Why Your VFD Won't Start – Troubleshooting Control Wiring & Start/Stop Logic Errors

Variable Frequency Drives (VFDs) are robust devices, but even a small control wiring mistake can leave a drive "not ready" or unresponsive to start commands. This article dives into common control wiring and start/stop logic errors that prevent VFDs from running, with a focus on real-world troubleshooting across major brands (ABB, Lenze, Eaton, Hitachi, Yaskawa). We'll cover the technical fundamentals – referencing manufacturer documentation and relevant standards (IEC 61131-2, UL508A) – and provide example scenarios where a simple wiring oversight caused **"VFD won't start"** situations. A comparison of terminal logic differences between brands is included, along with tips for interpreting fault/inhibit indications and a handy troubleshooting checklist.

Introduction: VFD Start/Stop Control Wiring Basics

Every VFD has control terminals for start/stop commands, often requiring external dry contacts or jumper wires to be correctly installed for the drive to run. **Two-wire vs. three-wire control** is a key concept: - **2-Wire Control:** A single maintained contact signals Run or Stop (like a selector switch or PLC output). Closing the contact runs the motor; opening it stops the motor [1] [2]. This is common in automated systems where a PLC or relay keeps the run signal on continuously. By default, many drives treat a closed digital input as a **"run"** command and interpret an open circuit as **"stop"** [2]. For example, Yaskawa drives' default *2-wire* mode uses a forward run input (S1) that **runs when closed and stops when open** [2]. - **3-Wire Control:** Separate momentary pushbuttons for **Start** and **Stop**. The VFD's internal logic latches the Start command when momentarily closed, and a normally-closed Stop contact must be closed for the drive to run [3]. Pressing Stop (opening the NC contact) immediately halts the drive. This configuration mimics a classic motor starter station (Start PB, Stop PB) and is often used for local operator control [4] [3]. Notably, drives in 3-wire mode expect the Stop input to be closed in normal operation – a broken or open stop circuit will keep the drive inhibited (fail-safe behavior per UL508A/NFPA79 guidelines).

Sinking vs. Sourcing Inputs: VFD digital inputs are typically 24 V DC and can be wired in either sinking (common negative) or sourcing (common positive) configurations, as defined by IEC 61131-2 Type 1 logic levels. In practice, this means one side of your control contacts must be tied to the drive's internal 24 V supply or ground, depending on the input mode. For example, ABB's ACS550 manual specifies that a valid high signal requires ≥ +10 V relative to DCOM (the digital common) [5]. The drive's built-in 24 V can be used for this – one can wire the common (DCOM) either to the drive's +24 V terminal or to ground, achieving sourcing or sinking logic respectively [5] [6]. Many drives provide internal jumpers or dip switches to select the input circuit mode: - On ABB drives, terminals X1:10 (+24 V) and X1:11 (GND) are available to power inputs; tying DCOM to GND configures **PNP (sourcing)** mode, whereas tying DCOM to +24 V configures **NPN (sinking)** mode [6]. - Eaton's PowerXL series explicitly notes the need to connect the common terminals (CMA/CMB) to the proper reference: **ground for sinking mode (default)** or to +24 V for sourcing mode [7]. The inputs are then activated by closing to the opposite reference (i.e. to +24 V in sinking mode, or to 0 V in sourcing mode) [7]. - Lenze/AC Tech SMVector drives use a physical "Assertion Level" switch and a parameter to set active-high vs. active-low logic for the digital inputs, accomplishing a similar task (A/Low for sinking, A/High for sourcing) as described in the manual. In all cases, **if the common reference isn't correctly wired or jumpered, none of the start/stop commands will register** – a very frequent cause of "VFD not running" troubles [8].

Typical VFD control terminals and a 3-wire start/stop configuration. A maintained contact or PLC output (Run Forward) is used in 2-wire control, whereas separate momentary Start (NO) and Stop (NC) buttons are used in 3-wire control (the drive latches the start internally). [9] [4]

Drive Enable and Safety Interlocks: Most VFDs have at least one "enable", "inhibit", or safety interlock input that must be closed to allow running. This could be a dedicated terminal labeled Enable, a "Safe Torque Off" circuit, or simply a digital input configured for an external interlock. Per safety standards (e.g. IEC 60204, UL508A), critical stop circuits are often wired normally-closed so that a fault or open circuit will prevent operation. The VFD will interpret an open interlock as a "not ready" or "inhibit" condition until the circuit is closed (jumpered). It's essential to identify these required circuits in the manual and ensure they are satisfied in the field wiring or parameter settings [10].

Common Wiring Errors That Prevent a VFD from Starting

Even experienced technicians can overlook small details in control wiring. Below are some of the most common errors and oversights across different drive brands that result in a VFD not starting or showing a constant "stop/inhibit" status:

- **Missing Jumpers on Enable or Safety Terminals:** Drives often ship with factory jumpers on safety interlock or run-enable terminals that are removed during installation (or lost when a drive is reused). If an enable circuit isn't closed, the drive remains in a "Disabled" or "Not Ready" state with no faults. **Example:** ABB ACS series drives use a digital input as "Run Enable" in certain macros, which must be closed for the drive to run [10]. If this terminal isn't wired out (or jumpered to 24 V/COM), the drive won't start. In an ABB ACH550 bypass unit, for instance, the **Enabled LED stays off** until two pairs of terminals are jumpered closed on the control board [11] – a hint that a missing jumper or open circuit is keeping the drive inhibited. Always consult the wiring diagram to find any "logic gate" interlocks (e.g. external stop, thermal trips, or "drive ok" contact loops) that need to be closed. This mistake is so common that a leading cause of a "new VFD won't run" is simply a factory-installed jumper left off or a safety circuit left open.

