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Lenze SCL Variable Frequency Drives (VFDs)

Overview

The **Lenze SCL Series** is a line of compact AC **variable frequency drives** designed for versatile motor speed control in a wide range of equipment. Manufactured by Lenze AC Tech, the SCL drives cover output ratings roughly from **1/3 HP up to 15 HP** (0.25–11 kW) and support common supply voltages (120 V, 230 V, and 480 V) for controlling standard three-phase AC motors [1] [2]. These drives are built in a space-saving **IP20 enclosed** format and utilize a robust **V/Hz (volts-per-hertz)** control scheme for reliable open-loop speed regulation of induction motors. Originally based on Lenze's popular SM/SC series sub-micro drives, the SCL models distinguish themselves by including an **integrated line filter** for electromagnetic interference (EMI) suppression, allowing them to meet stringent European EMC standards (EN 61800-3) for noise immunity [3]. In fact, the SCL series was developed to target applications requiring compliance with the **EU Low Voltage and EMC Directives**, making them suitable for export machinery and operation in noise-sensitive environments. Aside from the built-in filter, the SCL drives are functionally identical to Lenze's standard sub-micro drives (SCM series) – offering the same performance and features – but with the added benefit of **reduced RFI emissions** out-of-the-box [4] [5].

In practical terms, an SCL VFD enables precise **variable speed, soft starting, and reversing** of motors in industrial and commercial equipment. Instead of running motors at full speed or relying on mechanical speed changers, using an SCL drive allows speed to be **electronically adjusted to match the process requirements**, which improves efficiency and reduces wear. These drives can even serve as a **phase converter**, powering a three-phase motor from a single-phase 230 V supply – a useful capability in facilities that lack three-phase utility power [6] [7]. By virtually eliminating the need for multi-speed motors, mechanical variators, or separate reversing starters, the SCL series provides a modern all-in-one solution for motor control. Common applications include conveyors, packaging machines, pumps, fans, HVAC systems, material handling, and many other systems where **precise speed control and energy savings** are desired. The SCL drives are **ready to use out of the box** for simple applications, and they can be reprogrammed to handle more advanced functions (such as preset speeds, jogging, or dynamic braking) as needed [8] [5].

Technical Specifications

Lenze SCL VFDs are available across several input voltage ratings and motor power sizes, offering flexibility to match different electrical systems. Key technical specifications are summarized below:

- **Power Range:** Available models support motors from **0.33 HP up to 15 HP** (approximately 0.25–11 kW) at 208–240 V input, with single-phase input models up to 3 HP. (The SCL series specifically covers **240 V single-phase input models up to 3 HP**, while the broader Lenze SC family includes three-phase input models up to 15 HP) [4] [7]. All drives output three-phase power to the motor (e.g. 240 V three-phase output from a 240 V single-phase supply). This allows use of standard three-phase motors even on single-phase mains supply. Higher-voltage versions (400/480 V three-phase input)

exist in the product family for larger motors (5–15 HP), though those higher-power units are typically the SCM variant without internal filter.

- **Input Supply and Ratings:** SCL drives accept nominal input voltages of **120 V AC, 208–240 V AC, or 400–480 V AC**, depending on model [9]. The drives tolerate ±10% voltage fluctuation (down to –15%) and input frequencies of 48–62 Hz [9]. Single-phase input is used on 120 V and 240 V models (denoted by an "S" in the model number), and three-phase input on higher voltage models. Input current draw will vary by model and motor size – for example, a 0.5 HP (0.37 kW) unit draws about 5–6 A on 240 V single-phase, while a 3 HP (2.2 kW) unit draws around 21–24 A [10] [11]. Despite their small size, SCL drives incorporate a **built-in EMI/RFI line filter** (on the SCL models) to mitigate electrical noise back into the mains, which is crucial for meeting **CE EMC compliance (EN 61800-3)** without additional external filters [3] [5]. All units are **UL 508C approved** for power conversion equipment and carry the CE Mark, complying with the Low Voltage Directive (EN 61800-5-1 safety standard) and EMC Directive requirements [12] [13]. The drive electronics are highly efficient (up to ~98% efficiency) and offer a high input power factor (≥0.96) for minimal wasted energy [14].

