Managing VFD Overvoltage Faults During Deceleration (Regenerative Surges)

Introduction

Variable Frequency Drives (VFDs) often experience **DC bus overvoltage faults** when decelerating motors with large inertial loads. This typically happens because the motor, suddenly forced to slow down, behaves as a **generator**, sending energy back into the drive. The drive's DC bus voltage then rises above safe limits, triggering an overvoltage trip. Overvoltage faults during deceleration are especially common in applications like large fans, pumps, and conveyors where the rotating mass or load momentum is significant [1] [2]. This article provides a deep technical look at why these faults occur and how to mitigate them. We draw on manufacturer documentation (ABB, Eaton, Hitachi, Lenze, Yaskawa), industry standards (IEC 61800 series, IEEE 519), and real-world case studies to illustrate best practices for managing regenerative energy in VFD systems.

Why Overvoltage Occurs During Deceleration

When a VFD-commanded deceleration is too rapid for a high-inertia system, the motor cannot dissipate its kinetic energy fast enough through friction or losses. Instead, the motor's rotor "overruns" the commanded speed and **enters generator mode**, feeding current back into the VFD's DC link capacitors [1] [3]. In normal operation, a VFD's DC bus is around $\sqrt{2}$ × AC line voltage (e.g. ~650 V DC for a 480 V AC system) [4] [5]. But regenerative current will **charge the DC bus capacitors** above this nominal level. Most drives fault out if DC bus exceeds roughly 130–150% of nominal voltage [6]. For example, a 480 V drive might trip around 780–800 V DC. Figure 1 illustrates this process.

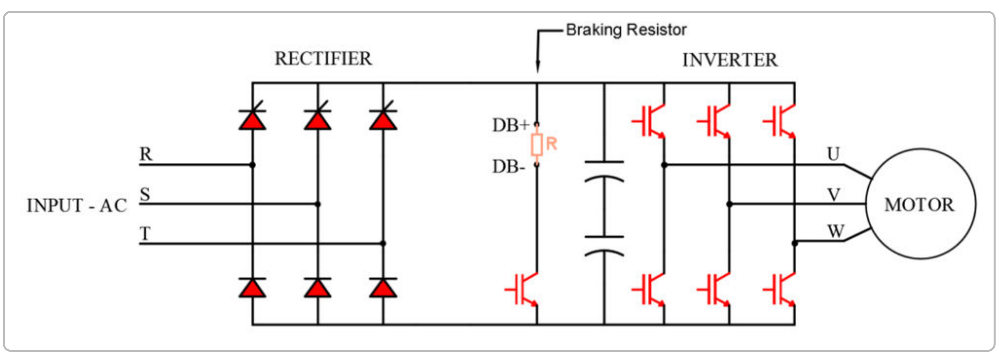

Figure 1: Simplified VFD schematic showing a rectifier (AC to DC), DC link capacitors, inverter (DC to variable AC), and a brake chopper + resistor on the DC bus. During deceleration of a high-inertia load, the motor (right) can generate power back into the DC link. A brake chopper transistor (DB+ to DB–) diverts excess energy into the braking resistor (R) to prevent DC bus overvoltage.

During a regenerative surge, DC bus voltage can spike quickly. **IEC 61800** (the standard for adjustable-speed drive systems) explicitly notes that during "special operation points" like *regenerative braking mode*, the DC link voltage will further increase beyond normal levels [7]. In other words, deceleration with an overhauling load raises DC bus voltage and risks tripping the drive on **OV (Overvoltage)** fault [1]. Many manufacturers document this behavior. For example, Hitachi's VFD manual explains that when the inverter commands a slowdown, *"the motor can temporarily become a generator… causing the inverter DC bus voltage to rise, resulting in an over-voltage trip"* [3]. Lenze likewise states that if a machine must be braked quickly, *"the motor… runs in regenerative mode"* and the energy must be dealt with (typically by a resistor) [8].

Why deceleration (vs acceleration) is a prime culprit: In acceleration, the VFD is drawing energy from the supply, and the limitation is usually current (leading to potential overcurrent faults if torque is insufficient). In deceleration, however, energy flows in reverse; a standard six-pulse drive cannot feed this energy back to the AC line because the input rectifier is one-way [9] [10]. The excess energy **charges the DC capacitors** instead. If the system inertia is large (e.g. big fan impellers, pump flywheels) or the decel time is very short, the bus voltage climbs until the drive's protection limit is exceeded. Overvoltage faults during decel are thus a telltale sign that *regenerative braking* is occurring without adequate handling [11] [2].