- **Start/Stop Wired with Wrong Contact Type (NO/NC):** Using the incorrect contact type for start or stop pushbuttons causes logical confusion. **For Stop circuits, a normally-closed (NC) contact is generally required** in a 3-wire control scheme [3]. If someone mistakenly uses a normally-open stop button, the drive sees an open circuit as an active stop command and will never run. **Example:** A Yaskawa drive in 3-wire mode expects a closed circuit at its STOP input (default "STOP" terminal is internally NC logic) – one technician unwittingly wired an NO stop button, and the drive remained in **STP** state (inhibited) the entire time. The fix was to use an NC contact for the E-Stop and Stop pushbutton, so that only when pressed (opened) would it issue a stop command. This aligns with fail-safe design: if a wire breaks, the circuit opens and safely stops the drive. Always double-check the drive's manual for whether a given input function is "active when closed" or "active when open" – manufacturers will specify this for each digital input function [12]. Hitachi's WJ200, for example, has separate function codes for 3-wire control: *STA* (Start) is active on a rising edge, whereas *STP* (Stop) must be held closed for run and opening it triggers a stop [13] [14].

- **Wrong Terminal or Common Connections:** It sounds obvious, but in the heat of installation it's easy to land a wire on the wrong terminal – especially since many drives label terminals with cryptic codes. For instance, on Eaton drives the commons CMA/CMB for inputs DI1–DI4 vs. DI5–DI8 are separate; using the wrong common will break the circuit to the input [15] [16]. Or a technician might accidentally wire a 2-wire control to the "STOP" input instead of the "START" input. A quick continuity check and comparing against the manual's terminal diagram can catch this. It helps to label each control wire and terminal during installation to avoid mix-ups. Additionally, **ensure analog commons and digital commons are not confused** – inserting a start/stop lead into an analog ground won't register the command.

- **Sinking vs. Sourcing Mix-ups:** As discussed, if the common reference isn't correctly set, your start/stop signals won't reach the needed potential. This is a subtle wiring detail often missed. **Example:** ABB's manual explicitly states *"DCOM must be jumpered to either +24V or 0V depending on sinking/sourcing"* for internal supply use [17]. If an installer leaves DCOM floating (neither tied to +24 nor ground), none of the digital inputs have a return path – the drive input LEDs won't even light. Similarly, Yaskawa drives have terminals *SN, SC, SP* for this purpose (providing flexibility to use an external 24 V supply or the internal one). On a Yaskawa V1000/A1000, setting the DIP switch for sink vs. source is crucial – one crew learned this the hard way when **no external start/stop commands worked** because the DIP was set to sourcing but the wiring was done for sinking. The solution was simply flipping the DIP (or moving the common wire to the other reference terminal) to match the wiring [7]. Always verify the drive's sink/source jumper position or parameter and ensure your wiring aligns with it.

- **Drive in Local Mode or Wrong Control Source:** Not a wiring error per se, but a configuration pitfall – if the VFD is left in "Hand" or local keypad mode, it will ignore your terminal wiring. For example, Lenze SMV drives have parameter P100 to select the start/stop source (0 = Keypad, 1 = Terminal strip, etc.) [18]. Yaskawa drives have a similar setting (b1-02 on many models) and a **Lo/RE** (Local/Remote) key on the keypad; if the green LED for local is on, the drive expects you to use the panel's start button. In one real case, a Yaskawa A1000's RUN light was flashing and it wouldn't accept PLC commands – it turned out the drive had been left in Local-Jog mode by an operator [19] [20]. Simply toggling back to remote (or cycling the "Local/Remote" button) restored control. Always check the drive's display for an indication of control mode (many show a icon or text like "LOC" or "REM") and ensure the drive is in the correct mode for your wiring scheme.

- **External Faults or Inhibits Active:** Many drives have configurable "External Fault" or "Safety Stop" inputs that, if active, will prevent starting and often display a message or flash an LED. These are meant to be tied to external protective devices (overtravel limits, external alarms, etc.). A common oversight is leaving such an input configured in the drive but not wiring anything to it – if the default logic is active-low (fault when closed, as is the case on some Yaskawa inputs by default [12]), an unwired input might float closed or noise can trigger it. Or if it's active-high (fault when open), an unused input might need a jumper to common. For example, Yaskawa's multi-function input for "External Fault" (often S3) causes an **"EF" alarm** when activated [21] [22]. If you see an unexpected fault code, always cross-reference it to the control inputs. On ABB drives, an open external interlock might show as "FAULT XX EXT SUPERV" or simply "NOT READY". Consult the manual's fault code section – it usually identifies if a digital input is responsible (e.g., "external fault input active"). The fix is either to properly wire the safety device to that input or disable/reconfigure the input if not used (per IEC 60204, unused safety circuits should be safely tied off or turned off in logic, not left floating).

