ABB ACS355 Variable Frequency Drives: Comprehensive Technical Overview

Overview of ABB ACS355 Machinery Drives

The **ABB ACS355** is a series of compact low-voltage **variable frequency drives (VFDs)** designed for controlling AC motors in machinery applications. Part of ABB's general machinery drive portfolio, the ACS355 represents the **"micro-drive" range** – combining a small form factor with high performance and intelligence [1] [2]. It covers motor power ratings from **0.37 kW up to 22 kW (0.5 to 30 hp)** in a single unified product family [3]. These drives are targeted at system integrators, OEM machine builders, and panel builders who need a cost-effective yet **feature-rich motor control solution**. By choosing the ACS355, users get not only the advanced capabilities built into the drive, but also the backing of ABB's global support network and services for industrial drives [4].

In terms of **applications**, the ACS355 is extremely versatile. It is suitable for an extensive range of machinery and industrial equipment. Typical use cases include **food and beverage processing, material handling systems, lifting equipment, textiles, printing, rubber and plastics machinery, and woodworking machines** [5]. The drive's robust design and broad feature set make it adaptable to many other sectors as well, from simple pumps and fans to more demanding uses like conveyors, mixers, and packaging lines. In all these environments, the ACS355 aims to improve process control, enhance efficiency, and ensure safe, reliable operation of motors.

Key Features and Highlights

The ABB ACS355 comes with a rich set of features that help it stand out in the micro-drive class. Some of the **key features and their benefits** include:

- **Wide Power Range & Compact Design:** The ACS355 covers one of the broadest power ranges in its class (0.37–22 kW) within a **uniform, space-saving design** [6]. All frame sizes share the same height and depth, simplifying panel layout when installing multiple drives side by side. With a power density of about *2.8 kW per dm³* (one of the highest in its category), it saves valuable cabinet space in tight installations [7]. This means machine builders can standardize on one drive family for various motor sizes, reducing engineering effort and inventory [8] [9].

- **Quick Commissioning with Macros and Assistants:** The drive is designed to be **fast to install and set up**, minimizing engineering hours [10]. It provides **application macros** – pre-defined parameter sets for common configurations (such as 2-wire/3-wire start/stop, PID control, motor potentiometer, etc.) – that can be selected to automatically configure I/O and control logic for typical scenarios [11]. In addition, an optional **assistant control panel** with a multilingual text display guides users through setup with built-in wizards for tasks like startup, motor tuning, and PID loop tuning [12].

These features greatly accelerate commissioning and reduce the learning curve for users, enabling quick **"out-of-the-box"** operation of the drive.

- **Advanced Motor Control (Vector Control):** Despite its compact size, the ACS355 offers **sensorless vector control** for both standard induction motors and permanent magnet (PM) synchronous motors [13] [14]. This means it can provide precise speed and torque control without requiring a feedback encoder. In practice, users get **accurate motor performance** (fast dynamic response and tight speed regulation) even in open-loop mode. The drive can run motors up to very high speeds – **output frequency up to 599 Hz** in standard configuration [15] – which is useful for high-speed spindles and centrifuges. ABB also offers a high-speed variant of the ACS355 for specialized applications, capable of output frequencies above 600 Hz (suitable for spindle motors running tens of thousands of RPM). The ACS355's software includes a *patented smooth start function for permanent magnet motors* to ensure reliable, jerk-free startup of PM motors [14]. By supporting PM motor control, the ACS355 enables use of newer high-efficiency motors (IE4/IE5 permanent magnet designs), helping increase system efficiency and performance.

- **Safe Torque Off (STO) Safety Function:** Every ACS355 drive comes with an integrated **Safe Torque Off (STO)** functionality rated to **SIL3 (Safety Integrity Level 3, PLe)** as per international safety standards [16] [17]. The STO feature, when activated (typically by a safety circuit), immediately removes torque output from the drive without fully powering it down. This prevents an unexpected startup and allows safe maintenance or emergency stops without the need for external contactors in the motor power circuit [18]. The ACS355's STO is certified to standards like **IEC 61508, EN ISO 13849-1, and EN 62061**, helping machine builders meet the stringent requirements of the EU Machinery Directive 2006/42/EC for functional safety [19] [20]. In practical terms, built-in STO reduces the need for additional external safety relays or hardware, simplifying system design and increasing reliability of the safety function.

- **Built-in Braking Chopper:** The drive includes an internal **brake chopper transistor** on all models as a standard feature [21]. This allows easy connection of an external braking resistor for applications that require rapid deceleration or have regenerative loads (e.g. lowering hoists or quick stops of high-inertia machines). With the braking chopper built-in, the ACS355 can safely dissipate regenerative energy and **brake motors faster**, without needing an add-on module. This not only saves cost and panel space, but also improves stopping precision for machinery.

- **Harsh Environment Protection (IP66/67/69K):** In addition to the standard IP20 (open/chassis) models for enclosure mounting, ABB offers **fully enclosed variants of the ACS355 with IP66/67 and UL Type 4X ratings** [22] [23]. These ruggedized versions are dust-tight, washdown-capable drives suitable for harsh environments and outdoor or high-cleanliness applications. They carry an **IP69K** rating as well, meaning they withstand high-pressure, high-temperature washdown – ideal for food & beverage processing or any setting requiring strict hygiene. Notably, the IP66/67 units are **NSF certified** for food zone use [24], indicating they meet sanitation standards. Using an IP66/4X drive can eliminate the need to put the VFD in a separate enclosure, saving cost and simplifying design for equipment that must operate in wet, dusty, or corrosive environments.

- **Special Application Variants:** ABB has developed firmware variants to optimize the ACS355 for particular applications. For example, a **solar pump drive variant** is available to interface with photovoltaic (PV) power sources for pumping water. This *solar pump version* includes dedicated pump

control features (such as dry-run protection and maximum power point tracking for PV) to reliably run pumps directly from solar panels [25]. Another variant is tailored for **high-speed spindle applications**, as mentioned above, providing enhanced speed controller tuning without an encoder and allowing up to six user-defined parameter sets for quick switching between different operating modes or tool profiles [26]. These specialized versions broaden the range of problems the ACS355 can solve – from agriculture (solar-powered irrigation) to machine tool spindles – while leveraging the same hardware platform.

