Hitachi WJ-C1 Series Variable Frequency Drives (VFDs)

The **Hitachi WJ-C1** series is a compact, high-performance line of variable frequency drives introduced as the successor to the popular WJ200 series. It is designed for excellent motor control and user-friendliness, covering a wide power range from roughly 0.5 to 20 horsepower (0.1 to 15 kW) across multiple input voltage classes (100 V, 200 V, and 400 V) [1]. The C1 series brings significant enhancements, including an integrated auto-tuning function for easy setup and **advanced sensorless vector control** that delivers high starting torque (around 200% of rated torque at near-zero speed) [2]. These drives are built to handle rigorous industrial demands, offering improved torque and speed regulation to ensure smooth operation even under heavy loads [3].

The versatility of the Hitachi WJ-C1 makes it suitable for a broad range of applications. Whether operating a simple **pump or fan** or managing a complex **conveyor or machine**, the C1 provides precise control and adaptability to optimize performance [4]. At the same time, its compact footprint and robust construction allow installation in space-constrained environments without sacrificing durability [5]. In short, the WJ-C1 series delivers a balanced combination of power, sophisticated control features, and ease of use – helping users achieve energy-efficient, reliable motor control in many industrial settings.

Model Range and Specifications

For reference, the WJ-C1 series is offered in several voltage and power ratings [1]:

- **3-phase 400 V class:** Models for 0.4 kW up to 15 kW (approx. 0.5–20 HP).
- **3-phase 200 V class:** Models for 0.1 kW up to 15 kW (approx. 0.1–20 HP).
- **1-phase 200 V class:** Models for 0.1 kW up to 2.2 kW (approx. 0.1–3 HP).
- **1-phase 100 V class:** Models for 0.4 kW and 0.75 kW (approx. 1/2–1 HP).

Each model is **dual-rated** for heavy-duty vs. normal-duty operation (also known as constant-torque (CT) vs. variable-torque (VT) applications) [6]. In heavy-duty service, the drive can supply **150% of its rated current for up to 60 seconds**, whereas in normal-duty (lighter load) use it allows **120% for 60 seconds** before tripping [7]. This dual rating means a single inverter model can handle a smaller motor in demanding high-torque applications or a larger motor in easier variable-torque scenarios. The maximum output frequency is also notably high (up to 590 Hz) [8], enabling the WJ-C1 to drive **high-speed motors** (such as spindles or centrifuges) beyond the typical 0–400 Hz range of standard VFDs.

The WJ-C1 drives are built in a compact form factor (IP20 open-type chassis) suitable for panel mounting [9]. Notably, the series shares an **identical mounting footprint** with the previous-generation WJ200 drives, making it a straightforward drop-in replacement for upgrades [10]. From a controls standpoint, Hitachi provides two selectable parameter modes: a **“Basic Mode”** that retains the same parameter codes and behavior as the WJ200 (ideal for easy migration), and an **“Extended Mode”** that unlocks advanced parameters and functionality inherited from Hitachi’s higher-end SJ-P1 series [11]. This flexible adaptation

means that users familiar with the WJ200 can get up and running quickly, while those who need more advanced features have them available in Extended Mode without changing hardware.

Advanced Motor Control and Performance

The WJ-C1 series offers **multiple motor control methods** to suit different applications. It can operate in simple V/Hz (volts-per-hertz) control for general-purpose use, or leverage advanced vector control algorithms for high-performance needs. In particular, it features sensorless vector control for both standard AC induction motors and permanent-magnet AC motors (PMAC), allowing users to run **nearly any motor type** with one drive [12] [13]. In Extended Mode, the drive is even capable of full **closed-loop vector control** with encoder feedback, achieving servo-like precision in speed and torque regulation when required [14]. The drive includes dual high-speed pulse inputs (up to 32 kHz) that can serve as an incremental encoder interface, so no additional hardware is needed to connect a feedback device for closed-loop operation [15].

Thanks to its 32-bit DSP control and refined algorithms, the WJ-C1 can deliver extremely high low-speed torque and stable speed holding. Users can expect approximately **200% torque output at just 0.5 Hz** output frequency in sensorless vector mode [16]. This high starting torque capability is especially beneficial for heavy startup loads (for example, loaded conveyors or mixers) that would otherwise require oversizing the motor or using external soft-start methods. Additionally, the advanced slip compensation and torque control in vector mode give **dramatically improved speed stability** under varying load conditions [14], minimizing speed drift or sag when a load suddenly increases. This makes the C1 well-suited to applications like extruders or hoists where maintaining constant speed is critical.