- **Safe Torque Off (STO) Circuit Open:** Nearly all modern VFDs (e.g. ABB ACS880, Yaskawa GA800, Lenze i500) include a **Safe Torque Off** function that uses dedicated terminals (often two redundant channels) to remove drive output per SIL/PL safety requirements. If your drive has STO and it's not wired into a safety relay, you may need to insert jumpers or enable a software override for commissioning. An open STO circuit will typically prevent the drive from enabling with a clear status message (e.g. "STO active" or just a ready LED that never turns on). Always confirm the STO terminals are closed or jumpered if you intend the drive to run. For instance, Hitachi's drive function list shows *GS1/GS2 inputs (STO1, STO2)* – if these aren't satisfied, the drive won't energize the motor [23]. This is a crucial one: a missing STO jumper is essentially an enable circuit problem but is often documented separately in the safety instructions. Check the installation manual section on STO whenever a drive won't start and no obvious fault is shown.

- **Parameter Mismatch (Logic Configuration):** Lastly, a subtle "wiring" issue is when the **physical wiring and parameter settings don't agree**. For example, if you wired a two-wire maintained start/stop circuit but the drive is set to 3-wire mode in parameters, it may be waiting for a "pulse" on a start input that never comes. Or the opposite: you wired momentary pushbuttons, but the drive is in 2-wire mode – the motor might only run while the start button is pressed, then stop (since it expected a maintained signal). An anecdote from a technician: they noticed the motor would not stay running unless the start button was held down – sure enough, switching the drive's control mode to 3-wire (which enables an internal latch for the start input) solved the issue. Likewise, many drives have a "Start on power-up" inhibit setting. Yaskawa drives by default have **parameter b1-17 = 0**, meaning the drive will **not** start if a run command was already present at power-up [24] – it requires the input to go low then high again. So if your system sends a run signal immediately on power cycle, the drive might ignore it until toggled. Recognizing this behavior can save a lot of confusion; the solution may be to enable auto-start on power-up (if safe to do so) or ensure the run input is off during power cycle. Always review the programming related to start/stop logic if the wiring alone doesn't reveal the problem.

Brand-Specific Terminal Logic Differences

While the fundamentals are similar, each manufacturer uses different terminal designations and default logic for start/stop and interlocks. Let's compare how ABB, Lenze, Yaskawa, Hitachi, and Eaton drives handle control wiring logic, so you know what to watch for in each case:

ABB Drives (e.g. ACS/ACH Series)

ABB AC drives typically label digital inputs as **DI1, DI2, … DIn**, with a common DCOM. The default configuration (in the standard macro) often uses DI1 as "start/stop" and DI2 as "direction" (forward/reverse) or as an enable, depending on the macro. **Factory macros:** ABB provides preset macros (industrial, HVAC, etc.) which assign meanings to the DIs. For example, in one macro DI1 might be Start/Stop, DI2 Run Enable, DI3 External Fault, etc. [10]. Always check the **User's Manual I/O configuration table** for your selected macro. One common pitfall is the **"Run Enable" input**: many ABB drives have a DI programmed as an enable or "purge" input that *must* be closed or jumpered, as noted earlier [10]. If an ABB drive shows "READY" but won't run with no fault, it's likely waiting for an interlock – check that all required DI signals are present (the drive's panel can usually display DI status).

ABB drives support both **2-wire and 3-wire control** via parameter selections (parameter 1103 on some models selects 2-wire/3-wire control logic). In 3-wire mode, ABB expects a momentary normally-open DI for Start and a normally-closed DI for Stop – similar to others. A specific example: the ABB ACS355 has a parameter-called *"Start/Stop logic"* where you can choose between "Edge" (3-wire) or "Level" (2-wire) control. If set to Edge (3-wire), DI1 might act as Start (edge-triggered) and DI2 as Stop (NC supervision). If set to Level (2-wire), DI1 becomes a maintained run command [9].

Safe Torque Off: Newer ABB drives (ACS380, ACS580, etc.) have dual STO terminals. By default, these must either be wired into the safety circuit or have factory jumpers. Consult the **ABB Safety Instructions** – trying to run without satisfying STO will keep the drive in a pre-enable state (often no error, just no motion). For example, on an ACH580 you'd wire terminals X1:1 and X1:2 together (or through a safety relay) to close the STO loop.

Tip: ABB manuals usually include a table of **logical signals** (like "5031 DRIVE NOT READY" or similar codes) – these can indicate exactly what interlock is open. For instance, code **"2021"** on some ABB units corresponds to a start inhibit because the start was true at power-up (similar to Yaskawa's behavior) [24]. And **"2041 EXT. LOCK"** may mean an external interlock input is open. Always leverage those diagnostics. Also note ABB's analog inputs sometimes require jumper/DIP settings (voltage vs current) – if mis-set, the drive might think you commanded 0 speed. For example, older ABB models had a physical jumper for AI1 V/mA selection, and if left in mA while giving 0-10 V, the input reads zero [25] [26]. This won't prevent starting, but the motor won't move since speed reference is zero.

Lenze Drives (Lenze/AC Tech)

Lenze's drives (such as the SMVector series and newer i500 series) often use a somewhat different labelling. In the SMVector (AC Tech) drives, the control terminals are numbered (e.g., **Terminal 1 = Start/Stop**, Terminal 2 = Common, Terminal 4 = Multi-function input, etc.) rather than named DI1, DI2. The **SMVector** default is 2-wire control: Terminal 1 expects a maintained closure to run. Specifically, closing Terminal 1 to Terminal 2 (common) runs the drive, opening it stops [27]. This single input acts as a combined start/stop depending on state. However, the SMV can be reconfigured for 3-wire control using the programmable multi-inputs (TB-13A, 13B, 13C). For example, one can set parameter P121=13 (TB13A = Start) and P122=14 (TB13B = Stop) to get a 3-wire scheme [28]. In that case, **TB-13B must be held closed (Stop NC)** for the drive to run, and a momentary closure of TB-13A will start the drive.