Overall, the ACS355's feature set is engineered to offer **maximum functionality in a minimal footprint**. Its combination of **compact size, fast setup, advanced control, safety, and flexibility** makes it a top-tier choice among micro drives for industrial and commercial motor control tasks [2] [27].

Technical Specifications

Below are some **technical specifications** and ratings for the ABB ACS355 VFD series:

- **Power and Voltage Range:** Supports both low-voltage single-phase and three-phase input supplies. Available in two main voltage classes – **200–240 V AC** and **380–480 V AC** [28] [29].
- For 200–240 V: Models exist for **single-phase input** (200–240 V 1Ø) up to ~2.2 kW, and **three-phase input** (200–240 V 3Ø) up to 11 kW.
- For 380–480 V: Three-phase input models cover **0.37 kW up to 22 kW output** (approximately 0.5 to 30 hp) [30] [31]. This wide range allows one drive family to handle small fractional horsepower motors through to larger 30 hp motors.

- **Output Current and Overload Capacity:** Each model is rated for a certain continuous output current corresponding to its power rating. The ACS355 drives are designed with a **150% overload capacity for 1 minute** (within a 10-minute cycle) by default [32] [33]. In other words, they support **150% of rated current for 60 seconds** to handle short-term high torque demands (e.g. during motor start or peak load). For very brief load spikes, the drives can typically deliver even higher current (around 200% for 2 seconds) without tripping. This **heavy-duty overload capability** makes the ACS355 suitable for high starting torque applications and for driving high-inertia loads that require a short burst of extra power.

- **Control Modes:** The ACS355 can operate in **scalar V/Hz control mode** or advanced **vector control mode**. Scalar (volts-per-hertz) mode is useful for simple applications or multiple motor control, while sensorless vector control provides **high dynamic performance** and torque at low speeds for single motors. For vector control, the drive performs an auto-tune (motor identification) routine to the connected motor – either with the motor at standstill or spinning – to optimize parameters [34] [35]. The drive's vector algorithm includes **slip compensation** and load torque estimation to maintain accurate speed under varying loads. Notably, the ACS355's vector control supports both asynchronous (induction) motors and **permanent magnet synchronous motors** in open loop [14]. This is an uncommon capability in its class, enabling the drive to run **brushless AC motors** (BLPM motors) without encoder feedback. For applications requiring closed-loop precision, an optional feedback module can be used to connect an encoder, allowing **full closed-loop vector control** for even tighter speed/torque regulation [34].

- **Speed Range:** In standard configuration, the drive provides an output frequency from **0 Hz up to 599 Hz** [15]. This corresponds to roughly a **120:1 speed range** for a 50 Hz base motor (or 10:1 in open-loop vector with full torque down to 1/120 of base speed in scalar mode). The high maximum frequency enables the ACS355 to drive **high-speed motors** such as spindles, centrifugal blowers, or grinders. For instance, 599 Hz on a 4-pole motor equates to about 18,000 RPM. As mentioned, there is a special high-speed variant that can go even further (allowing frequencies up to ~1,400 Hz in scalar mode, or around 320 Hz in vector mode for ~30,000 RPM on a 4-pole motor). This wide speed range provides great flexibility in matching motor speeds to process requirements.

- **PWM Switching and Noise:** The ACS355 uses a **pulse-width modulated (PWM)** inverter with an adjustable switching frequency (typically ranging from 4 kHz up to 16 kHz). The drive features **"drive temperature controlled switching frequency"** — it can automatically lower the switching frequency at higher internal temperatures to protect power devices [36]. This ensures reliability in warm conditions while still allowing higher switching frequencies (which reduce motor noise) when thermal headroom permits. Additionally, the drive includes a **motor noise smoothing** feature [37] that can randomize the switching pattern to avoid resonant acoustic noise in the motor, resulting in quieter operation.

- **Efficiency and Power Factor:** The drive itself is highly efficient (typically **95–97% efficient** at full load, depending on switching frequency and power rating). It has an active front end rectifier design with built-in DC choke on some models, achieving a high input power factor (usually >0.98 at full load). For improved energy efficiency during operation, the ACS355 offers a **Flux Optimization** mode [36]. This feature automatically reduces the motor's magnetization (excitation current) when full torque is not needed, thereby **lowering energy consumption at partial loads**. Flux optimization can significantly cut losses when a motor is running at less than full load or speed, translating to energy savings and cooler motor operation.

- **Built-in EMC Filtering:** Most ACS355 models include an **integrated EMC filter** to meet emission standards. The standard "E" variants come with an internal **EMI/RFI filter** connected (suitable for 1st environment, Class C2 in IEC/EN 61800-3), while "U" variants have it disconnected for 2nd environment or if an external filter is to be used [38] [39]. The filter can be enabled or disabled as needed. With the built-in filter, the drive meets CE requirements for **EMC** in industrial applications, minimizing electrical interference on the mains and in nearby equipment. If longer motor cable lengths are required or stricter EMC compliance is needed, ABB offers external AC line chokes and additional RFI filters as accessories [40].

- **Environmental Ratings:** Standard ACS355 units are IP20 (open type) for installation inside control cabinets. They are designed for ambient temperatures up to around **40 °C without derating**; with derating (or using a cooling fan), they can operate in environments up to ~50 °C (and 55 °C for short durations) [41]. The drives include internal cooling fans and require air circulation clearances as specified in the manual. For altitude above 1000 m, derating of output current is typically required (per ABB's guidelines). The optional IP66/67 models, as discussed, are sealed for harsher conditions and come in a **NEMA 4X enclosure** suitable for outdoor use (protected against rain, hose-directed water, and corrosion). These enclosed versions can handle ambient humidity and dust, and are **coated (conformal coating on electronics)** for protection against contaminants, contributing to a robust design with long field life.

- **Protection and Fault Handling:** The ACS355 has comprehensive built-in protection functions for both the drive and the motor. It monitors for conditions such as **over-current, short-circuit, ground fault, DC bus over-voltage, under-voltage, and overtemperature** and will trip to prevent damage if limits are exceeded. The drive includes an electronic **motor overload protection** (thermal model) that tracks motor heating and simulates an **I^2t curve**, preventing motor overheating (this negates the need for separate thermal overload relays in many cases). It also features **stall protection** and **acceleration monitoring** – if the motor is not responding (e.g. jammed load), the drive can stop and fault out to avoid equipment strain. For power loss situations, an **automatic restart** function can be enabled: the drive will attempt to re-start the motor after a fault or power dip once conditions stabilize [42] [43]. Additionally, the ACS355 firmware supports **configurable fault responses** (coast, ramp, or maintain last speed) and can trigger external fault signals through its outputs. The **Safe Torque Off** function, as noted earlier, is a safety protection that can be used for emergency stopping without physical contactors [18]. Overall, these protections enhance the reliability of the system and safeguard both personnel and equipment.