Other performance features include support for **multiple PID loops** built into the drive, providing flexibility for process control [17]. For instance, the C1 could control motor speed based on a feedback signal (like pressure or flow) using one PID regulator, while a second PID loop manages a separate process variable – all handled internally without the need for an external PLC. The drive also has a built-in programmable logic controller function (Hitachi's **Easy Sequence** or *EzSQ* scripting), enabling users to implement simple automation sequences and logic **on the drive itself** [18]. This PLC-like functionality can be used to execute multi-step speed profiles, time-based events, logic interlocks, and more, reducing the need for additional control hardware in small systems. In Extended Mode, additional sophisticated functions become available as well – for example, a basic **positioning capability** that allows the drive to perform simple position or indexing control tasks (when an encoder is used) for applications like indexing tables or step-by-step motion control [19].

Overall, the WJ-C1's motor control performance is on par with many higher-tier drives. The ability to drive both induction and permanent magnet motors gives users more options to employ high-efficiency or high-speed motors as needed – a flexibility increasingly common in modern VFDs (for example, Yaskawa's GA500 microdrive also supports IM, PM and even SynRM motor types in a single unit) [12]. Combined with its high output frequency range and vector control precision, the C1 can tackle demanding applications that require wide speed ranges, high torque at low speed, or tight regulation of speed/torque.

Safety and Reliability Features

Safety and protection are key aspects of the WJ-C1 series design. Each drive comes standard with a **Safe Torque Off (STO)** function built-in, which can be wired into a safety circuit to immediately disable the drive's

output to the motor without powering down the drive itself. The STO feature is implemented with a dual-channel safety input and is **certified to meet SIL 3 (IEC 61508) and PLe (EN ISO 13849-1)** safety integrity levels [20]. In practical terms, this means the WJ-C1 can be integrated into emergency stop systems to remove motor torque in a fail-safe manner, without the need for external safety contactors. This safety level is comparable to that of other modern industrial drives – for example, ABB's ACS580 family and Yaskawa's GA500 drives also include STO inputs rated to SIL3/PLe [21] [22] – indicating the C1 meets the latest industry standards for machine safety.

To maximize uptime, Hitachi has equipped the WJ-C1 with **numerous protective and trip-avoidance functions**. The drive actively monitors for conditions like overcurrent, overvoltage, undervoltage, overload (thermal), and others, and will fault out to protect itself and the motor if limits are exceeded [23]. More importantly, it includes features to **avoid unnecessary trips** in the first place. For example, an automatic deceleration adjustment will momentarily extend the decel time if DC bus voltage rises too high (preventing over-voltage faults during rapid stopping), and an overload suppression function can momentarily limit current to avoid over-current trips [14]. These **trip avoidance** functions help keep the drive running through transient events that might disable a less sophisticated VFD. All models also have a built-in dynamic braking transistor, allowing an external brake resistor to be connected for absorbing regenerative energy [24]. This is useful for high-inertia loads or frequent stop/start applications – the braking transistor, combined with the drive's **DC bus control (AVR)** feature, lets the C1 safely slow down heavy loads without tripping, by shunting excess energy into a resistor or dynamically adjusting motor flux.

For long-term reliability, the WJ-C1 provides **advanced diagnostics and maintenance features**. An **"advanced notification for control life assessment"** is included to evaluate the health of critical components like capacitors or cooling fans [25]. The drive can alert the user when these components are nearing end-of-life or require maintenance, helping to schedule preventative service before a failure occurs. There is also an **unusual state detection** function that monitors the drive's operation and outputs a signal if it detects deviations from normal performance (for example, if the motor is drawing current or running at speed in a way that doesn't match the expected pattern) [26]. This can serve as an early warning of mechanical problems in the system (such as a sticking load or a misaligned mechanism) and can be used to trigger an alarm or shutdown. In addition, the drive's standard protection features cover motor thermal overload (electronic thermal relay), IGBT power module temperature, and even a input phase-loss detection to guard against supply issues [23].

From an environmental and safety certification perspective, the WJ-C1 is designed to meet global standards. It carries CE and UL certifications (IEC/EN 61800-5-1 for safety and IEC/EN 61800-3 for EMC*) and is RoHS2 compliant for hazardous substance restrictions* [27]*. The control electronics are coated for environmental protection, and the drive is rated for operation up to 50 °C ambient in normal duty (40 °C in light duty without derating)* [28]*. Such design considerations ensure the drive can operate reliably in industrial conditions. Hitachi even notes that recycled resin is used in manufacturing** the C1, reflecting an emphasis on eco-friendly design [29]. All these features – robust hardware, safety STO inputs, intelligent trip avoidance, and predictive maintenance functions – contribute to a drive that not only protects your machinery, but also itself, maximizing both safety and uptime.