Common conditions leading to regenerative overvoltage include:

- **High-inertia loads decelerating too fast:** e.g. stopping a large fan or centrifuge quickly. The stored rotational energy flows to the drive as a surge [12].
- **Overhauling loads**: vertical loads or conveyors moving downhill – here gravity drives the motor faster than commanded, forcing energy into the drive.
- **Multiple coupled motors:** one motor acting as a generator on a shared load when another slows down.
- **External forces on stop:** e.g. water backflow turning a pump impeller when flow is suddenly reduced.

In all cases, the **DC bus acts as an energy buffer**. If its voltage isn't managed (through extended decel time or a braking mechanism), the drive will fault to protect itself [13]. Notably, overvoltage faults can also occur in other scenarios – power line surges, capacitor switching transients, etc. – but *deceleration regen is the most common cause* in healthy systems [11] [14].

Regenerative Energy, DC Bus Voltage, and Braking Circuits

Managing regenerative energy is crucial to prevent DC link overvoltage. Modern drives incorporate several features and optional hardware to handle this:

- **DC Bus Regulator / Overvoltage Control:** Many VFDs can automatically adjust or extend the decel ramp to limit bus voltage. For instance, ABB's drives have an *Overvoltage Control* algorithm that temporarily reduces the deceleration torque to keep the DC bus below the trip threshold [15]. On ABB ACS880 drives, this kicks in around 775–800 V DC for a 480 V system. Similarly, Yaskawa VFDs use **Stall Prevention** during decel (parameter L3-04 on GA800/A1000 series) which monitors bus voltage and modulates the slowdown rate to avoid tripping [16]. If enabled, the drive will **pause or slow the decel** whenever DC bus exceeds a preset level, then resume deceleration once voltage is under control [17]. These features are usually default-enabled and greatly reduce nuisance OV faults by "giving the bus more time to bleed off energy."

- **Dynamic Braking (Resistor + Chopper):** This is a hardware method to dissipate excess energy. A **braking chopper** (often an IGBT transistor, sometimes called the "7th transistor") is connected across the DC bus internally. When DC voltage rises to a trigger point (typically ~5% below the OV fault threshold), the transistor **turns on** and shunts current into an external **braking resistor** [18] [19]. The resistor, usually mounted outside the drive, converts the electrical energy into heat. For example, on a 460 V drive the brake chopper might activate around ~760 V DC, diverting energy so that the bus stays below ~800 V DC trip level [19]. Figure 1 (above) shows where the resistor ties into the DC link. Hitachi's drives note that their built-in braking unit will "send the regenerative energy from the motor during deceleration to the optional braking resistor(s)" to absorb it [20] [21]. Lenze likewise offers **ERBS brake resistor** modules for their inverters, stating that the regenerative energy *"can be dissipated with a brake resistor"* during rapid stops [8]. Dynamic braking is very effective and fast-acting – it engages in real-time as the voltage rises – but it *wastes* the energy as heat and requires correctly sizing the resistor (ohmic value and wattage) to the drive and duty cycle.

- **Regenerative Drives (Active Front Ends):** Unlike standard diode-bridge drives, **regenerative VFDs** or those with an Active Front End (AFE) can push power back onto the AC supply. These drives use an IGBT-based rectifier that allows bidirectional power flow. During decel, instead of dumping energy into a resistor, the drive actively inverts DC to AC and **sends energy back to the grid** or to a common DC bus shared by other drives. Fully regenerative drives eliminate the heat losses of dynamic braking and can improve efficiency in systems with frequent braking cycles (e.g. downhill conveyors, test dynos, elevators). However, regen drives are costlier and require attention to power quality – they often include filtering to meet IEEE 519 harmonic standards for feeding energy to the grid [22]. (IEEE 519 is the recommended practice governing harmonic distortion and clean power injection in industrial power systems.) Many modern drives (ABB ACS880, Rockwell PowerFlex 755TL/TR, Yaskawa U1000 matrix converter, etc.) offer regenerative or low-harmonic front-end options that comply with IEEE 519 limits out-of-the-box [23] [24]. Use of regen drives should also follow applicable IEC 61800-3 EMC requirements, since putting power back on the line can introduce electrical noise if not filtered.

