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Reinforcing Reliability: Advanced Cell Bypass

VFDs offer effective process control, but only Siemens SINAMICS PERFECT HARMONY VFDs reinforce critical process reliability with fault-tolerant Advanced Cell Bypass technology.

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For decades, versatility and potential cost savings have spurred the use of medium voltage variable frequency drives (VFDs) in a wide range of applications (Table 1). Very few medium-voltage applications require full motor use at all times, so VFDs are an effective way to adjust the power accordingly and reduce superfluous energy consumption.

From pipelines with fluctuating flows to mine conveyors with variable throughput, even trimming a small percentage of an application's operating load can lead to significant energy savings. In this way, VFDs give manufacturers greater control over their processes and energy costs; but aside from reducing motor wear and tear, they don't inherently prevent process breakdown.

The Advanced Cell Bypass technology found in Siemens SINAMICS Perfect Harmony VFDs adds reliability to the list of advantages offered by VFDs. Drawing on the drive's modular series-cell topology, Advanced Cell Bypass keeps the cells in each phase isolated, allowing the drive to bypass failed cells and maintain a balanced power output. Other popular multilevel topologies—such as the flying capacitor circuit, NPC and CSI topologies—are unable to tolerate power component failure without total VFD system shutdown.

To optimize production, the ideal drive solution for a medium-voltage application is one that matches power output with load demand and promotes fault-tolerant reliability. Any VFD can improve process efficiencies, but only Siemens SINAMICS Perfect Harmony VFDs also reduce downtime by integrating the failsafe assurance of Advanced Cell Bypass.

Leading Medium Voltage VFD Applications in Major Vertical Industries	
Building automation	Cooling tower pumps, cooling tower fans, chiller fans, chilled water pumps, refrigeration compressors
Chemical and petrochemical	Utility pumps, process pumps, fans, blowers, air compressors, process compressors, coolers, cooling tower pumps, cooling tower fans
Food and Beverage	Utility pumps, fans, blowers
Mining	Conveyors, ball mills, grinders, crushers, mobile equipment (haul trucks, draglines, shovels)
Oil and gas	Utility pumps, process pumps, fans, process compressors, air compressors
Power	Induced draft fans, forced draft fans, cooling tower pumps, cooling tower fans, atomization air compressors
Water / wastewater	Process pumps, fans, blowers, air compressors

Table 1

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The Impact of Failed Power Components

In traditional VFDs, if a power component fails, it brings the entire process—and sometimes the entire plant—to a standstill. Before the cell component can be replaced, the drive and motor have to wind down; once it is replaced, more production time is lost while the drive restarts and the motor gets back up to speed. These interruptions not only affect the production line, but also have an impact on the entire supply chain. Fines and business relationships damaged by missed delivery dates can quickly snowball into significant losses. In the year 2000, unexpected downtime cost U.S. manufacturers an estimated $1.5 million per hour in revenue.

Costs related to downtime include:

- Wages of idle workers
- Overtime wages for maintenance workers
- Spare part and repair expenses
- Startup power consumption
- Waste due to incomplete production
- Delayed shipment charges
- Damage to stakeholder relationships

If no replacement components are on hand, lengthy lead times can render equipment inoperable for weeks, extending downtime to the point where, for some facilities, it actually becomes more cost-effective to purchase an entire new drive. For many topologies, component failure and system shutdown are virtually unavoidable due to a lack of redundancy. But with SINAMICS Perfect Harmony, Advance Cell Bypass protects critical process reliability by ensuring 99.99 percent availability even in the event of power component failure.