Lenze drives offer an **assertion level switch (A/L)** on the control board to select sinking vs sourcing logic, as mentioned. The default **A/Low** position configures inputs for active-low (sinking, common = 0V) which suits dry contact to +24 V usage [29]. Changing it to A/High would invert the logic if needed. Importantly, on Lenze's older 8200 series drives, there were physical jumper banks (X2, X3) on the pluggable terminal card that set up various I/O behaviors [30]. If you're dealing with legacy Lenze equipment, track down the manual for those jumper settings – for instance, one jumper might enable a built-in 5 V supply on a sensor input, or select between two start/stop control modes.

A common Lenze-specific gotcha is the **"enable" input (sometimes called the "CE" or "controller enable")**. Some models have a dedicated terminal that must be tied high for the drive to function, separate from the Start/Stop terminal. If the drive displays "CE" or similar fault, it means "Control Enable" is not satisfied. This is analogous to an STO or run-permit and requires a jumper if not used. Always scan the wiring diagram for any note like "link terminals X and Y for normal operation."

Finally, Lenze drives follow IEC and UL standards for stop circuits – e.g., an E-Stop should be wired NC into a digital input configured as "Baseblock" or "Fast Stop" so that breaking the circuit triggers a coast or fast stop. If your Lenze VFD isn't starting, verify none of the TB13x programmable inputs are unintentionally set to a function that could inhibit running (like "external trip" or "fast stop") due to a default parameter. In the SMV, P121–P124 set the functions of TB13 terminals; check that none of these are inadvertently active (the SMV's status LEDs can help here, as it has indicators for the TB13 inputs being active or not).

Yaskawa Drives (V1000, A1000, etc.)

Yaskawa drives are known for their flexible **multi-function digital inputs** labeled **S1, S2, … S8** with a common **SC** (and sometimes a separate +24 V output on **SP** or **RP**). Out-of-the-box, Yaskawa typically configures S1 as Forward Run, S2 as Reverse Run, S3 as External Fault (normally open trip), S4 as Reset, S5/S6 for multi-speed presets, etc. [31] [32]. The default control mode is 2-wire: close S1 to SC to run forward, open to stop [2]. (S2 can be used similarly for reverse, if enabled – if you don't need reverse, leaving S2 open yields no effect, or you can reprogram S2 to some other function or disable it.)

To use 3-wire control on a Yaskawa, you must change a parameter (`b1-03` on many models) to "3-Wire." In that mode, the drive internally reassigns input functions: typically S1 becomes the momentary Start input (edge-triggered), S2 might serve as the latch for Run (or as Reverse selection), and **S3 is automatically configured as the Stop input which must be NC**. The Yaskawa manuals explicitly show wiring diagrams for 3-wire control – often depicting S3 tied through a NC stop button to SC (so that pressing it opens the circuit) [9]. If you forget to change the parameter and wire a 3-wire scheme, the drive won't latch the start. Conversely, if you enable 3-wire mode but still only provide a maintained contact on S1, the drive will require a transition (off to on) each time to start – it won't start just from a constant on state. Another Yaskawa quirk: **power-on start prevention** (parameter b1-17). By default, if S1 was already closed when the drive powered up, the drive will **not run** until that input opens and re-closes [24]. This is to prevent unexpected automatic restarts after a power loss (compliant with safety norms). This can confuse folks during commissioning – the drive seems to ignore the start input on first power-up. The remedy is to cycle the start input or change b1-17 = 1 (allow start on power-up) if the risk assessment permits.

Yaskawa's **Safe Disable (STO)**: On models like the A1000, two terminals labeled **H1, H2** (or SN/SP on some, depending on model options) are used for Safe Torque Off. If these are open, the drive's RUN LED may flash and the drive won't run. In one scenario on Reddit, an A1000 had a **flashing RUN indicator**; the manual indicated this can happen "during stop by interlock (Safe Disable)" [33] [34]. Indeed, an STO circuit was open. Ensuring those are closed (or the associated safety plug is inserted) cleared the condition.

Yaskawa drives provide handy diagnostics: the LED status and the HOA keypad. If the RUN LED is blinking, it often signals an **inhibit state** (e.g. "Baseblock" active, which is their term for an interlock that shuts off output). The drive's LCD will also show if a "BB" (baseblock) command is present. Moreover, Yaskawa fault codes like "EF" for external fault, or "HF" for hardware fault, etc., can point to input issues. If no fault but not running, check the **digital input monitor** (most Yaskawa VFDs have a monitor function where you can see the status of each S1–S8 input in the parameters). This will quickly tell you if the drive thinks an input is ON or OFF when it shouldn't be. It's a great way to spot, say, a miswired common or a noisy connection flickering.

One more brand-specific note: Yaskawa's older drives had an input called **"Baseblock"** that could be assigned (it forces a coast-to-stop without fault, used often as an emergency stop input). If by chance that got assigned to one of the default inputs and pulled active, the drive won't run. Verify H1-0x parameters (for input functions) to ensure no unwanted assignments are active [21] [35].