- **Coast-to-Stop and DC Injection Braking:** These are alternative stopping methods. **Coasting to stop** simply means the drive disengages and lets the motor freewheel to a stop without actively decelerating – this avoids regeneration entirely (no active braking torque), at the cost of a longer uncontrolled stop. It's a viable strategy if overvoltage faults persist and fast stopping isn't required. **DC injection braking**, on the other hand, applies DC current into the motor windings to produce a stationary magnetic field that resists rotation (slowing the motor). DC injection **consumes energy from the DC bus** rather than supplying it, effectively acting as a brake without feeding energy back. Some drives allow a period of DC braking at the end of a ramp to help stop quickly without regen. However, DC injection can overheat the motor if used for too long, and it's typically only useful to stop the last bits of motion (it usually cannot absorb large amounts of energy as effectively as a resistor). Still, it's mentioned as an option in manufacturer guides for fast stops if dynamic braking isn't available [25].

To summarize, an overvoltage fault during deceleration is essentially the VFD protecting itself from excessive DC bus voltage. The cure is to give that regenerative energy somewhere to go (time, heat, or back to the source). In smaller drives, the DC bus capacitors and internal losses might absorb small regen surges. In larger systems, *either the decel is softened or additional hardware (resistors or regen units) is needed*. Table 1 below lists the typical overvoltage trip points and mitigation trigger points for various solutions:

Table 1 – Example DC Bus Voltage Levels (400–480 V class drives)

Condition	DC Bus Voltage (approx)	Action Taken
Idle / Nominal DC bus (480 V)	~650 V DC [4] [5]	(Normal operation)
Overvoltage fault threshold	~780–800 V DC [26] [27]	Drive faults if exceeded
Overvoltage Control kick-in	~750–770 V DC (5% below trip) [19]	Drives start extending decel (ABB, etc.)
Brake chopper activation	~750–760 V DC [19] [28]	Excess energy shunted to resistor
Absolute maximum DC (hardware limit)	~900+ V DC (varies)	Internal hardware protection, possible damage if exceeded

(Values are illustrative; exact numbers vary by manufacturer. For example, ABB ACS880 triggers OVC at ~775 V; Yaskawa GA800 at ~820 V; Rockwell PF755 at ~780 V, etc. Brake chopper turn-on is typically a few percent below the fault level.)

Relevant Standards and Regulations

Industry standards provide design and safety guidelines for handling regenerative energy in drive systems:

- **IEC 61800 series (Adjustable Speed Electrical Power Drive Systems):** This set of IEC standards covers general requirements, safety, and EMC for VFDs. For instance, IEC 61800-2 and -5 address safety of power drive systems, and acknowledge the need for managing regenerative energy. IEC 61800-8 (Technical Specification) explicitly discusses DC link dynamics, noting that *"network overvoltage or regenerative braking"* conditions can raise DC bus voltages above normal [7]. Compliance with IEC 61800 ensures the drive design accounts for such phenomena and includes appropriate protective functions. Additionally, IEC 61800-3 is the EMC (electromagnetic compatibility) standard ensuring that drives (including those with regen capability) do not emit excessive interference or harmonics into the environment [29].

- **IEEE 519 (IEEE Recommended Practice for Harmonic Control):** Regenerative drives injecting power back to the AC line must also control the quality of that power. IEEE 519-2014 sets guidelines for limiting total harmonic distortion (THD) and voltage distortion caused by nonlinear loads like VFDs. Drives with active front ends or regen units are often designed to meet IEEE 519 limits for current harmonics [24]. For example, GE's MV6 series regenerative medium-voltage drives are certified to meet IEEE 519 requirements without external filters [30] [24]. While IEEE 519 is primarily about steady-state harmonics, following it helps ensure that regenerative braking events don't cause unacceptable voltage distortion or transient disturbances on the supply. In practice, this may involve using filters (LCL filters on AFE drives), multi-pulse or active rectifiers, and proper system impedance to keep harmonics in check when feeding energy back.

- **Machine Safety Standards:** If a VFD-driven machine has to perform emergency braking or controlled stops, functional safety standards may apply (e.g., **IEC 61800-5-2** for safety functions in drives). Safe brake control and Safe Torque Off (STO) functions might be required for certain applications (like lifts or mixers) to ensure the braking action is failsafe. While not directly about overvoltage, these standards influence how braking is implemented (e.g. a safety-rated brake transistor or ensuring the dynamic brake doesn't interfere with safety stop logic).