- **Standards and Certifications:** The ACS355 carries the necessary certifications for global markets. It is UL listed (and cUL for Canada), and CE marked for the EU. It conforms to IEC/EN 61800-5-1 (drive safety requirements) and IEC/EN 61800-3 (EMC requirements for power drive systems). The STO function meets **ISO 13849-1 PL e / Cat. 3** and **IEC 62061 SIL 3** capability [19]. The IP66 models have **NSF** and **UL Type 4X** certifications for sanitary and outdoor use [23]. These credentials assure users that the drive can be implemented in regulated industries and is built to recognized safety and performance standards.

Motor Control and Performance

One of the standout aspects of the ABB ACS355 is its sophisticated **motor control algorithms** packed into a small drive. It delivers performance features typically found in larger, high-end drives:

- **Sensorless Vector Control:** As mentioned, the ACS355 uses sensorless vector control to achieve **high torque and precise speed regulation** without an encoder. In vector mode, the drive actively calculates motor slip and torque producing current, allowing it to maintain near full torque even at low speeds. For example, it can provide around **200% torque at start** for heavy breakaway loads (depending on motor and tuning) and maintain smooth control down to a few Hz or even zero speed with only slight torque ripple. This is particularly useful in applications like cranes or hoists (lifting), conveyors with varying loads, or machines that need tight speed holding. Users have the flexibility to configure **torque limits, speed limits, current limits, and frequency limits** to protect the mechanics and process [44]. The result is **accurate motor behavior**: the drive can quickly respond to load changes, accelerate or decelerate on command, and settle at the target speed with minimal overshoot.

- **Permanent Magnet Motor Control:** Unlike many drives in its class, the ACS355 can control **permanent magnet AC motors (PMAC)** in open-loop (also called BLDC or synchronous motors). This includes both surface permanent magnet and interior permanent magnet motors. The drive performs an **ID run (identification run)** to establish motor parameters, after which it can start and run the PM motor sensorlessly [45]. ABB incorporated a **patented "Smooth Start" function for PM motors** [14], which aligns the rotor gently at startup to avoid the sudden jerks or high current spikes that can occur when starting sensorless PM machines. This capability opens up use of **high-**

efficiency IE4/IE5 motors and **compact high power-density motors** with the ACS355, providing energy savings and performance benefits. For example, a user could pair an ACS355 with an efficient permanent magnet gearless conveyor motor, achieving improved energy efficiency while still controlling speed and torque precisely. The ability to run PM motors without feedback also reduces system cost (no encoder or servo drive needed) for moderate performance applications.

- **High-Speed Operation:** The ACS355 is well-suited to **high-speed applications** such as machine tool spindles, centrifuges, or specialized fans/compressors. In standard form it supports up to 599 Hz output, and with the high-speed firmware variant, it can drive motors at even higher frequencies (well into the kHz range in V/Hz mode). ABB notes that in the high-speed version, the drive can run 2-pole motors up to ~ **60,000 RPM** in scalar mode (or about 18,000–30,000 RPM in vector mode for 4-pole motors) [26]. To handle these scenarios, the drive's **speed controller can be auto-tuned** for different load inertias and tool dynamics, even without an encoder, ensuring stable operation throughout the speed range. This is critical in applications like precision grinding or routing, where maintaining consistent spindle speed under changing load is important for quality. The ACS355's ability to control high frequencies also implies it can generate the required voltage at those frequencies (within its voltage class), meaning it can drive special **high-speed motors or spindles directly** without needing a step-up gearbox or specialty drive.

- **Precision Stopping and Positioning:** For machinery that requires accurate positioning or stopping at a certain point, the ACS355 includes a feature called **"Speed Compensated Stop."** This function allows the drive to decelerate and stop the motor with high repeatability, independent of the initial speed or load inertia [46] [47]. Essentially, the drive dynamically adjusts the deceleration profile to ensure the motor comes to rest exactly at the intended position or in the desired time, even if conditions vary. This is very useful in applications like indexing conveyors, packaging machines, or material handling systems where products must stop at exactly the right spot. By using speed-compensated stop, **production flow is improved** and external sensors or braking mechanisms might be unnecessary for achieving the required accuracy [47].

- **Embedded Functionalities:** The ACS355's firmware provides a suite of embedded functions that often eliminate the need for external controllers or circuitry. For example, it has an **internal pulse counter and timer** that can be used for simple process automation. In a packaging line, one could use the drive's built-in counter to count products via a sensor input and automatically stop the motor after a set count is reached (e.g. package 20 items then stop) [48] [49]. The counter can accept high-frequency pulses (up to 10 kHz on a digital input) and be configured with preset limits and reset conditions [50] [51]. Similarly, a **timer function** can trigger actions after a time delay – useful for sequences or dwell times. The drive also provides **mechanical brake control** logic (to coordinate with a motor's electro-magnetic brake, often used in hoists or cranes) and can manage a **"safe stop" emergency ramp** when the Safe Torque Off is activated. Other control features include **flying start (catch a spinning motor)** for smooth restarts of windmilling fans, **flux braking** which dynamically injects flux to slow down the motor quicker without a resistor [36], and the ability to avoid certain speeds (skip frequencies) to bypass mechanical resonances. Many of these functions are configurable via parameters – giving the user a toolbox to fine-tune performance for the application at hand [42] [52].