Hitachi Drives (WJ200, SJ series)

Hitachi VFDs, like the WJ200, use a mix of code-based function assignments and labeled default terminals. Typically you'll see terminals labeled **FW (Forward Run)**, **RV (Reverse Run)**, **BX (Baseblock)**, **STOP (ST)**, etc., along with one or two commons (often "L" or "PLC" for 0V, and a +V supply terminal for sourcing). On the WJ200, the default is 2-wire control using FW and RV. For example, closing FW to the common (which might be labeled "CM" or "L") causes a forward run. If you want 3-wire control, Hitachi provides those special function codes: *STA* (start 3-wire), *STP* (stop 3-wire), *F/R* (toggle forward/reverse in 3-wire) which can be assigned to inputs via parameters [36] [37]. When 3-wire mode is configured, typically the FW terminal might not be used; instead, one input becomes the momentary Start (STA) and another the NC Stop (STP). **Important:** The factory default wiring on many Hitachi models has a small **jumper between "PLC" and "L"** terminals – this selects the internal 24 V supply reference. If you remove it to wire an external supply or due to confusion, the inputs might not have a return path (similar to the sink/source issue). Ensure that either the jumper is in place or you properly provide the common from your external control source.

Hitachi drives often label the "enable" or "not stop" input as **BX** or sometimes "SAFE." BX stands for "Baseblock" (basically a coast-to-stop interlock). By default BX might be tied high through a jumper on some units. If BX is open (active), the drive will not run and may not throw an obvious fault (it just removes gate signals). So check for any BX terminal – it must be closed for normal operation. In the WJ200 Quick Reference, BX is mentioned under function code 11 (FRS – free run stop) and is typically active when that input is **closed** [36]. So a normally closed contact between BX and common is expected; if unused, jump BX to common.

Another scenario: A user on a forum struggled with a Hitachi VFD not responding – they had wired run/stop to the FW terminal but hadn't realized the drive was in 3-wire mode from a previous setup. The FW terminal in 3-wire mode did nothing (the drive was actually waiting for a *STA* pulse). Setting the correct mode or wiring to the proper terminals fixed it. This underscores that Hitachi's approach with assignable codes is powerful but can lead to mismatches if a drive was pre-programmed differently than assumed.

Hitachi fault codes related to wiring include "E13" (External Trip), which means the configurable external trip input was activated. Also "E14" for a USP (Unattended Start Protection) trigger – Hitachi drives have a USP feature that if the drive is powered on with a run signal present, it won't start and will show "E14" to require a manual reset. This is analogous to the Yaskawa and ABB start inhibit on power-up, but Hitachi makes it a distinct fault code and it's enabled if parameter USP is on. So if your Hitachi shows "E14", it's telling you it prevented an auto-restart; you'll need to clear the run command and reset power or the fault to proceed.

Eaton Drives (DE1, DC1, SVX/PowerXL DG1)

Eaton's VFD lines (some of which originated from former Cutler-Hammer or Moeller products) have their own default schemes: - The **Eaton SVX9000** (which is actually based on Finnish Vacon drives) uses numbering like **DIN1, DIN2...** for digital inputs. By default, DIN1 might be Run forward, DIN2 Run reverse (start enable signals) [16] [38]. Notably, on many Eaton drives **both a forward and a reverse start enable are used** – meaning you may need to jumper one if you only intend to run in one direction. For example, the PowerXL DG1 Quick Start shows **DIN1 = Run Forward (start enable)** and **DIN2 = Run Reverse (start enable)** [16]. If you only wire DIN1 and leave DIN2 floating, the drive might not care if reverse is absent (it will just never run reverse, which is fine). However, some models or certain parameter settings might expect a contact on DIN2 as an "enable" even if not using reverse. It's a good idea to explicitly disable the reverse command in parameters if you are not using it, to avoid any ambiguity. - **Enable Circuit:** Eaton often uses DIN3 or DIN4 as an "External fault" or "Enable". In the DG1 default, DIN3 is an External Fault (active-high = causes fault when closed) [39] and DIN4 is a Fault Reset [40]. Some enclosed Eaton drives or bypass packages wire an auxiliary contact from the bypass or safety circuit into the drive's DIN3 to serve as a "proof" or inhibit. If your Eaton drive reads "EF" fault or similar, check if DIN3 needs a jumper or if a safety device (like an E-stop string) is connected there.

Eaton's **DC1 and DE1** micro drives (which are more simplified) often have fixed control schemes unless reprogrammed via software. The DC1, for instance, has a parameter P-12 to choose between 2-wire and 3-wire control, and P-15/P-16 to assign the digital inputs. By default, one digital input is indeed an enable (for DC1, Terminal 1 is "Enable/Run" that must be closed) and another is a forward/reverse selector. **Tip:** The product manual will have a table "Factory I/O Setup" – always review it. For DC1 drives, the default expects a RUN enable and a separate FWD/REV selection. A common error is not realizing two contacts must be closed: one to enable the drive, second to actually run. If either is open, no motion.

With Eaton's PowerXL DG1 and SPX drives (newer generation), they support **sinking/sourcing via jumpers or wiring**, similar to others. The DG1 quick start manual explicitly shows the needed wiring for sink vs source and notes that *"terminals CMA/CMB are common for DI1-4 and DI5-8 respectively"*, and that the factory config is sinking (common grounded) [7]. So ensure those commons are tied down accordingly. The DG1 also has parameter menus where each digital input can be reassigned; if someone inadvertently changed DIN1's function (say to "Start Pulse") whereas wiring still expects level start, that mismatch can cause the drive not to respond as expected.

