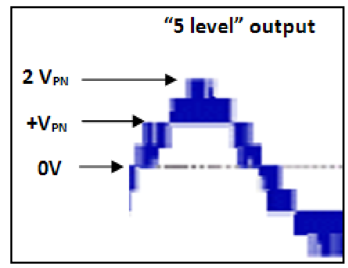
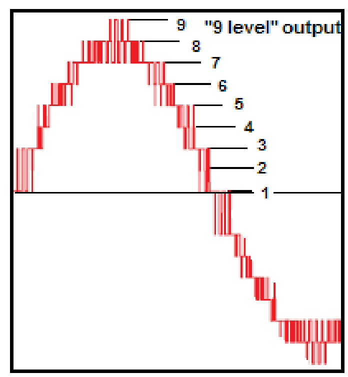
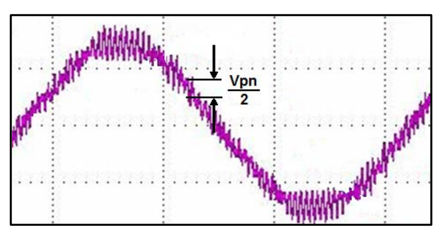
Frequently Asked Questions (FAQs) MV1000 Drive

QUESTION	ANSWER
1. What is a conventional PWM Inverter?	A conventional Pulse Width Modulated (PWM) Inverter uses a rectifier bridge to convert commercial three-phase power to direct current (DC) and stores the energy in a capacitor bank. An output inverter section of IGBT switches uses a sine weighted PWM switching algorithm to create a variable voltage and frequency three-phase alternating current (AC) output. This output is applied to an AC motor to provide adjustable speed. The design is known as a **Voltage Source Inverter (VSI).**
2. What is a medium voltage inverter?	ANSI/IEEE defines Medium Voltage as 1 - 35kV. Medium Voltage (MV) inverters in industry typically operate from line voltages of 2.4, 3.3, 4.16, or 6.6kV. Some MV drives offer input voltages to 13.8kV, often transforming down the input voltage and outputting one of the standards in the 2.4 - 6.6kV range.
3. Are all MV inverters Voltage Source (VSI) design?	No. Some MV inverters are Current Source Inverters (CSI), sometimes called Load Commutated Inverters (LCI).
4. What is a Current Source Inverter (CSI)?	CSI (or LCI) drives are an older technology that stores the DC energy in inductors rather than capacitors. CSI drives can experience catastrophic failure if the output is open circuited while in operation. Control system bandwidth (torque response and speed response) is typically slower in CSI than PWM inverters. Also, output torque perturbations are typically higher in CSI drives than PWM drives, sometimes enough to cause mechanical instability.
5. What output power configurations are used in MV PWM inverters?	There are three topologies used in contemporary PWM MV inverters: 3 level, 5 level, and "multi-pulse" or "series connected" inverters.
6. What are "multi-pulse" or "series connected" inverters?	Multi-pulse inverters use single phase bridges (U1, U2, etc.), connected in series to create an output for each phase of the three phase VFD output voltage. 

7. What is meant by 'level'? "3 level" vs. "5 level", etc.?	"Level" has been traditionally used to describe the number of voltage increments in a PWM drive output, counted from neutral to output line. (See also *"What are levels line-to-line?*"). A conventional "2 level" inverter would have either 0V or bus voltage (V_{PN}) applied. 2 level is typical for most low voltage (LV) products.  A "3 level" output has 3 voltages from neutral to line, 0V, V_{PN} /2, and $V_{PN.}$ This configuration is used in several MV designs and in the Yaskawa G7 low voltage (LV) drive.  A "5 level" output has 5 voltage increments from neutral to line. This configuration is used in several MV designs.  A "9 level" output has 9 voltage increments from neutral to line. This configuration is used in the MV1000.  More levels = more sinusoidal output. More sinusoidal output = cooler running motor, less filtering required, minimal reflected wave issues, etc. *(See also "What are levels line-to-line?")*
8. How many levels are produced with the MV1000?	The MV1000 uses multiple bridges of 5 voltage steps each, requiring only 2 bridges per phase at 4.16kV. The result is a 9 level waveform, or 17 levels line to line. Oscilloscope trace of 4.16kV MV1000 output voltage, line to neutral. 