- **Auto-Tuning and Adaptation:** Commissioning tools in the ACS355 help achieve optimal performance easily. The drive's **auto-tune (ID Run)** measures the motor's characteristics (stator

resistance, inductance, etc.) to set up the vector control automatically. It supports a **standstill auto-tune** (for when the motor cannot be decoupled from the load) as well as a **rotational auto-tune** (where the motor is briefly spun for more precise identification) [34] [53]. In vector mode, the ACS355 also offers an **automatic speed regulator tuning** – essentially a one-parameter tuning of the PI controller based on the moment of inertia and damping in the system, which simplifies achieving stable yet responsive speed control. Additionally, the drive can perform a **"flying start"** to catch and match the speed of a coasting motor and smoothly bring it under control (preventing trip faults on start if the motor was already moving). For multi-motor or multi-speed systems, it allows **up to 7 preset speeds and 2 separate acceleration/deceleration ramp sets** that can be selected on the fly via digital inputs [43] [54]. This flexibility means one drive can easily switch between different speed profiles or duties (for example, a machine might have slow, medium, fast speeds selectable, or a conveyor might use a different ramp time when stopping vs starting). All these capabilities ensure that the ACS355 can be **fine-tuned to deliver smooth, efficient motor performance** tailored to the application's needs.

In summary, the ACS355 provides **high-performance motor control** in a micro-drive package. It brings many of the advantages of larger drives – high torque at low speed, multiple control modes, adaptive algorithms – into the realm of small motors. Whether running a standard induction motor or an advanced permanent-magnet motor, the ACS355 gives reliable and agile control, which translates to better machine productivity and product quality.

Ease of Use and Programming

ABB has placed strong emphasis on **user-friendliness and programming flexibility** in the ACS355. This drive is built to simplify the life of both installers and automation engineers:

- **Intuitive Keypad Control:** The ACS355 can be operated and programmed via an attached control panel (keypad). A **basic control panel** with a numeric LED display comes standard on many models, allowing direct access to parameters and local control of start/stop, speed, etc. Additionally, ABB offers an **Assistant Control Panel** with a multi-line alphanumeric display and context-sensitive help messages [12]. This advanced keypad provides menus and built-in assistants (wizards) that guide the user through common setups – for example, a Start-up Assistant for basic drive and motor parameters, a PID Setup Assistant for configuring pump/fan control loops, and a Diagnostics Assistant for fault tracing. The panel supports multiple languages and includes a **built-in help** function that explains parameter meanings, which lowers the need to constantly consult the manual. Parameters are organized into logical groups (e.g. group 99 for quick setup, group 10 for startup, group 20 for ramps, group 30 for protections, etc.), making navigation straightforward. For OEMs or maintenance, the panel also allows **copying parameters**: you can upload the configuration from one drive and download it to others, simplifying the deployment of identical setups across many drives.

- **Application Macros:** As introduced earlier, the ACS355 features **pre-programmed application macros** that configure the drive I/O and control for specific common scenarios. Examples include: **2-wire/3-wire control macros** (for different start/stop circuit arrangements), a **PID Control macro** (to use the drive's internal PID regulator for process control like in pumping), a **Motor Potentiometer macro** (where the drive's digital inputs mimic an "up/down" button speed control), **Hand/Auto** and **Jogging macros**, etc. [55] [56]. When a macro is selected, the relevant digital/analog inputs are

automatically assigned to certain functions and the drive's control logic is set accordingly – this can save a lot of time in setup. For instance, if you choose the PID macro, the drive will use one analog input as a feedback (from a sensor) and regulate motor speed to maintain a setpoint, without needing an external PID controller. The macros can be further tweaked by the user, but they provide a **quick starting point that covers ~90% of typical use cases**.

- **Sequence Programming:** A powerful feature of the ACS355 is its ability to perform simple automation sequences internally. The drive supports **Sequence Programming with up to 8 programmable states (steps)** [57] [58]. This is essentially a mini-PLC capability: the user can create a sequence of operations (each state can run the motor at a certain speed/direction, wait for a condition or time, activate outputs, etc.) and the drive will execute this state machine on its own. Transitions between states can be triggered by events like a digital input change, a timer completion, or a counter reaching a value. For example, you could program a sequence for an indexing table: accelerate to a certain speed, run for a specific angle (using the counter), then decelerate and stop, wait for an external signal (like a process done), and repeat. Up to 8 states can be defined in one sequence program, and the program is created using drive parameters (no external software required). This feature can **eliminate the need for an external PLC** in simple machines, thereby cutting costs and hardware complexity [57] [59]. Many machine builders use it for tasks like simple positioning, cyclic operations, or interlocking multiple drives. ABB provides documentation and examples of sequence programs to help users implement this. The key benefit is **embedded intelligence** – the drive isn't just a motor controller, but also can make basic decisions and control flows on its own.

- **FlashDrop Tool for Parameter Configuration:** For high-volume machine builders or situations where quick drive setup is needed without power, ABB offers the **FlashDrop tool (MFDT-01)** [60]. FlashDrop is a handheld programming device that can **upload/download parameter sets into the drive in seconds, without powering up the drive**. There is a dedicated FlashDrop port on the ACS355; by simply plugging the tool into a powered-down drive, you can transfer a pre-defined configuration file. This is extremely useful in production environments – for example, an OEM can program dozens of drives on a production line rapidly with an identical setup. One FlashDrop device can store multiple parameter files (up to 20 parameter sets can be saved and selected) and it comes with PC software ("DrivePM") to manage these configurations [61] [62]. The tool also allows "hiding" of selected parameters to simplify the menu for end-users. Overall, **FlashDrop provides fast and error-free commissioning** for large batches of drives and does not require specialist knowledge to operate [60]. This contributes to the ACS355's appeal in OEM scenarios – you can ship drives pre-configured for your machine with minimal effort.

- **PC Software and Connectivity:** In addition to keypad programming, the ACS355 can be connected to a PC for more detailed configuration and monitoring. ABB's older tool **DriveWindow Light** and the newer **DriveComposer/Automation Builder** environment support the ACS355 [63]. Using PC software, users can access all parameters on one screen, set up monitoring graphs for signals (like speed, current, torque), and backup/restore configurations to files. ABB also provides function block libraries for integration with their PLCs (AC500 series) and support for **IEC 61131-3 programming** to control drives via PLC programs [64]. For example, premade function blocks can implement things like explicit speed or torque control, or reading diagnostic data from the drive, simplifying integration into automation systems. While the ACS355 is not an Ethernet-native drive, with the appropriate fieldbus module (discussed below) it can even be commissioned and monitored over a

network. **Firmware updates** (if ever needed) are usually done via the PC tools or by ABB service, but for the most part the drive's embedded software is fixed and robust out-of-the-box.