One particular Eaton quirk: some drives have a **"Safety input" (TI)"** – for example, DIN7 and DIN8 in the DG1 are labeled as "Emergency Stop (TI–)" and "Force to remote (TI+)" [41] [42]. The naming is a bit confusing; essentially one is an E-stop input and the other is its complement for a two-channel safety. If you're not using a two-channel E-stop with the drive's internal safety function, you must jumper those appropriately or disable the function. Eaton documentation shows DIN7 and DIN8 tied together through a NC contact for E-stop in some wiring diagrams. If left open, the drive will think an E-stop is pressed and will not run. Always refer to the wiring examples in the manual for the E-stop circuit – if you see a "TI" terminal, treat it like an STO or e-stop interlock.

General Note on Standards Compliance

Regardless of brand, keep in mind standards like **UL508A** (industrial control panels) and **IEC 60204-1 / NFPA 79** (machine electrical safety) govern how stop circuits and control wiring should be implemented. For example, these standards mandate that a hardwired Stop function (Category 0 stop) should be normally closed and fail-safe. All the major VFDs provide means to implement this – either via a dedicated safe input or by using a standard digital input programmed as normally-closed Stop. In troubleshooting, this means if you see a Stop circuit wired normally open, it's likely not per standard and could be the source of the issue. Another aspect is noise and grounding: UL508A and good practice call for separation of control wiring from power wiring and proper grounding of commons. A noisy reference or a floating ground can simulate false signals. ABB's commissioning guide recommends grounding control cable shields at the drive end only, to reduce noise on the inputs [43]. Excessive electrical noise can cause a drive's inputs to flicker on/off (observing the input status LEDs can reveal this). In one case, a drive's analog input was reading erratically (causing the drive to not run at full speed) until the commons were properly bonded to ground, resolving a ground loop issue [44] [45]. So, proper wiring per standards not only ensures safety but also reliability of the control signals.

Real-World Troubleshooting Examples

To solidify these concepts, let's look at a couple of anonymized real-world cases where minor wiring mistakes caused major headaches, and how they were resolved:

Example 1: The Missing Enable Jumper – A mid-sized manufacturing plant had installed a **used 20 HP ABB VFD** for an exhaust fan. Everything was wired seemingly correct: start/stop contacts to DI1, analog speed reference to AI1, etc., yet the drive refused to start (no output, no fault – just idle). The **"Ready"** LED was on, but the **"Run"** LED never came on when commanded. The installation manual was consulted and it turned out this ABB drive model required **Digital Input 2 to be tied high as a "Run Enable"** when using 2-wire control [10]. On new drives, ABB often ships a factory jumper on that terminal, but in this used unit the jumper was missing. The technician quickly placed a wire linking the drive's +24 V supply to DI2 – effectively enabling the run permissive. Instantly, the drive came to life and responded to the Start command. This scenario is incredibly common – one user on an online forum even noted *"Drives ship from the factory with a jumper in place, but used ones may not include it,"* in reference to ABB VFDs arriving in a disabled state [46]. The takeaway: always verify any **enable, interlock, or permissive circuits** on a new VFD installation. A $0.05 jumper wire can be the difference between a dead drive and a working system.

Example 2: Normally-Closed Stop Circuit Blunder – In a **packaging machine**, a new Lenze VFD was added to control a conveyor. The wiring included a fancy operator station with illuminated Start and Stop pushbuttons. After power-up, the drive showed no faults, and the start button LED would light when pressed, but the motor never ran. The Lenze drive's status display showed "rdy" (ready) but would momentarily flicker "Sto" when the start button was pressed, then go back to "rdy". This hinted that the drive *did* see a start command but immediately went back to stop mode. After some debugging, the engineer realized the **Stop button was wired incorrectly** – it was using a normally-open contact, but the drive was expecting a normally-closed Stop circuit in the 3-wire control scheme [3]. Essentially, the drive always thought "Stop" was active because the NO contact was open at rest. They rewired the Stop button with its NC contact in series with the drive's common. Now the stop circuit was closed during normal operation and would open only when the button was pressed (which would command a stop). Once this change was made, the drive started functioning perfectly with the start/stop station. This example reinforces the importance of using the correct contact types – a normally-closed stop circuit is a must in most control schemes. It also illustrates how reading the drive's manual and status indications (the flicker of "Sto" was a clue) can lead you to the root cause.

Example 3: Sinking vs. Sourcing Confusion – A systems integrator was commissioning a **Yaskawa A1000 drive** controlled by a PLC. The PLC's digital outputs were NPN (sinking type), pulling the line to 0 V to activate. They wired the outputs to the drive's S1 and S2, and tied the drive's SC (0 V common) to the common of the PLC outputs. On power-up, nothing worked – the drive inputs showed no response. The issue was that the Yaskawa was still set in its factory default **sinking mode (SC as common)**, *and* they effectively wired it correctly for sinking – so why no action? It turned out the integrator had used the drive's **internal +24 V supply (terminal SP)** to power the PLC output card, not realizing the **drive's SP and SC were**

not bonded to the same ground as the PLC's supply. The PLC output card's 0 V and the drive's SC were floating relative to each other. The fix was either to common the grounds (bond drive SC to PLC 0V) or use the drive's +24 V as intended: as the supply and pull **that** to SC through the outputs. They bonded the commons and the inputs immediately lit up, the drive started from the PLC commands. Moral: when mixing different devices, always ensure the reference common/ground is shared if you intend to use their signals. In line with IEC 61131-2, the drive's input needs a clear return path for the current – a floating common means no circuit. In troubleshooting, a quick voltage measurement revealed that closing the PLC output only pulled the drive input to ~12 V, not 0 V, because of the half-referenced connection (half the supply potential was dropping elsewhere). This also serves as a reminder to **use the drive's internal supply correctly** or a proper external supply configured for the right input polarity.