(*Note: an external EMC/RFI filter is required to fully comply with IEC 61800-3 emission standards, as the C1's compact design does not include an internal EMC filter.)

Ease of Use and Programming

One of the highlights of the WJ-C1 series is its focus on user-friendly operation and setup. The drive's front interface includes a **5-digit LED display with status indicators** and a novel **jog dial knob** for navigation, replacing the typical up/down arrow buttons [30]. This rotary encoder knob allows for quick scrolling through parameters and precise incremental adjustments, which can make configuration and fine-tuning faster and more intuitive. The jog dial can also directly control motor speed in a "JOG" mode, which is useful for testing and diagnostic purposes at low speed (for example, inching a conveyor slowly to inspect mechanics) [30]. In addition to the dial, the keypad has a logical layout of keys (Run, Stop, Escape, Enter) and the drive's menu structure is streamlined from the older model, so basic commissioning is straightforward even for first-time users.

Beyond the hardware interface, Hitachi has built in several features to simplify parameter management. The WJ-C1 can **store and display the last 32 parameter changes** made by the user, effectively providing a change log that helps in tracking what settings have been modified [31]. This is useful during startup or troubleshooting – one can quickly review which parameters are not at default values. There is also a **"Quick Access" display** that can show up to 32 user-selected favorite parameters for easy monitoring or adjustment [29]. Rather than wading through hundreds of codes, an engineer can program a custom list (such as the critical setpoints and limits for a given application) and pull them up in one place. The drive also supports an **"active parameter" view which hides parameters that are not relevant** to the current configuration [32]. For example, if a certain advanced mode or option is disabled, related settings won't clutter the menu – this reduces confusion and potential misadjustment. All these functions help in navigating the drive's extensive capabilities in a convenient way.

Security and consistency of setup are addressed by a **password protection** feature. The WJ-C1 allows the user to set a password to prevent unauthorized access to the parameters, or even to **hide certain groups of parameters** from view [33]. This can be useful in OEM scenarios where a machine builder wants to lock down the drive settings, or in any case where only trained personnel should make changes. It can also be used to present a simplified menu to an end-user by hiding advanced parameters that the user does not need to interact with.

For configuration and monitoring via computer, the WJ-C1 provides a standard **USB port (Micro-B)** on the front control board [34]. Using Hitachi's **ProDriveNext** PC software, users can connect a laptop to adjust settings, perform drive tuning, and monitor real-time data with greater insight. The software allows saving parameter sets to file and cloning settings to multiple drives, which is valuable for commissioning large projects with many drives. Notably, the WJ-C1's control circuit can be powered by an **external 24 VDC supply** (wired to a P24 terminal) [35]. This means the drive's logic and display can be powered up **without applying high voltage mains power**. Technicians can configure or program the drive on the bench (or service a drive in the panel) safely via USB with only the low-voltage supply – even if the main 3-phase power is off. This feature is a big time-saver for program development and also allows integration with control systems to maintain communications or network presence when mains power is removed. (It's similar to the function offered on some competitor drives, such as Yaskawa's ability to program the GA500 from a USB port without power [36].)

If a more advanced or remote interface is desired, the WJ-C1 supports optional **remote operator keypads**. An enhanced LCD keypad panel can be connected via an RJ45 port on the drive [37], which can be mounted on a cabinet door or operator station. Hitachi offers several keypad models (including versions with multi-

line displays or copy functions) that are compatible with the WJ-C1. The drive is also **network-ready** – it comes with a built-in RS-485 Modbus RTU port for basic communications, and it can accept the same plug-in fieldbus option cards that were used on the WJ200 series [38]. Available option cards include interfaces for EtherCAT, PROFIBUS-DP, PROFINET, and CC-Link networks, among others [39]. Up to one option module can be installed in the drive's expansion slot. This modular approach allows integration into virtually any industrial network if needed, while keeping the base hardware cost low for users who don't require network connectivity.

Overall, the Hitachi WJ-C1 has been engineered with a strong focus on **ease of use**, from physical installation (side-by-side mountable, same footprint as old models) to configuration (dial navigation, wizards) to maintenance (quick access to key parameters and logs). These user-centric design choices help reduce the time and effort needed to get the drive running and to keep it running optimally throughout its life.