- **User I/O Configuration:** The ACS355's **inputs and outputs are fully programmable**, giving a lot of flexibility in interfacing with external control logic. Using parameter settings, each digital input can be assigned to various functions (start/stop, forward/reverse, jog, preset speed select, external interlock, etc.), analog inputs can be scaled and assigned (e.g. speed reference, PID feedback), and outputs can be set to indicate drive status or errors. The drive comes with **several preset I/O macros** as mentioned, but those can be manually overridden if a custom configuration is needed. This adaptability means the drive can fit into many control schemes without external relay logic. For instance, one digital output could be configured to activate when the motor at target speed, which might interlock another device in the system. Or an analog output could be set to represent motor torque and feed into an analog meter or PLC analog input for monitoring. The ACS355 essentially provides a small **I/O hub** near the motor, reducing wiring back to PLCs for certain signals and enabling decentralized decision-making via the drive's logic.

In summary, ABB designed the ACS355 to be *easy to deploy and program*, whether you are setting up one drive or a hundred. The combination of a friendly keypad interface, out-of-the-box macros, advanced programming tools like sequence control and FlashDrop, and PC connectivity gives users **multiple ways to quickly tailor the drive to their needs**. This reduces commissioning time and costs and allows even complex control tasks to be accomplished with minimal extra hardware. The learning curve for basic operation is shallow – as one integrator noted, *"ABB drives are known for easy setup and commissioning… even with complex applications"* [65] [66]. The ACS355 upholds that reputation by making sophisticated functionality accessible and convenient.

I/O and Communication Capabilities

The ACS355 is equipped with a flexible set of **input/output (I/O) interfaces and communication options** to integrate with industrial control systems:

- **Digital Inputs:** The drive provides **5 digital inputs** (logic level 12–24 VDC) which are user-programmable. These inputs can be wired to switches, sensors, or PLC outputs to control the drive. By default, they cover functions like Start/Stop, Direction, and Preset Speed selection, but each input can be reassigned to various functions as needed. One of the digital inputs can be configured as a **high-speed pulse input (up to 10 kHz)** [50] [67]. This is useful for connecting an external incremental encoder or a flow meter, for instance, to serve as a feedback source for the drive's internal counter or speed measurement. The high-speed input enables the drive to do simple positioning or speed following tasks by counting pulses. For example, DI5 could be fed by an encoder to count revolutions or act as a frequency input for synchronization purposes. The flexibility of 5 DIs with configurable logic (active high/low, filter enable, etc.) allows interfacing to a variety of external control schemes.

- **Analog Inputs:** The ACS355 includes **2 analog inputs**. Each analog input can be independently configured for either **voltage (0 to +10 V, or -10 V to +10 V bipolar)** or **current (0 or 4–20 mA)** signals [55] [68]. This accommodates a wide range of analog sensors and reference signals. Typically, one analog input (AI1) might be used for the main speed reference (e.g. a 0-10 V control knob or a 4-20 mA command from a PLC analog output), while the second analog input (AI2) could be used for feedback in PID control (receiving a signal from a transducer like pressure, flow, etc.). The analog

inputs are **scalable** via parameters – you can set custom scaling and bias (for example, 4 mA = 0% speed, 20 mA = 100% speed) [69] [70]. The drive's configuration allows enabling built-in filtering on analog inputs to smooth out noise if needed. Thanks to these analog inputs, the ACS355 can easily interface with analog control systems or sensors, enabling **closed-loop control** or remote speed setting without additional converters.

- **Analog Output:** There is **1 analog output** provided (configurable for 0–20 mA or 4–20 mA). This output can be programmed to represent various real-time values from the drive, such as motor speed, motor torque, motor current, output frequency, DC bus voltage, or even drive temperature [71] [72]. For example, the analog output could be wired to an external meter to display motor speed, or to a building management system to monitor drive power. It could also serve as a feedback to a PLC analog input if the PLC needs to monitor a drive parameter continuously. The analog output is scalable as well, so it can be calibrated to match the range expected by the receiving device. This feature effectively makes the drive a sensor for mechanical variables – a way to **transmit live motor data** to other systems. If not used for analog signaling, this output can alternatively function as a digital output (on/off) to indicate a status by saturating at max or min current, although in practice the ACS355 also has a dedicated digital output for that purpose (see next).

- **Digital Output / Relay:** The ACS355 comes with **1 digital output** (an open-collector transistor type) and **1 relay output** (Form C relay). The transistor digital output can be used to drive an external relay, indicator light, or PLC input (max 24 V, a few hundred mA). It can be configured to activate under certain conditions – for instance, it could be set as a **"Drive Running" indicator,** or **"Fault Alarm"** output, or to indicate **"At Reference Speed"** or other statuses. The **programmable relay output** provides an isolated switching contact (usually rated around 2 A at 250 VAC or 30 VDC). Like the transistor output, the relay can be assigned to numerous drive events or warnings. Common uses would be wiring the relay to an external fault alarm buzzer or to break power to a feeder when the drive faults. By having both a transistor output and a relay, the drive can interface with both electronic systems and higher-power or AC circuits for signaling. According to one vendor's listing, the ACS355's outputs are described as "**2 programmable outputs: 1 analog/digital & 1 relay**," indicating the analog output can double as a digital if needed and the relay as a second digital output for flexibility [73] [74]. In practice, between the open collector and the relay, the user has two independent signaling outputs to work with.

- **Safe Torque Off Inputs:** For the Safe Torque Off safety function, the ACS355 has dedicated safety input terminals (often two channels that must both be opened to trigger STO). These inputs are to be wired to an external safety device or relay (such as an E-stop button or safety PLC output). When the STO inputs are activated (opened), the drive immediately disables its output to the motor (taking torque to zero) in a fail-safe manner. The STO circuit is internally redundant and monitored to meet SIL3/PLe requirements [75]. The presence of STO inputs means the drive can be integrated into a machine's emergency stop safety loop without additional power contactors, as discussed earlier. It's a direct interface for functional safety, ensuring that even if the main control system fails, removing the STO signal will reliably cut power to the motor.

- **Control Terminals Power:** The drive provides a small +24 V DC supply output on its control terminals to power the digital inputs or external sensors (often around 100 mA capacity). It also typically has a +10 V reference output for analog input (useful for potentiometer connection). For

example, one can connect a 10 kΩ speed potentiometer directly between the drive's +10V reference, analog input, and common, to provide a user-adjustable speed reference.