9. What are "levels line-to-line"?	Some manufacturers describe the number of levels of their output waveforms measured from output 'line-to-line' rather than the traditional description from Neutral-to-line. A "3 level" drive would be "5 level line-to-line" and a "5 level" drive would be "9 level line-to-line". The "9 level" MV1000 would be "17 level line-to-line". (See also *"What is meant by 'level'? "3 level" vs. "5 level", etc.?"*)
10. What power configuration is used in the MV1000?	The MV1000 uses single phase power bridges, configured to provide 5 voltage steps each. 2 bridges are connected in series for each output phase. This is called a "Cascaded H Bridge" (CHB) configuration. The resulting output is a 9 level waveform. This is the optimum design in consideration of small physical size, quality output waveform, and minimal number of cells (See also "*What is meant by 'level'? "3 level" vs. "5 level", etc."?)*
11. What power configuration is used for 3 level ("5 level line-to-line") VSIs?	These drives typically use medium voltage IGBTs or Insulated Gate Commutating Thyristors (IGCTs) in a 3 level Neutral Point Clamp (NPC) configuration. Sine wave output filters are required for use on existing motors or moderate to long lead lengths. MV IGCTs are quite reliable, but their gate drive circuitry is complex and very fragile.
12. What power configuration is used for "multi pulse" or "series connected" VSIs?	Most series connected VSIs use multiple 2 level bridges, requiring 3 or 4 bridges per phase for a 4.16kV VSI. The MV1000 uses bridges with 5 voltage steps, requiring only 2 bridges per phase for 4.16kV, while providing a superior output waveform.
13. How does the MV1000 address input harmonic current issues?	Input harmonic currents are a major concern in MV drives. The MV1000 uses an input transformer with Smart Harmonics™ Technology. No additional harmonic mitigation components (Inductors, LC filters, etc.) are required. The standard MV1000 exceeds IEEE 519 industry guidelines for THD at the input to the drive.
14. What is Smart Harmonics™ Technology?	The Smart Harmonics™ Technology transformer incorporates unique phase shifting windings that minimize Total Harmonic Distortion (THD). The MV1000 is TUV certified at <2.3% THD, lower than conventional 36 pulse rectifiers.
15. What is the control platform of the MV1000?	The MV1000 control is based on the hugely successful Yaskawa A1000 series Low Voltage (LV) drive. The MV1000 uses a common parameter set with the A1000, with additional functionality as needed for the MV drive.
16. Can multiple motors be driven using a single MV1000?	Yes, using the V/Hz control mode. V/Hz is the control method appropriate to multiple motor operation. The drive current rating should be selected to be >1.1*(total FLA of the connected motors). Each motor must be provided with its own thermal overload relay.
17. Is the MV1000 UL listed? CSA Approved?	Yes – the 2.4 and 4.16kV products are UL listed. They are also CSA approved
18. Where is the MV1000 manufactured?	The 2.4 and 4.16kV products are manufactured at Yaskawa America Inc. (YAI)'s facility in Oak Creek Wisconsin (OC) for the Americas market. The investment will total >$3M at the end of a phased build, with load testing capability to 5,000HP.
19. Can I operate a 4.16kV motor from a 2.4kV supply with the MV1000?	Yes!! 2.4kV power distribution is limited in served area and is being gradually converted to 4.16kV. Planning for the future, it may be advantageous to use a 4.16kV motor for a new or retrofit application. The input transformer of a 4.16kV MV1000 is normally connected in a wye configuration. It can be reconnected to delta, and accept 2.4kV in, with the MV1000 outputting 4.16kV. If the power supply is updated to 4.16kV, all that is needed is reconnection of the input transformer primary to wye.

20. What is the difference between a commercial motor and an inverter duty motor?	A commercial motor has lower cooling capacity at reduced speed because its external fan speed drops. The motor will overheat unless the load is reduced in the low-speed range. Inverter duty motors are specially designed to operate without overheating at low speeds and full load. They are often provided with a constant speed fan.
21. What is an IGBT?	The acronym stands for Insulated Gate Bipolar Transistor. An IGBT is a power element combining the low saturation voltage of a bipolar power transistor and the high-speed operation of a MOSFET (Metal Oxide Semiconductor Field-Effect Transistor). It is capable of high-speed switching and has low loss characteristics. The MOSFET gate is easy to switch and requires low power, making the gate drive circuitry simple and highly reliable.
22. What is electrothermal motor protection? How does it work?	It protects the motor from overheating across the entire speed range by simulating the thermal characteristics of the motor (winding temperature) based on the motor current and the operating frequency information. During startup, the motor type is selected to optimize the motor overload algorithm. If multiple motors are driven by a single conventional inverter, each motor will need its own thermal relay.
23. Why do Yaskawa inverters have such excellent starting characteristics?	It is due to Yaskawa's proprietary full-range/fully-automatic Torque Boost function. It can output the torque needed by the load at startup.
24. What is Torque Boost?	Torque Boost raises the voltage with load increase (not just at start, but over the entire frequency range).
25. Why is Torque Boost needed?	As load increases on the motor, current increases. With a constant applied voltage, the motor would be underexcited with increasing current due to the motor winding resistance. Performance would suffer. Torque Boost compensates for this.
26. What is “stall”?	Stall is a point where the load torque requirement is higher than an Induction Motor (IM) can produce (even if the drive has the capacity to deliver more current). When a stall condition is reached, the motor will slow, its current draw will go up, and the drive will trip.
27. Do Yaskawa drives have a stall prevention function?	Yes. Stall is usually an issue during acceleration, when trying to accelerate a high inertia load too quickly. Yaskawa drives stop acceleration (hold speed constant) until the output current is reduced below a preset level, then acceleration resumes. The stall prevention function can also be used while at speed or during deceleration.
28. What is the purpose of overtorque and/or undertorque detection?	Overtorque detection is a selectable preset level used to protect the machine rather than the inverter or motor. The drive can be programmed to either output a signal indicating overtorque or shut down the drive. Undertorque detection performs the same function, but for an output torque below a preset value. This is typically used for broken belt detection, or to signal an unexpected low load condition.
29. How do I select a drive, by motor HP rating or current rating?	Always select a drive with a current rating > the Full Load Amps (FLA) of the motor. If long term, full torque, low speed operation (<6Hz) is anticipated when using a conventional inverter, consult Yaskawa. Drive derating may be required. If long term, full torque, low speed operation (<6Hz) is anticipated when using a Yaskawa Matrix Converter (MX1S), no derating is necessary.
30. What is meant by “Four Quadrant” operation?	The four quadrants are used to define power flow and direction. ‘Quadrant 1’ is forward rotation and motoring, ‘Quadrant 2’ is reverse rotation and motoring, ‘Quadrant 3’ is reverse rotation and regenerating, ‘Quadrant 4’ is forward rotation and regenerating. A conventional inverter is capable of operating in quadrants 1 and 2. Adding a regenerative module to a conventional drive, or using a fully regenerative drive like the G7 (LV) or MX1S (MV) allows full four quadrant operation.