Typical Power Schematic of SINAMICS Perfect Harmony Drive

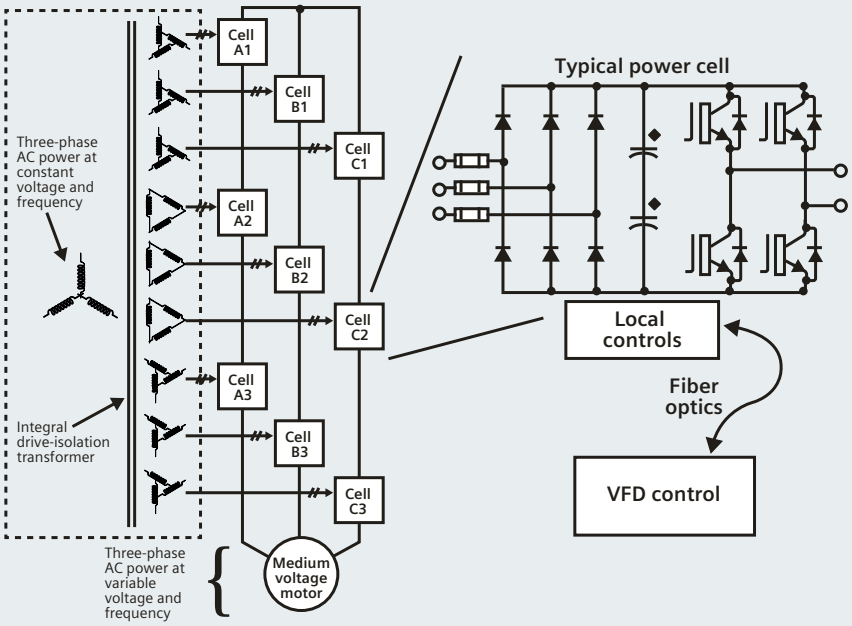

Figure 1

How Advanced Cell Bypass Prevents Shutdowns

In the SINAMICS Perfect Harmony topology, a series of low-voltage cells are linked together to provide the power output of the drive system (Fig. 1). This provides the modularity needed to achieve optimal reliability and power quality. SINAMICS Perfect Harmony is unique because its redundant bypass controls are kept separate from each cell, allowing the drive to withstand failures that would overwhelm conventional drives.

Figure 2 illustrates a simplified diagram of a 15-cell drive under normal operating conditions. 100 percent of the cells are functional and producing 100 percent of the voltage required by the application. Figure 3 reflects a scenario in which two of the cells in phase A have failed and are automatically bypassed. Here, 87 percent of the cells are in use, but because the star point is fixed to the neutral of the motor, the output voltage becomes unbalanced.

The simplest way to bring the voltage back into balance would be to bypass an additional pair of cells in each of the other phases (Fig. 4). However, this approach reduces the drive's output capabilities, delivering only 60 percent of the original voltage. The optimal solution, then, is a series-cell configuration in which the star point is not connected to the neutral of the motor.

Because the cells in each phase of a SINAMICS Perfect Harmony drive are in series, the star point is floating and can be shifted away from the motor neutral to adjust the phase angles and maintain a balanced output. Figure 5 illustrates how this neutral-shift approach rebalances the drive output by adjusting phase angles rather than bypassing functional cells.

If a cell in a SINAMICS Perfect Harmony drive fails, Advanced Cell Bypass automatically isolates the cell by activating its mechanical bypass contact (Fig. 6) and then adjusts the phase angles of the remaining cells accordingly. As a result, the drive is able to bypass failed cells and resume operation in less than 0.25 seconds—at a balanced voltage of up to 80 percent—effectively preventing process interruption (Fig. 7).