- **Fieldbus Communication:** To interface with modern automation networks, the ACS355 supports a range of **fieldbus communication options via plug-in modules**. By default, the drive is equipped with an **RS-485 serial port** and supports the **Modbus RTU** protocol as standard (up to 115 kbps) [76]. This allows direct connection to many PLCs or HMIs that use Modbus for basic start/stop and reference control or monitoring. For more advanced networking, ABB offers optional fieldbus adapter modules that attach to the drive. These modules cover all the major industrial protocols, for example:

- **Profibus DP** module,
- **CANopen** module,
- **DeviceNet**,
- **EtherNet/IP** and **Modbus TCP** combined module,
- **PROFINET IO** Ethernet module,
- **POWERLINK**, **EtherCAT**, etc.

Multiple options are often combined in one module for flexibility. For instance, ABB's *FENA-01* and *FENA-11* options provide **EtherNet/IP, Modbus/TCP, and PROFINET IO** interfaces on a single card [77] [78]. Using these, an ACS355 can be directly connected to an Ethernet network of PLCs and controlled or monitored via standard protocols. There are also multi-drop network modules (like one supporting **Modbus RS485 daisy chaining** of multiple drives). The availability of these options means the ACS355 can **seamlessly integrate into distributed control systems** or IoT platforms. For example, on a PROFINET network in a factory, an ACS355 drive with a FENA module can be an addressable node, receiving speed setpoints from a Siemens PLC and reporting its status back, all in real-time. This network capability is crucial for larger automated systems where centralized control of many drives is required. It also enables using advanced features such as ABB's Drive Manager for PLCs (an add-on that simplifies drive parameter management from PLC engineering software) [79].

- **PC and Diagnostic Connectivity:** Even without a fieldbus module, the ACS355's Modbus interface can be used with a simple USB/RS485 converter and ABB's PC software for commissioning or diagnostics. Many ACS355 users connect via the **DriveWindow Light** PC tool to adjust parameters using a laptop, especially if tuning multiple drives. The drive also supports **remote monitoring** through the fieldbus – e.g., one can read diagnostics or send commands from a SCADA system. Some of the Ethernet modules (like the FENA-21) even have a built-in web server for remote access, and support technologies like **web services or OPC UA** (though these are more common on higher model drives; on ACS355 the module mainly provides raw network interface) [80] [81]. In essence, the communications capabilities ensure that the ACS355 can be **fully integrated into Industry 4.0 environments**, providing data for predictive maintenance or energy management systems in addition to performing its control duties.

With its rich I/O and communication feature set, the ACS355 can either operate **standalone or as part of a complex automated system**. It has enough I/O to handle local control tasks on its own (and even run simple sequences), and at the same time it can talk to virtually any PLC or plant network when coordinated control or monitoring is needed. This dual ability – local autonomy and easy system integration – is a significant advantage for machine builders and end-users alike, offering flexibility in control system design.

Energy Efficiency and Reliability

Using VFDs like the ABB ACS355 is widely recognized as a key strategy for **improving energy efficiency** and equipment longevity in motor-driven systems. The ACS355 contributes to savings and reliability in several ways:

- **Energy Savings with Variable Speed:** By enabling motors to run only as fast as needed for the process, the ACS355 can drastically cut energy consumption, especially in variable-torque applications like fans, pumps, and blowers. The physics are such that **a small reduction in speed yields a large reduction in power demand** – for instance, reducing a centrifugal pump's speed by just 20% can reduce its input power by approximately **50%** [82]. This is due to the cubic relationship between speed and power in fluid systems (affinity laws). In practical terms, if a fan or pump doesn't need full flow, slowing the motor with a VFD avoids wasting energy across throttles or dampers. The ACS355, when used in HVAC, pumping, or compressed air systems, often pays for itself through energy savings. Even in constant-torque machines, running at optimal speeds and avoiding over-speeding or mechanical flow control saves energy. Many industrial users have reported significant cost reductions after retrofitting fixed-speed motors with VFDs. The ACS355 makes this accessible for lower power ranges (fractional to 30 HP motors) which are ubiquitous in plants.

- **Flux Optimization:** The ACS355 includes an automatic energy optimizer function called **Flux Optimization** [36]. When enabled, this feature fine-tunes the motor's magnetic flux in real time to the minimum level required to produce the needed torque. At lower loads or speeds, a standard V/Hz drive might over-magnetize the motor (wasting energy as heat in the iron core). Flux optimization actively reduces the V/Hz ratio under light loads, cutting magnetizing current and improving the motor's efficiency. The result is lower power drawn from the mains when the motor is not heavily loaded. This is especially beneficial in applications with varying loads, like a conveyor that is sometimes empty or a mixer with different batch sizes. Flux optimization can also **reduce motor heating** at no-load or low-load, potentially extending insulation life. Overall, it ensures the system runs at peak efficiency across the load range, not just at full load.

- **Reduced Mechanical Wear and Stress:** A VFD like the ACS355 greatly **softens the mechanical stresses** on a motor and the driven machine. Instead of across-the-line starting (which causes high torque transients and current surges), the ACS355 provides **soft start and stop** — ramping the motor smoothly up to speed and back down. This avoids the sudden jerks and strain on belts, gearboxes, couplings, and bearings that full-voltage starting or plugging can cause. According to industry analyses, adjusting motor speed with a VFD not only optimizes energy use but **also reduces mechanical wear**, thereby extending the lifespan of both the motor and the driven equipment [83]. For example, pump impellers experience less water hammer and cavitation when ramped down gently, and conveyor belts see less shock loading. Over time, this means fewer mechanical breakdowns and lower maintenance costs. The ACS355's ability to control acceleration profiles (including S-curve ramps for extra smoothness) and deceleration (with braking control) provides a much kinder operation for machines compared to traditional contactor control.

- **Improved Power Quality and Reduced Peak Demand:** When a motor starts across the line, it can draw 6-7 times its rated current inrush, causing voltage sags and high peak demand charges from utilities. Using the ACS355 to start a motor virtually eliminates high inrush currents by limiting the current during acceleration. This not only avoids flicker in the power system, but can reduce the

facility's peak demand, potentially lowering electricity bills. Moreover, the ACS355's input rectifier and optional input choke help maintain a high power factor and low harmonic distortion (meeting IEEE 519 or IEC 61000-3-12 guidelines in many cases) [84]. Lower harmonics mean less waste and less interference with other equipment. In essence, the drive makes the motor a more `grid-friendly` load.