Example 4: Parameter Mismatch – 3-Wire vs 2-Wire – A maintenance electrician was perplexed by a **Hitachi SJ-series VFD** on a machine that would not stay running. It was set up with a start/stop station (momentary NO start, NC stop). He would press Start, the motor would run but the moment he released the Start button, it stopped again. Classic symptom of a 2-wire vs 3-wire mix-up: the drive was in 2-wire mode (level-sensitive) so it only ran while it "saw" the start input closed – and releasing the spring-return pushbutton opened the circuit, stopping the drive. The solution was to change the drive's control mode parameter to 3-wire, which then caused the drive to latch the run command internally on a rising edge of the Start input [13]. After that, one tap of the Start button would start the motor, and it continued running until the Stop was pressed. This example is straightforward but happens more often than you'd think, especially on drives that default to 2-wire. Always confirm the control mode in the parameters matches your wiring scheme. Many drives have an explicit 2/3-wire toggle; on some (like Hitachi) you essentially achieve 3-wire by assigning the dedicated STA/STP functions to inputs. Either way, if the drive stops immediately after start, investigate this aspect.

Each of these cases underscores a simple principle: **when a VFD "won't start," the issue is very often in the tiny details of control wiring or logic settings rather than a major hardware fault**. It pays to methodically check each input, each jumper, and each parameter related to start/stop logic.

Troubleshooting Checklist for VFD Start/Stop Issues

When faced with a VFD that isn't running when it should, use this checklist to quickly pinpoint the problem:

1. **Verify Control Mode (Local/Remote):** Check if the drive is in "Hand" (local) mode expecting keypad commands. Look at the keypad indicators or parameters to ensure it's in "Remote"/"Terminal" mode. If not, switch it or adjust the appropriate parameter (e.g. ABB parameter 1103, Yaskawa b1-02, Lenze P100, etc., depending on drive).

2. **Inspect Start/Stop Wiring and Contact Types:** Trace the start and stop circuits. Is the Stop wired as a normally-closed loop through the correct terminal? Is the Start wired to the proper input? Use a multimeter or input status monitor to confirm the start button actually changes the state of the intended drive input. If using a selector switch (2-wire), verify it indeed outputs a maintained signal and isn't spring-loaded. Compare to the wiring diagram in the manual – are you on the right terminals?

3. **Check for Required Jumpers or Closed Circuits:** Identify any enable, interlock, or safety inputs on the drive:

4. Are there terminals labeled Enable, Safe, STO, or similar? Ensure they are jumpered or properly wired through safety contacts. For dual-channel STO, both channels must be closed.
5. Any terminal that the manual or wiring diagram shows a jumper across – make sure it's there (common examples: jumper between +24 and a DI for "Drive enable", or between two safe terminals).

6. If the drive has a "jumper plug" (some STO circuits use a removable plug), confirm it's inserted.

7. **Examine Digital Input Status LEDs/Display:** Most drives have LEDs near the terminals or a software monitor for inputs. Check which inputs the drive thinks are ON. This can be extremely revealing:

8. If your start input isn't lighting when you press start, you have a wiring or logic issue (wrong common, bad switch, etc.).
9. If an input you didn't expect is ON (e.g. an unused "Fault" input), that could be holding the drive in fault/inhibit.

10. If the Stop input is off (when it should be on), you likely have an open stop circuit (bad E-stop button, wiring open, or wrong NO/NC used).

11. **Look for Fault Codes or Alarm Messages:** Even if no overt "Fault" is blinking, check the drive's fault log or status word. Some drives indicate inhibit conditions via codes (like "UV" for undervoltage, "BB" for baseblock, "Not Ready", etc.). Compare any code or status message to the manual's list. For instance, an **"EF"** fault = external fault input triggered [21], **"SF"** = safety function active, **"USP"** (on Hitachi) = unattended start protection active, etc. These clues directly point to a wiring/logic cause.

12. **Measure Voltages at Control Terminals:** Using a multimeter, measure the voltage between the drive's +24 V and the digital input common (should be ~24 V). Then check each digital input terminal to common:

13. An active (closed) input in sourcing configuration will read close to 24 V (since it's connected to +24 through the contact) [5]. An inactive (open) one will read 0 V.
14. In sinking config (common = ground), an active input will be near 0 V (contact brings it to ground), and an open one will float high (somewhere near 24 V or whatever the pull-up voltage is).
15. If you see a half voltage (e.g. 12 V) or fluctuating reading, that suggests a floating reference or wrong wiring (the input's not being solidly pulled up or down). That's a sign to recheck your common wiring and sink/source setup [7].

16. Measure continuity on stop and interlock contacts to ensure they are closed when expected (e.g. E-stop circuit continuity should be good in normal condition).

17. **Confirm Parameter Settings for Inputs:** Dive into the programming if needed:

18. Ensure the drive is configured for the correct control scheme (2-wire vs 3-wire, keypad vs terminal, etc.).
19. Check if any digital input functions were altered from defaults. Sometimes a drive might be set up in a special mode (e.g. "3-wire with external trip"). Resetting to a known macro or default can be a quick way to rule this out, as long as you note any needed custom settings beforehand.