Key point: Adhering to these standards means selecting VFDs and options that have been tested for regenerative handling and integrating any additional equipment (line reactors, filters, etc.) needed for compliance. For example, a fully regenerative VFD system should meet IEC 61800-3 for EMC, and its installation might reference UL or IEC guidelines on resistor thermal protection, wiring, and grounding (since brake resistors dissipate heat and can be a fire hazard if not installed properly). Always consult the drive's manual and application notes for how standards are met – many vendor manuals (ABB, Schneider, etc.) have specific sections on compliance with IEC/EN 61800-x and IEEE 519 for their solutions.

Mitigation Strategies for Deceleration Overvoltage

Manufacturers and industry experts recommend a combination of parameter tweaks and hardware additions to prevent overvoltage faults when stopping motors. Below are the **primary mitigation strategies**:

- **1. Increase the Deceleration Time:** The simplest fix is often to lengthen the VFD's decel ramp. A longer ramp means the motor's energy is spread out over more time, reducing the instantaneous power fed back. If an overvoltage fault occurs, doubling the decel time (or more) can often eliminate it [31] [13]. The downside is a slower stop, which may or may not be acceptable for production. Many drives also offer an "**auto-regulate**" feature (as discussed earlier: ABB Overvoltage Control, Yaskawa Stall Prevention) that *dynamically* extends the decel as needed. Enable these features if available – they effectively do this step for you by automatically adjusting decel to suit the load inertia. **Tip:** When commissioning a new VFD on a high-inertia system, start with a conservative (longer) decel time and shorten it gradually to find the point where OV trips occur. If a quick stop is essential, you'll likely need one of the hardware methods below.

- **2. Activate or Install a Dynamic Braking Resistor:** Adding a **braking resistor** is a highly effective solution for frequent or rapid decel requirements. Most VFDs in the medium power range (say 5 HP and up) have a built-in brake chopper transistor or offer it as an option. By wiring an appropriately sized resistor to the drive's DC brake terminals (often labeled B+ and B– or DC+/DB, etc.), regenerative energy during decel will be diverted to this resistor and burned off as heat [32] [8]. Manufacturer documentation (ABB, Eaton, Yaskawa, etc.) provides resistor ohmic values and power ratings suitable for each drive model – it's critical to follow these specs. **Selecting a resistor:** Every drive has a **minimum resistance** it can safely switch; using a lower-than-specified ohm value can draw excessive current and damage the chopper transistor [33] [28]. Conversely, a higher resistance limits current (which is safer for the drive) but also yields less braking torque (slower stopping). Also size the wattage and duty cycle for your application's braking energy – e.g. a 10 kW resistor at 10% duty might handle short braking events on a 100 kW motor, but continuous cyclic braking could require a higher duty or multiple resistors. As a rule of thumb, if a load is causing OV faults, adding dynamic braking will almost always cure it, provided the resistor can absorb the energy. Be sure to mount braking resistors with adequate ventilation and use the thermal switch (if provided) to fault or alarm the drive on resistor overheating [34].

- **3. Use an Active Regenerative Front End or Regen Unit:** For applications where energy saving is a priority or the braking duty is high, a regen-capable drive is ideal. Instead of dissipating the energy as heat, a regen unit (either a full Active Front End drive or a retrofit module like those from Bonitron or Rockwell Line Regeneration units) will feed the power back to the facility's AC supply. This can improve efficiency (especially for very frequent braking, e.g. downhill conveyors, test stands, elevators making many stops, etc.). From a user perspective, a regen VFD will not trip on overvoltage during decel because it actively regulates the DC bus by exporting power. However, the system design is more complex: regenerative drives must be tuned for power quality and often need line filters to meet IEEE 519. They also tend to be more expensive upfront. Use regen drives when the recovered energy justifies it or when braking power is beyond what resistors can reasonably handle (for example, stopping a 1000 HP motor frequently might make resistor banks impractical, whereas a regenerative unit can handle it continuously by design). Ensure any regen solution is compatible with the local grid (some regions have codes for feeding energy from drives back into the network).