- **High Reliability Design:** ABB drives, including the ACS355, are known for robust design and long service life. The ACS355 uses **conformal coated circuit boards** to resist dust and humidity, and quality components that contribute to a high MTBF (mean time between failures). The drive is protected by the extensive self-protection features described earlier, which prevent most failure modes from causing damage. For example, if the ambient temperature is too high, the drive will derate or trip rather than overheat; if a short circuit occurs on the motor side, the drive's IGBTs shut off in microseconds to avoid device failure. ABB likely designed the ACS355 for **10+ years of maintenance-free operation** under normal conditions. Additionally, the presence of built-in **thermal management** (like fan control and over-temperature warnings) means the user is alerted to any unusual stress before it causes a failure. The IP66 models even have their electronics completely sealed from the environment, further improving reliability in adverse conditions. All these factors result in **minimized downtime**.

- **Maintenance and Diagnostics:** The ACS355 aids reliability by making maintenance easier. It can track running hours, number of starts, and even trigger a **maintenance alert** after a certain time or number of operations (these are the "maintenance triggers" in the firmware) [43] [85]. For example, one could set a reminder in the drive to check the motor bearings or filter after X hours of run-time. The drive's **diagnostic fault log** stores the last several fault events with timestamp and status data, which helps in troubleshooting issues if they arise (technicians can quickly identify if a trip was due to over-voltage, over-temperature, etc., and take corrective action). This reduces the mean time to repair. ABB also provides excellent documentation and support for the drive, so maintenance personnel have resources to refer to. Overall, the ACS355 contributes to a **proactive maintenance approach** by providing data and not overstressing system components.

In summary, implementing the ACS355 VFD yields both immediate and long-term benefits: substantial **energy cost savings**, compliance with energy efficiency goals, smoother machine operation, and enhanced longevity of equipment. Real-world use has demonstrated these advantages. For instance, one case noted that using VFDs on pump motors allowed a factory to cut energy use by 40% and virtually eliminate water hammer on startup, saving wear on pipes and valves [86] [87]. Another example is in HVAC systems – adding drives like the ACS355 to fans can reduce airflow when full capacity isn't needed, easily saving **20-50%** of the fan's energy and extending the life of belts and filters by reducing airflow surges. These improvements align with sustainability goals and can provide a return on investment in just a couple of years or less, especially with rising energy costs. The ACS355, with features like flux optimization and inherent soft start, is a valuable component in any **energy-efficient and reliable motor control strategy**.

Applications and Real-World Use Cases

Thanks to its versatility, the ABB ACS355 is used across a broad array of industries and applications. Here we highlight several scenarios to illustrate how the drive's features can be applied to solve practical problems:

- **Material Handling (Conveyors and Logistics):** In conveyor systems, the ACS355's compact size and uniform design allow multiple drives to be fitted into decentralized control boxes along a conveyor line. Its sensorless vector control ensures that even if a conveyor is loaded with heavy product, the speed remains constant and throughput is maintained. The **safe torque off** feature is valuable for conveyor E-Stop circuits – if someone hits an emergency stop, drives immediately remove power to motors, bringing all belts to a halt safely. The drives can be quickly restarted without waiting for motor cooling because of the soft start (no large thermal shocks to motors). Additionally, **sequence programming** can coordinate actions like indexing or reversing the conveyor after X number of items have passed, without a PLC. For example, on a packaging conveyor, an ACS355's internal counter could be used to stop the belt every 10 products to align with a picker robot. Users have found that using VFDs like ACS355 on conveyors reduces product damage (gentler starts/stops) and improves reliability compared to simple motor starters. In one demonstration, an ACS355 was used to maintain precise **linear speed of a winding conveyor** by adjusting motor speed based on roll diameter feedback – all done with the drive's analog input and internal scaling without an external controller [88] [89]. This shows how the drive can handle dynamic speed adjustment tasks (in this case, keeping a constant 25 ft/min line speed as a roll builds up, using an ultrasonic sensor and no encoder).

- **Food and Beverage Machinery:** The washdown-rated IP69K versions of the ACS355 have been a boon for food processing environments. These drives can be mounted near motors on food conveyors, mixers, or fillers where they are regularly exposed to high-pressure cleaning and caustic wash solutions. Being NSF certified, they can even be in direct contact with food zones (like operating a mixer in a vat). In a bakery, for example, ACS355 drives might control dough mixer motors – the **high overload capacity (150% for 1 minute)** allows the mixer to knead tough dough without stalling, and the drive's **torque control** can even act as a feedback to detect consistency (thicker dough draws more torque, which could trigger the drive to slow or stop when a certain threshold is reached). The **flashdrop tool** is handy here if a batch of identical mixers needs to be configured the same way; maintenance can re-flash a drive's parameters in seconds if one is replaced, reducing downtime. Additionally, **speed compensated stop** is useful in bottling or filling lines where precise stops improve accuracy (e.g., stopping a conveyor at the exact position for filling bottles). The ACS355's ability to maintain consistent speed regardless of load means uniform product quality – for instance, in a conveyor oven, each product spends the same time under the heater. Overall in F&B, the ACS355 provides **robust, easily-cleanable motor control** that meets hygiene and safety requirements.

- **Pumps and Fans:** Although ABB has specific pump/fan drives, the ACS355 is often deployed for smaller pump and fan applications as well – including its special **Solar Pump variant**. For irrigation or remote water pumping, an ACS355 with the +N827 solar pump firmware can connect directly to **solar PV panels** and drive an AC pump motor [25]. It maximizes water flow based on available sunlight, using pump-specific protections like dry-run detection (if the well is empty) and sleep/wake functionality (stopping the pump when target tank level is reached, then restarting when level drops). This showcases the drive's adaptability – running off DC solar input via its rectifier and

controlling a standard AC motor efficiently. In building HVAC systems, ACS355 drives on fans or blowers improve comfort and cut energy usage by modulating airflow. The built-in **PID controller** can take a feedback signal (e.g., duct pressure or room temperature) and automatically adjust fan speed to maintain the desired setpoint, with no external controller needed. This decentralized control simplifies wiring and commissioning. Pumping applications also benefit from soft start (reducing water hammer) and the **auto-restart** function in case of power dips (important for critical sump pumps or cooling pumps). The ACS355's reliability in these 24/7 operations ensures minimal unexpected stops. Even in wastewater or industrial pumping, where the environment might be corrosive or outdoors, the IP66 drives have proven durable. In summary, whether grid-powered or solar-powered, the ACS355 can effectively handle **variable flow applications** with energy optimization and built-in safeguards for the pump/motor system.