20. If using analog signals for speed, verify those too (e.g. correct AI scaling, or if using 4-20 mA, is a loop powered and jumper in place?). An incorrect analog configuration won't stop the drive from starting, but it may appear to "not run" if the speed reference stays zero. For instance, a drive set to receive 4-20 mA will treat 0 V as a fault or 0% speed, whereas if you're giving 0-10 V, the drive sees nothing. Many drives allow you to monitor the reference input value – check if it's changing as expected when you adjust speed command.

21. **Safety and External System Checks:** Ensure that any external interlocks (beyond the drive) are satisfied:

22. If there is a safety relay in series with the run circuit, is it energized and its contacts closed?
23. Are there any PLC interlocks or logic that might be preventing the drive from getting the start signal (for example, a PLC program might not be sending the run bit due to a permissive not met)?

24. If the drive is network-controlled (fieldbus), check that the drive is in remote mode and the control word from network is enabling it. A common hiccup is forgetting to send the "enable drive" command via network or the drive remaining in a mode waiting for hardwire control while you're sending network commands (or vice versa).

25. **Consult the Manual and Schematics:** This almost goes without saying, but the drive's user manual and the electrical schematics of the system are your best friends. Cross-verify the terminal numbers, any note about "factory default jumper" or "link terminals X-Y for 2-wire control" etc. Pay attention to footnotes in wiring diagrams. If the manual references IEC 61131-2 input type, it might list the voltage thresholds (e.g. >11 V = "1", <5 V = "0") – this helps in understanding any measured voltages that are borderline. Also check the **application notes** or troubleshooting section in the manual; manufacturers often list symptoms like "Drive indicates ON but motor not turning" with causes such as "Start command present at power-up – enable parameter to allow" [24] .

26. **Test in Manual Mode (if possible):** As a diagnostic step, try to run the motor from the keypad (most drives allow a manual run via the panel in local mode). If it runs fine locally, that proves the power section and motor are okay – the issue lies in the control wiring or configuration. If it doesn't run even in local mode, the problem might be more fundamental (e.g. motor wiring, drive fault, or the drive still seeing a safety inhibit that even local can't override, like STO open).

By methodically going through these steps, you can isolate nearly any start/stop wiring issue. Most fixes will be simple: adding a missing wire, flipping a switch, swapping NO/NC contacts, or toggling a parameter. Once corrected, your VFD should exit the "won't start" state and operate as intended.

Conclusion

Troubleshooting a non-starting VFD often comes down to carefully examining control wiring and logic. Seemingly minor details – a single jumper, a DIP switch, a normally-closed vs. normally-open contact – can determine whether the drive runs or stays stubbornly idle. By understanding how different brands implement start/stop and safety circuits, and by using a systematic approach (with reference to manufacturer documentation and industry standards), technicians and engineers can resolve these issues efficiently. Remember that modern VFDs provide a wealth of diagnostic information; interpreting indicators, fault codes, and input statuses is key to pinpointing a miswire or mis-configured setting. In practice, the question **“Why won’t my VFD start?”** is answered more often in the wiring diagram than in the repair shop.

With the tips, examples, and brand-specific notes provided here, you should be well equipped to diagnose common control wiring errors on VFDs from ABB, Lenze, Eaton, Hitachi, Yaskawa, and beyond. Always prioritize safety when making wiring changes – lock out power, confirm voltages – and verify operation thoroughly after the fix. In the end, attention to detail and adherence to the fundamentals of control circuit design will keep your drives running and your downtime minimal.

References

- ABB ACS550-01/U1 Drive **User’s Manual** – Sections on digital input wiring and sink/source configuration [5] [6]. (ABB Library No. 3AUA0000001367)
- ABB **Commissioning Guide** for ACS550 – Notes on using the drive’s internal 24 V for digital inputs and the need to jumper DCOM to 24 V or GND for proper input logic [8].
- ABB **E-Clipse Bypass** Panel **User Manual** – Example of required jumpers on enable circuits (terminals X2:3–X2:4 and X2:2–X2:7) to satisfy the “Enabled” interlock [11].
- **Lenze SMVector (AC Tech) Manual** – Terminal descriptions and configuration for Start/Stop, including the assertion level (A/L) switch for active-high/low selection and parameter settings for 2-wire vs 3-wire control [27] [28].
- **Yaskawa E7/A1000 Technical Manual** – Default control terminal functions (S1: Forward Run, S2: Reverse, S3: External Fault, etc.) and wiring diagrams for 2-wire vs 3-wire control [31] [9]. Also covers the start inhibit on power-up feature (parameter b1-17) [24].
- **Hitachi WJ200 Inverter Manual** – Function code reference for digital inputs (e.g. STA, STP, F/R for 3-wire control) and default terminal wiring expectations (FW, RV for 2-wire). Includes details on the USP (Unattended Start Protection) fault and BX interlock behavior [36] [37].
- **Eaton PowerXL DG1 Quick Start Guide** – Control wiring diagram and terminal functions (DIN1: Forward Start, DIN2: Reverse Start, DIN3: External Fault, DIN4: Reset, etc.), plus notes on configuring sinking vs sourcing input mode and the use of commons CMA/CMB [16] [7].
- **IEC 61131-2 Standard** – Defines digital input characteristics (Type 1, 2, 3) for 24 V DC inputs, which drive manufacturers adhere to for input threshold levels and currents [5].
- **UL508A / NFPA 79 Standards** – Guidelines ensuring industrial control wiring is safe and fail-safe. Emphasize use of NC stop circuits, separation of control and power wiring (to reduce noise), and proper grounding/shielding practices [43]. These standards provide the rationale behind many VFD default wiring practices (e.g. normally closed stop for safety).

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