- **4. Enable Coast or use Mechanical Braking if Possible:** In scenarios where product or process doesn't demand an electronic deceleration, simply allowing the motor to **coast to a stop** can avoid overvoltage trips. This might be acceptable for fans or blowers where an uncontrolled rundown is fine. If an **external mechanical brake** is present (such as on a hoist or winch), the VFD can be programmed for "coast stop" and let the mechanical brake bring the load to rest – this way the drive isn't actively braking and thus no regen occurs (the motor just goes idle and the brake absorbs the energy). This method should be approached carefully: coasting means loss of electrical control during stopping, and mechanical brakes have wear and tear. But as a backup or added measure, many drives let you select "Ramp" vs "Coast" stop modes; choosing *Coast* will eliminate regenerative faults (the trade-off being the motor might take a long time to stop if not mechanically braked) [25] [35]. Mechanical braking is commonly combined with VFDs in elevators and cranes – the VFD does most deceleration but the physical brake sets at very low speed or at stop to hold the load. In case of an overvoltage fault scenario, you might increase the role of the mechanical brake to shed more energy.

- **5. Check Incoming Supply and Add Line Choke if Needed:** Although deceleration regen is usually the culprit, sometimes a drive faults on OV due to a high or unstable supply voltage. If your facility voltage is at the upper end of the drive's tolerance (e.g. a "480 V" system actually running at 495 V AC), the DC bus is closer to the trip point even without regen. In such cases, a small overshoot can trigger a fault. A solution is to ensure the drive is tapped to the correct nominal voltage in parameters (some drives let you set input voltage which biases the OV threshold) [36] [37], or use an AC line reactor / DC choke. **Line reactors** add impedance that can reduce the rate of rise of the DC bus during surges and also protect against line-side transients. They won't absorb major regen energy (they mainly filter harmonics and limit inrush), but they can attenuate nuisance tripping from minor bus spikes or resonance. In summary, verify the supply voltage and grounding: an ungrounded system or phase imbalance can confuse the VFD's sensing and cause false OV trips [38]. Ensuring a solid ground and proper supply within spec (or using a transformer to buck high voltage) provides more headroom on the DC bus.

- **6. Maintain the Drive and Braking Components:** An often overlooked aspect – if a drive *used to decelerate fine* but now suddenly trips on overvoltage, it could indicate a failed component. For example, a **braking resistor that went open-circuit** or a blown fuse on the brake unit will disable dynamic braking, causing immediate OV faults on decel [39] [40]. Similarly, a failed brake chopper transistor (stuck open) means no energy gets diverted. Regularly check the resistor continuity and the brake transistor's operation (many drives have a "brake test" or you can simply monitor DC bus on a fast stop to see if it clamps). Degraded DC bus capacitors can also reduce the drive's energy absorption capacity – if the caps are old, the DC voltage may rise faster than it used to. Preventative maintenance (capacitor replacements per manufacturer's interval) keeps the drive's internal buffering effective. Keep cooling fans and heatsinks clean too; overheated drives can malfunction or trigger faults erroneously. In short, ensure all the pieces of the braking system (software and hardware) are healthy to minimize overvoltage risk.

By combining these strategies, you can often **eliminate overvoltage trips** even for very demanding deceleration profiles. For instance, one could both increase decel time moderately *and* add a small braking resistor – the decel doesn't have to be made overly long, and the resistor only handles the peak energy. Or use an active regen unit for continuous braking and a resistor as a backup for abnormal conditions. The right approach depends on the application's needs (cycle time, energy efficiency goals, budget, etc.).

Real-World Application Examples

Example 1: High-Inertia Fan – An HVAC plant had a large centrifugal **blower fan** driven by a 100 HP VFD. When the stop command was given, the drive frequently tripped on DC bus overvoltage. The fan's inertia kept it spinning (acting as a windmilling generator) for too long during the 5-second decel ramp. As a quick test, the technicians extended the decel to 15 seconds; the overvoltage faults stopped occurring, but the slow coast-down was impractical for operations. The solution was to install a dynamic brake resistor sized for 100 HP duty. With the resistor in place, the drive could stop the fan in 5 seconds without any OV trips – the DC bus peaked at about 730 V (well below the 780 V trip point) as the excess energy was dissipated in the resistor. The baseline vs. outcome: before, a 5s stop caused repeated faults; after, the 5s stop was achieved reliably, and measurements showed the resistor momentarily absorbing ~8 kW of power during each stop (preventing the DC bus from rising too high). This matches common practice: fans are classical cases for needing braking resistors or longer decel times due to their rotational energy [12] .