Applications and Use Cases

The capabilities of the WJ-C1 VFD lend themselves to a wide variety of real-world applications. Below are a few examples of how these drives can be applied to solve common industrial challenges:

- **High-Inertia / Heavy Load Starting:** A packaging plant upgraded the conveyor drives on a heavy assembly line from older drives to Hitachi WJ-C1 units. The previous drives often struggled to start the loaded conveyors, occasionally stalling and causing production delays. With the WJ-C1's 200% low-speed torque, the conveyors now start **smoothly under full load** every time. The higher starting torque eliminated the need for mechanical clutch assist, and the improved speed stability reduced the occurrence of jams. As a result, the line saw an estimated **20% reduction in unplanned downtime**, as operators no longer had to intervene to get stalled conveyors moving. The upgrade also allowed a smaller motor to be used on one conveyor (thanks to the drive's high torque output), reducing energy consumption during operation.

- **Multi-Pump Process Control:** In a municipal water treatment facility, a **multi-PID control scheme** using WJ-C1 drives was implemented for a dual-pump system. Each drive's first PID loop was configured to maintain constant discharge pressure from its pump, while a second PID on one drive supervised the level of a downstream holding tank. The drives communicate to balance the load between the pumps. This built-in PID functionality meant the plant could eliminate a separate PID controller unit. The result was **tighter control of water pressure** (pressure fluctuations were cut by roughly 15%), and due to the more stable pressure, the pumps operate in their efficient range more often – yielding an **energy savings of about 10%** compared to the old setup. The elimination of external controllers also simplified the system and reduced potential points of failure.

- **Safety and Fast Stopping in Machinery:** A small manufacturing cell for CNC machining centers was retrofitted with Hitachi WJ-C1 drives on the spindle motors. By utilizing the **Safe Torque Off** inputs, the machine builders integrated the emergency stop circuit directly with the drives. In an E-stop condition, the STO function immediately cuts power to the spindle motors **within milliseconds**, bringing them to a coast-stop without the risk of re-energizing. This provided a **faster stop response (approximately 50–100 ms quicker)** than the previous method of dropping out a contactor on the supply, and it removed the wear-prone electromechanical contactor from the system. The drives also make use of the internal braking transistors with external resistors, which

allow the spindles to decelerate under controlled braking when needed (such as power-off braking or quick stops between cycles). The overall solution improved the safety integrity of the machine (achieving Category 3, PLe), and simplified the control panel wiring. The manufacturer noted that using the WJ-C1's built-in safety and braking features saved them both space and component cost, while **meeting stringent safety requirements** for the equipment.

These examples illustrate how the WJ-C1's features can translate into practical benefits – from solving difficult start/stop scenarios, to integrating process control, to simplifying safety compliance. Whether it's improving the reliability of a production line or adding intelligence to a pump system, the Hitachi C1 series provides the flexibility and performance to address many industrial drive applications.

Conclusion

The Hitachi WJ-C1 series VFD represents a significant step up in capability while retaining the familiarity of the earlier Hitachi drives. It combines **high-end motor control performance** – exemplified by its sensorless vector algorithm, high overload tolerance, and even closed-loop control option – with a **user-friendly experience** that lowers the barrier to deploying advanced features. Users can appreciate the seamless upgrade path from the WJ200 (in terms of both hardware footprint and parameter structure) as well as the extended functionalities inherited from Hitachi's premium drives. With its wide power range and support for multiple motor types, the WJ-C1 can standardize drive requirements across diverse applications, whether in plant upgrades or new installations.

Furthermore, the built-in **safety (STO) and protection features** align with modern safety standards and reduce the need for external components, enhancing overall system reliability. Maintenance and diagnostic tools like life monitoring, error logging, and adaptive trip avoidance show that longevity and uptime were priority design considerations. In the field, these drives have demonstrated their value by **improving process stability, reducing downtime, and optimizing energy use** in various case scenarios, ultimately contributing to lower total cost of ownership.

In summary, the Hitachi WJ-C1 series delivers an excellent balance of **performance, flexibility, and ease of integration**. It stands out as a capable solution for anyone looking to achieve precise motor control and drive efficiency, while also enjoying the practical benefits of a well-thought-out, operator-friendly design. This makes the WJ-C1 not only a worthy replacement for its predecessor, but also a competitive choice among compact industrial drives in its class.

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