- **Machine Tools and Spindles:** Many small CNC machines, routers, and textile spindles require high-speed motor drives. The ACS355, especially with the high-speed spindle variant (+N826), is used to run **spindle motors and high-frequency motors** in wood carving machines, small milling machines, or textile yarn spinning lines. Its ability to drive motors at hundreds of Hz frequency means it can create the high RPMs needed for cutting or spinning. Importantly, it does so with **smooth acceleration** and deceleration which protects delicate mechanical parts from shocks. The **speed controller auto-tuning** in the high-speed variant helps maintain constant speed even as cutting load changes – this is crucial in machining to ensure a consistent surface finish. Some woodworking CNC manufacturers choose ACS355 drives for their reliability and because the drives can be panel-mounted away from dust with only the motor on the machine. Additionally, **Safe Torque Off** can be integrated into the machine's safety circuit so that if the machine door is opened or a safety sensor is triggered, the spindle drive immediately cuts torque, stopping the spindle faster than a free coast (often combined with the drive's flux braking to halt it quickly). For multi-spindle setups, the ACS355's small footprint allows several drives to fit in one cabinet without overheating issues (given their efficient design and manageable heat dissipation with proper cooling). Real-world usage in this sector has shown the ACS355 to be a cost-effective alternative to more expensive servo drives when ultra-precise positioning isn't required but good speed control is – for example, driving a grinding wheel at 20,000 RPM or a saw blade with variable speed for different materials.

- **Plastics and Rubber Processing:** Equipment like extruders, mixers, and injection molding machines often use VFDs for smaller auxiliary motors (feed screws, puller rolls, etc.). The ACS355's **high starting torque** and overload rating come in handy for extruder screws, which might need a strong push to start turning a cold, viscous material. Using the drive's **torque limit** function, an extruder manufacturer can prevent the screw from applying excessive force (to avoid equipment damage) – the drive will hold at a set torque and wait, effectively acting like an electronic torque wrench. In rubber mills or calenders, precise speed ratios are needed between rollers; multiple ACS355 drives can be synchronized via analog references or a fieldbus to maintain those ratios. If one roller's load increases, sensorless vector control keeps its speed, while another drive might slightly adjust to maintain tension – all without encoders. The **coordination via fieldbus** (e.g., using a PLC with Profibus or CANopen modules in each drive) makes integration straightforward. Moreover, the drives' **robust electronics** handle the often warm environments near plastic machinery, and their predictive fault features (like warning of an impending overheat) can alert operators to vacuum out dust from panels or clean filters before a shutdown occurs.

- **Renewable Energy and Miscellaneous:** Beyond typical industrial uses, ACS355 drives have found homes in creative applications. For example, in small wind turbines or micro-hydro systems, they have been used as part of control schemes to dynamically adjust generator load by driving a secondary dummy motor or pump. In theme park rides or theater stage productions, their **compact size and smooth control** allow moving parts to be operated gently and safely (with STO ensuring compliance with safety norms for rides). Because the ACS355 can run off single-phase in smaller sizes, it's also used in agricultural or rural settings with only single-phase utility power: the drive can efficiently run a three-phase motor from a single-phase source by internally creating the three-phase output – a common trick to utilize industrial motors on farms for things like grain augers or milking pumps.

Each of these cases highlights how the **ACS355's features translate into practical benefits**: energy savings, improved control precision, safer operation, reduced component count, and adaptability to special power sources. To give a concrete real-world anecdote, consider a **winding application** demonstrated by an integrator: An ABB ACS355 was paired with a sensor to create a simple closed-loop winder that kept linear speed constant as the roll diameter grew, all without a PLC or dedicated winder controller. The operator taught the sensor the empty and full diameters (4 mA at empty, 20 mA at full), and configured the drive to scale that input to adjust motor speed from 200 RPM (at empty) to 82 RPM (at full) to maintain ~25 ft/min line speed [55] [56]. The drive handled the continuously changing analog signal and modulated the motor in real time, and **"the encoder [was] not used"**, showing the high capability of the sensorless control [89] [88]. This not only achieved the process goal but did so with minimal hardware – the ACS355 effectively acted as drive and controller in one.

Such flexibility means engineers can get creative and solve control challenges efficiently with the ACS355. It provides a great balance between **simplicity and functionality**, which is why it remains popular in many industries even as new models come out.

Conclusion

The ABB ACS355 VFD exemplifies a **well-rounded, high-performance drive** in the compact class, offering a wealth of features to meet modern industrial requirements. Its combination of broad power range, advanced motor control (including sensorless vector for both induction and permanent magnet motors), and integrated safety and programmability makes it a standout solution for machine builders and end-users seeking to improve their systems. The drive's **plug-and-play ease of use** – with quick macros, assistants, and FlashDrop – means faster commissioning and less hassle in both initial setup and maintenance updates. At the same time, its **rich functionality** (from Safe Torque Off to sequence programming and fieldbus communications) provides the tools to tackle complex control tasks that once required additional devices or custom electronics.

In operation, the ACS355 contributes to significant **energy efficiency gains and enhances reliability** by reducing mechanical stress and offering intelligent control that adapts to process conditions. Real-world implementations have shown it can boost productivity (through precise control and minimal downtime) and reduce costs (energy savings and fewer components). Importantly, ABB's global support and the drive's compliance with international standards give users confidence in deploying it across various projects and regions.

In summary, the ABB ACS355 Machinery Drive is a powerful example of how far compact VFDs have evolved. It enables engineers to **do more with less** – achieving fine-tuned motor performance, ensuring safety, and optimizing processes, all within a small, cost-effective unit. Whether it's improving an existing system's efficiency or designing the next generation of machinery, the ACS355 provides a proven, versatile platform that can help solve customers' motor control challenges and deliver tangible improvements in their operations.

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