Example 2: Pumping System Water Hammer – A large water pump (300 kW) in a municipal water treatment facility was VFD-controlled. During an emergency stop, the sudden reduction in flow caused water in the vertical pipe to reverse briefly, turning the pump into a turbine. The VFD would fault on overvoltage nearly every time the pump was stopped quickly, due to the surge of regenerative energy from the backflow. The immediate fix was to program the drive to **coast to stop** for emergency conditions (allowing the pump to freewheel and the check-valves to catch the reverse flow). This eliminated the faults since the drive no longer tried to actively brake the pump. However, it also meant the pump took longer to stop and there was a risk of mechanical strain from the water hammer. The engineering team opted to add a combination of a braking resistor and a slower ramp: a 20-second controlled decel with dynamic braking. This reduced the water hammer effect while still controlling the stop. No more OV faults occurred because the resistor absorbed the energy from the residual backflow generation. In summary, the **baseline** was OV faults on fast stops; the **outcome** was a compromise solution (moderate decel + brake resistor) that protected both the electrical and mechanical system.

Example 3: Downhill Conveyor – Consider a conveyor belt in a mining operation that runs downhill loaded with material. The VFD driving the conveyor was experiencing frequent overvoltage warnings when trying to slow or hold a constant slow speed downhill – essentially the load was *continuously* pushing the motor. In the **baseline scenario**, the operator had lengthened the decel time and even set the drive to a higher speed in attempts to avoid regeneration (effectively using the material's potential energy to keep the belt moving). This was suboptimal for control and caused excessive speed variation. An engineered solution was implemented: the drive was upgraded with an **active front end (regen capability)** so it could hold the conveyor speed and dynamically send excess power back to the grid. After this retrofit, the conveyor could be brought to a stop under full load without any fault, and even during running, the drive in regen mode maintained a stable speed while returning about 50 kW of braking power to the supply (measured as reduced line draw). In terms of metrics, previously the conveyor's decel had to be very gentle (to avoid OV, taking ~60 seconds to stop), whereas **after** the regen drive, it could stop in 20 seconds while actually regenerating energy. Additionally, production was improved since the drive could actively control speed downhill rather than "riding" the load. This example highlights that for continuous or high-duty braking, a regen solution is often more appropriate than a resistor (which would overheat on a long downhill run). As noted in an industry case, simply increasing decel time can reduce trips but at the cost of process efficiency – *"deceleration had been increased on the drive to prevent tripping, and this decreased production"*; adding a proper braking method lets you regain that performance [41].

Example 4: Medium Voltage Compressor – In an oil & gas application, a medium-voltage VFD driving a large gas compressor occasionally tripped on overvoltage when the compressor was tripped (emergency shutdown). The inertia in the compressor and the high-speed motor (>3000 RPM) meant a huge amount of energy was in the system. Initially, they relied on the drive's internal **bus capacitors and overvoltage control** to catch this, but that was insufficient for a fast stop. The resolution was installing a **crowbar circuit** (a form of dynamic brake in MV drives) that could dump the energy into a resistor bank. Additionally, the system was tuned per **IEEE 519** and IEC standards by adding a line filter to handle the transient when the resistor dumped energy (to avoid sending a spike back into the grid). Post-fix, the drive could survive an emergency stop without any OV fault, and the energy was safely discharged. This example underscores that at higher power levels, custom braking solutions (and adherence to standards) become crucial – the drive was certified to IEC 61800-4/5 and IEEE 519 as part of ensuring stability in such events [42].

Each of these examples reflects a common theme: **before mitigation**, the drive's DC bus would reach the overvoltage trip point during decel, causing faults or necessitating undesirable slowdowns; **after mitigation**, the regenerative energy was either gradually bled off or actively handled, keeping the DC voltage in check and eliminating the fault. In quantitative terms, successful mitigation often keeps the peak DC bus voltage tens of volts below the trip threshold where previously it was exceeding it. For instance, one might see a peak of 720 V DC after fixes versus 810 V DC before – a small difference in voltage but the difference between normal stop and a fault lockout. Operationally, downtime is reduced and the drive/system life is preserved (since frequent overvoltage trips can stress the capacitor bank and other components).