31. What are ‘Control Modes’?	The Control Mode (or Control Method) defines the type of algorithm used by the drive to provide the motor excitation. Yaskawa drives use one of four control modes. Some models offer more than one mode. Refer to the specific drive model for choices. Control Modes available are: V/Hz, Closed Loop V/Hz, Open Loop Vector (OLV) and Closed Loop Vector (CLV). See specific faqs for details.

32. What is V/Hz control?	In V/Hz mode, in inverter outputs a voltage and frequency in a preprogrammed ratio. An induction motor (IM) is fully excited when its nameplate rated Voltage divided by its nameplate rated Frequency (Hz) is applied. The IM speed changes with applied frequency. Providing a constant V/Hz ratio to the motor allows control of speed while providing full motor excitation. Early in the history of static voltage source inverters, simple V/Hz was the only control. As increased intelligence was available in the drives, the V/Hz control algorithm became more sophisticated, including features like: slip compensation, torque boost, selectable V/Hz curves, etc. V/Hz is widely used in applications where dynamic response is slow and precise speed control is not required. It is simple to set up, does not require knowledge of motor parameters or autotuning. Speed range is limited to 40:1. V/Hz is the proper control mode when multiple motors are being operated from one inverter.
33. What is Closed Loop V/Hz control?	Closed Loop V/Hz offers precise speed control using feedback from a motor mounted pulse generator (PG). It retains the advantages of simple V/Hz while providing improved speed accuracy. Dynamic response is not improved from open loop V/Hz. Speed range is limited to ~40:1.
34. What is Vector Control in general and, specifically, Open Loop Vector (OLV) control?	In an Induction Motor (IM) the magnetizing current trails the applied voltage by 90^{o}. The torque producing current is in phase with the applied voltage. A Vector Control algorithm calculates the magnetizing current and keeps it optimum, while adjusting the torque producing component of current to meet load demands. Precise speed control and high dynamic performance can be achieved with quick torque response. Motor parameters need to be input to the drive or autotuning is required. Speed range is 120:1 or more since vector control provides high torque capability at low speed.
35. What is Closed Loop Vector (CLV) control?	Closed Loop Vector (CLV) adds speed feedback from a motor mounted pulse generator (PG) to a vector controlled inverter. {See faq *"What is Vector Control in general and, specifically, Open Loop Vector (OLV) control?"* for background}. Speed range is increased to ~1500:1 in CLV mode.
36. What control modes are available in the MV1000?	The MV1000 can be configured for V/Hz (typically only used when driving multiple motors), OLV (most applications), and CLV (where top performance and most accurate speed control is required).
37. Is there a list defining the acronyms used in these FAQs?	AC - Alternating Current ANSI - American National Standards Institute BG - Buffalo Grove CHB - Cascaded H Bridge CLV - Closed Loop Vector CSI - Current Source Inverter DC - Direct Current FAQ - Frequently Asked Question FLA - Full Load Amps HP - Horsepower HQ - Headquarters (Waukegan, IL) Hz – Frequency (Hertz) IEEE - Institute of Electrical and Electronic Engineers

	IGBT - Insulated Gate Bipolar Transistor IGCT - Insulated Gate Commutating Thyristor IM - Induction Motor LCI - Load Commutated Inverter LV - Low Voltage MV - Medium Voltage NPC - Neutral Point Clamp OC - Oak Creek OLV - Open Loop Vector PG – Pulse Generator PM - Permanent Magnet Motor PWM - Pulse Width Modulation (or Modulated) SM - Synchronous Motor TDD - Total Demand Distortion THD - Total Harmonic Distortion TUV - *Technischer Überwachungs-Verein* (Technical Inspection Association) V/Hz - Volts per Hertz VFD – Variable Frequency Drive VSI - Voltage Source Inverter YAI - Yaskawa America Incorporated