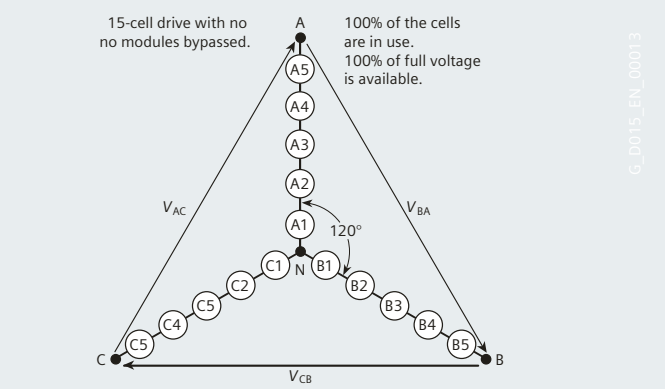

Figure 2 — Simplified diagram of a 15-cell drive

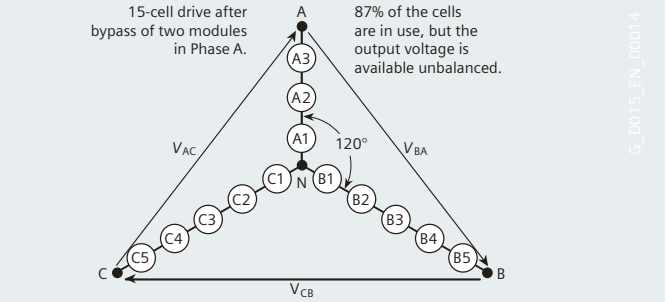

Figure 3 — Drive with two cells bypassed in Phase A

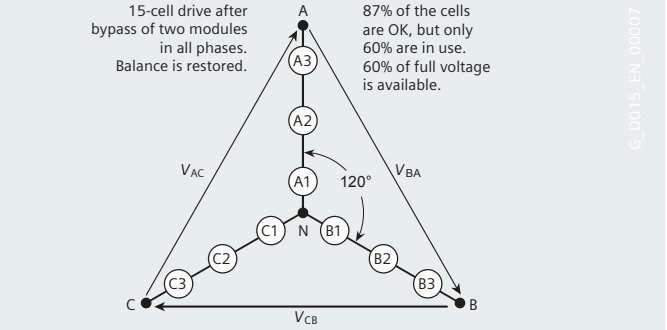

Figure 4 — Bypassing functional cells to rebalance drive output

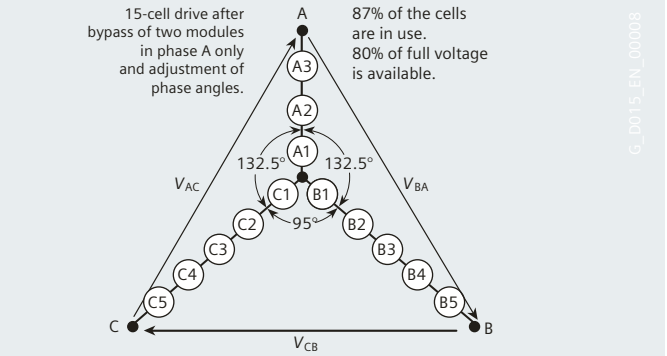

Figure 5 — Adjusting phase angles to rebalance drive output (neutral shift)

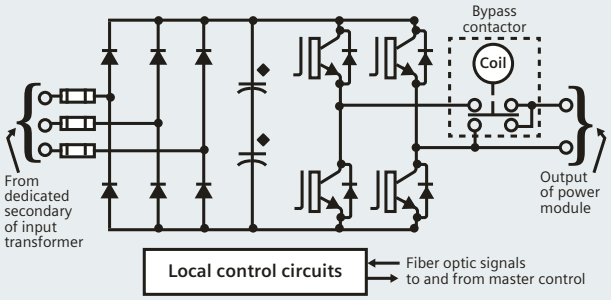

Figure 6 — Power cell with mechanical bypass contactor

Figure 7 — Failed cells bypassed and power restored in < ¼ of a second

A Reliable Process Maximizes Profits

Unplanned shutdowns are anathema to manufacturers in any industry. Downtime not only halts production—cutting into profits—it also results in additional maintenance costs and drives up the total cost of ownership for critical equipment. When it comes to drive systems, reliability is the industry watchword for good reason: A more reliable drive facilitates a more reliable process that, in turn, yields a more reliable product. In this way, reliability directly contributes to profitability.

The SINAMICS Perfect Harmony drive is engineered to maximize productivity and protect manufacturing processes in a way other drives cannot. Its modular topology and Advanced Cell Bypass technology allow for a scalable, fault-tolerant solution with more than 200,000 hours MTBF. This translates to greater throughput, superior reliability and a significantly reduced total cost of ownership over the drive's lifecycle.

As mentioned before, energy efficiency is another cost-effective benefit of VFDs with high reliability. VFDs can help minimize energy consumption, but in many cases all it takes is a single cell fault for downtime costs and restart expenditures to negate any cost savings. The inherent reliability of the fault-tolerant Advanced Cell Bypass technology found in SINAMICS Perfect Harmony VFDs protects against these losses to maximize the savings gained through precision process control.

Conclusion

VFDs have long been the industry go-to for improving the efficiency of variable processes, and their economical energy use has saved manufacturers significant sums in operating costs. But they can only provide these benefits when they're up and running. If a VFD is unreliable, unexpected downtime expenses have the potential to not only wipe out the cost savings associated with VFDs, but also chip away at profits.

This means that, ultimately, the ideal solution is a VFD with proven reliability—and the Siemens SINAMICS Perfect Harmony VFD delivers just that. With 50+ patented technologies, a modular series-cell topology, cell redundancy and Advanced Cell Bypass, it offers 99.99 percent availability for critical applications.

Advanced Cell Bypass prevents process interruption by bypassing failed cells in less than a quarter of a second and adjusting the phase angles to provide continuous balanced output voltage. The reliability this technology offers manifests itself as a precision-controlled process that yields greater profits by minimizing unplanned downtime. This has led the SINAMICS Perfect Harmony VFD to become the only drive approved for use in nuclear applications—and the No. 1 selling drive worldwide.

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