Implementation Tips and Best Practices

When selecting, programming, and installing VFDs to minimize overvoltage risk, consider the following best practices:

- **Assess the Application's Braking Needs:** Before finalizing a drive, evaluate if the load can become regenerative. High inertia (fans, flywheels) or potential energy (hoists, downhill conveyors) are red flags. Choose a drive that either has a built-in brake transistor or offers a braking module option. If braking energy is significant, consider a regenerative drive or at least ensure the drive is **oversized** enough to handle transient bus overvoltages (some drives have bigger capacitor banks or DC chokes internally which raise their tolerance).

- **Follow Manufacturer Sizing Guidelines:** Use manufacturer tools or tables to size dynamic braking resistors. For example, Rockwell's drives have a minimum ohm value listed for each power rating [28] ; Yaskawa and ABB provide resistor kits with known safe values. Also account for duty cycle – how frequently and for how long braking occurs. **Never undersize** a brake resistor (risk of overheating or insufficient braking) and **never go below min resistance** (risk of transistor failure) [33] . If unsure, err on the side of a larger resistor (higher ohms) and longer decel time, then adjust as needed.

- **Enable Overvoltage Control Features:** Make sure any overvoltage suppression, stall prevention, or power ride-through settings in the drive are properly configured. ABB drives, for instance, have a parameter to turn on Overvoltage Control (which is usually on by default) – this allows the drive to automatically extend decel to avoid tripping [43] . Yaskawa drives default to Stall Prevention "General" mode, which helps avoid trips during decel [17] . Understand these parameters from the manual and use them; they act as a safety net. One caution: if you do install a physical braking resistor, some drives recommend **disabling the overvoltage stall function** so that the drive doesn't fight the resistor (Yaskawa's manual suggests turning off stall prevention if dynamic braking is used, so that it fully dumps energy into the resistor) [44] [45] . The idea is to either use the resistor or the slow-down method, but not both simultaneously, unless the drive coordinates them (some have a specific mode for "with DB resistor" as Yaskawa does with L3-04 setting 3) [46] .

- **Use Proper Braking Transistor Wiring and Fusing:** When installing external brake resistors, always follow the wiring diagrams. Keep the leads from drive to resistor short (manufacturers often specify a max cable length, e.g. <5 m [47]) to avoid inductance that could cause voltage spikes. Use the recommended fuses or thermal cutouts in series with the resistor – these protect against resistor overheating or a shorted transistor. Mount resistors away from heat-sensitive equipment and provide enclosures or guards as needed (they can run very hot). If multiple drives need braking, you generally need separate resistors per drive, unless using a common DC bus system with a shared chopper.

- **Consider a Common DC Bus for Multiple Drives:** In some installations with multiple motors, linking their DC buses together can let them share energy. For example, if one motor is braking while another is accelerating, the regen energy can be used by the other drive. This requires drives that support DC bus sharing (often same model family and some configuration of tie chokes or DC connections). A common DC bus or a DC-link choke between drives can reduce the amount of energy that goes wasted and minimize overvoltage incidents by balancing energy flow. This is an advanced design approach and needs careful engineering, but it's employed in systems like paper mills or multi-axis machines where motors frequently alternate between motoring and regenerating.

- **Implement IEEE 519 Compliance for Regen Units:** If using an active front end, ensure the installation meets harmonic guidelines. This may involve adding line reactors or filters. Many regen drives come with built-in filters (as noted in some Schneider and ABB regenerative unit datasheets compliant with IEC 61800-3 EMC standard [48]). Double-check if additional external filtering is needed to hit IEEE 519 limits at your point of common coupling (PCC), especially if the power system is weak or the drive is a large portion of the load.

- **Test Under All Operating Conditions:** Don't just test deceleration under no-load; also test under full load and worst-case scenarios. Some overvoltage faults only appear in specific conditions (e.g., a conveyor may not regenerate when empty but will when loaded). If the drive has a **"stop mode"**

setting, try both ramp and coast to see how the system behaves. Use the drive's monitoring features or a multimeter on the DC bus to observe the peak voltage during stops. Many VFDs can display DC bus voltage on their keypad – watch it during a normal stop vs an emergency stop. This helps verify if your mitigation (resistor or extended ramp) is sufficient, or if the voltage still nearly hits the limit (in which case, further action is needed).

- **Plan for Fault Handling:** Despite best efforts, there may be scenarios (emergency stops, power failures causing regenerative "bus pump-up" effects [49]) that still produce an OV fault. Ensure your control system safely handles a drive fault – e.g., mechanical brakes engage if the VFD faults so the load doesn't freewheel dangerously. Some drives offer a "bus overload ride-through" that tries to use regenerative energy to keep running (or powers the logic) during a power outage – understand these features if applicable (sometimes called KEB – kinetic energy buffering). The goal is a controlled response even in fault conditions.

By following these guidelines, you'll greatly reduce the risk of overvoltage trips and improve the reliability of VFD-driven systems. In essence, always give regenerative energy the respect it deserves: either *provide it a path to dissipate safely or prevent it from building up in the first place*. A well-configured VFD system can handle deceleration of large loads gracefully, as evidenced by countless industrial applications where dynamic braking or regen drives keep things running smoothly.

Conclusion

Overvoltage faults during deceleration are a common challenge in VFD applications, but they are well-understood and manageable with the right techniques. By recognizing why they occur – regenerative energy returning to the drive – and implementing appropriate countermeasures, engineers can **ensure safe and efficient braking** of motors without nuisance trips. Whether it's through simple parameter tweaks (longer decel time, enabling overvoltage control) or adding hardware like braking resistors or regenerative front-ends, there are proven solutions for every scale of problem. It's also important to consider industry standards: designs that align with IEC 61800 guidelines and IEEE 519 recommendations will not only solve the immediate issue but also integrate well into the broader electrical system. The examples from fans, pumps, and conveyors show that after mitigation, operations can achieve the desired stopping performance reliably – often turning a troublesome, fault-prone process into a smooth one with minimal downtime. Ultimately, managing regenerative surges in VFDs is about balancing energy: capturing it, redirecting it, or dissipating it in a controlled manner. With proper drive selection, tuning, and accessories, **overvoltage faults on decel can be virtually eliminated**, leading to safer and more productive automation systems.

References:

1. Voltage Disturbance – *"Troubleshooting VFD Problems – Overvoltage Fault."* (2018) – Guide explaining VFD DC bus overvoltage causes and solutions [50] [32] .

2. Joliet Technologies Blog – *"Over-Voltage: Typical VSD Faults and How to Troubleshoot Them."* (2019) – Technical article discussing drive OV faults, regenerative braking, ABB and Yaskawa drive features [1] [51] .

3. Hitachi Industrial – **Hitachi SJ200 Series Inverter Manual**, Section 5.2 (Dynamic Braking) – Explains regeneration during decel and use of internal braking unit with resistor [52].

4. Lenze Product Catalog – *ERBS Brake Resistors Description* – Notes that in regenerative braking mode the energy can be dissipated in a brake resistor [8].

5. ESE (Electric Supply & Equipment Co.) Knowledge Base – *"Drive Overvoltage Fault – Causes and Mitigation."* – Lists overvoltage causes and suggests extending decel time or adding dynamic brake for regen during decel [2].

6. ABB Drives Technical Note – **ABB ACS880 Overvoltage Control** – Describes overvoltage control function that extends decel to avoid OV trips (referenced in Joliet blog) [15].

7. Yaskawa Electric – **Yaskawa A1000/GA800 Drive Technical Manual**, "Stall Prevention" – Parameter L3-04 options to prevent OV by pausing decel or working with brake resistors [17].

8. IEC Standard 61800-8:2010 – *Adjustable speed electrical power drive systems, Part 8* – Notes that regenerative braking mode can raise DC link voltage [7].

9. IEEE Standard 519-2014 – *IEEE Recommended Practice on Harmonic Control* – (Referenced via GE MV6 drive documentation showing compliance [42]) relevant for drives with regen to ensure power quality.

10. Rexel USA – *"Basic Rules for Dynamic Braking Resistors."* (2020, Scott Savage) – Blog post with example of downhill conveyor needing bus regulator and brake resistor to stop without OV fault [41] [28].

11. Reddit r/PLC Thread – *"VFD overvoltage issue."* (Discussion) – Community advice noting OV faults are common on decel without a braking resistor [53] and importance of correct drive voltage settings [37] (Not an official source, but experiential insight).

12. GE Automation – **MV6 Medium Voltage VFD Brochure** – Highlights an active front end drive capable of four-quadrant (regen) operation and certified to IEC 61800-3/4/5 and IEEE 519 standards [42].

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