- **Output and Control:** The SCL drives provide a three-phase AC output with sine-coded PWM waveform to run standard induction motors smoothly. The **output frequency** is fully adjustable from 0 Hz up to **240 Hz** maximum [14], allowing for considerable overspeed in applications like spindles or high-speed fans if the motor is capable. **Carrier frequency (PWM switching frequency)** is programmable between 4 kHz and 10 kHz; higher carrier frequencies can reduce motor noise but may require derating the drive output slightly (the drive is rated for full load up to ~8 kHz carrier, with a derating factor applied at 10 kHz) [15]. The drives are rated for a **service factor of 1.0** (no continuous overload) under normal conditions, but they can handle **overload surges of 150% for 60 seconds (1 minute) or up to 180% for 30 seconds** before tripping, providing ample torque for starting heavy loads or overcoming brief overloads [16]. This built-in solid-state motor overload protection is UL-recognized, so no external thermal overload relay is required for motor protection [17]. The SCL can operate in standard **V/Hz control mode** with either a **constant torque** profile (for loads like conveyors or positive displacement pumps) or a **variable torque** profile (for centrifugal fans/pumps where torque drops with speed) [18]. An automatic **slip compensation** feature adjusts output frequency under changing load to help maintain steady motor speed, which means the drive will slightly increase voltage/frequency as load increases to counteract motor slip [19]. For stopping, the drive can apply **DC injection braking** (DC current into the motor) to bring the motor to zero speed quickly – programmable for up to 60 seconds or more of braking at stop, and even capable of continuous DC hold for use as an electronic holding brake in some cases [20] [21]. An optional **dynamic braking kit** is available as well, which includes a resistor module and control electronics to dissipate energy from high-inertia loads, allowing **fast deceleration and stopping** without tripping on overvoltage [22] [23].

- **Environmental Ratings:** The drives are designed for indoor installation (IP20 enclosure) with an ambient operating temperature of **0°C to 40°C**. Above 40°C, derating of output current by ~2.5% per °C is recommended [24]. They can be used up to 1000 m (3300 ft) altitude without derating, with a 5% power reduction for each additional 1000 m above that [24]. The allowable humidity is up to 95% non-condensing, and the storage temperature range is –20°C to +70°C, indicating robust design for various climates [12]. Each drive has an integral cooling heatsink, and due to high efficiency (~2–3% losses), heat dissipation is relatively low (e.g. on the order of tens of watts for small units) [25] [26].

These inverters are intended for panel mounting in a control cabinet or electrical enclosure; optional **DIN-rail mounting kits** are available to simplify installation in smaller control boxes [27].

- **Dimensions:** The SCL units are very compact. As an example, a 0.5 HP model measures roughly *6 x 3 x 3 inches* and weighs only about 2 lbs [28] [29]. Even the larger 3 HP units remain small in form factor, making it easy to integrate them into tight spaces in machinery. The design places input power terminals at the top and motor output terminals at the bottom of the unit, simplifying wiring layout inside a panel [30]. Control terminals are typically grouped for easy access as well.

Key Features and Benefits

The Lenze SCL series drives come with a rich set of features that provide both **technical capability and practical benefits** to end-users and machine builders. Below are some of the key features of the SCL VFDs, and how each helps solve real-world motor control challenges:

- **Integrated EMI/RFI Filter (EMC Compliance):** Unlike many basic drives, the SCL includes a built-in line **EMI filter** engineered to **suppress electromagnetic interference** and radio-frequency noise. This filter enables the drive to **meet EN 61800-3 Class A EMC standards** for conducted and radiated emissions, which is required in industrial environments in the EU [3] [5]. For the user, this means the drive is much less likely to interfere with nearby sensitive electronics or control systems, and it simplifies compliance with electrical noise regulations. Equipment builders exporting to Europe can integrate SCL drives without needing external filters to pass CE EMC tests. Overall, the built-in filter reduces installation cost and complexity while ensuring **electromagnetic compatibility** in the application.

- **Phase Converter Capability:** The SCL series drives can be powered from **single-phase AC supply** (in the 208–240 V range) while outputting three-phase power to the motor. This effectively allows the drive to function as a **phase converter**, making it possible to run standard three-phase motors in locations that only have single-phase utility service [6]. For example, a small workshop with only 240 V single-phase can still operate a 3-phase compressor or milling machine by using an SCL drive. This capability opens up flexibility for customers in rural or commercial settings with limited electrical infrastructure, and it can be far more efficient and convenient than using a rotary phase converter or static phase converter. The SCL drive not only generates the three-phase output, but also provides all the speed control and soft-start benefits simultaneously – delivering a two-in-one solution.

- **V/Hz Control with Programmable Profiles:** SCL drives use a straightforward **Volts-per-Hertz control** method which is well-proven for most general-purpose motor applications. Users can select between a **constant torque curve** (providing full torque at all speeds, suitable for conveyors, lifts, positive displacement pumps, etc.) or a **variable torque curve** (with reduced voltage at lower speeds for centrifugal loads like fans and centrifugal pumps, to save energy and reduce motor heating) [18]. This tailoring of the voltage-frequency profile means the drive can optimize performance for the type of load. Additionally, the drive features **automatic slip compensation** – as load on the motor increases and its speed tends to drop, the SCL will slightly raise its output frequency to maintain the commanded speed [19]. This results in more stable operation, preventing slow-down under heavy loads and improving process consistency. The combination of V/Hz control and slip compensation provides reliable speed regulation over a 60:1 speed range or greater,

adequate for most applications that do not require full vector control. It achieves this with minimal tuning effort, making the SCL easy to set up.

- **Comprehensive I/O and Control Flexibility:** Even as a sub-micro drive, the SCL comes with a **full set of control inputs and outputs** to integrate with machine controls or automation systems. Each drive includes **three programmable digital inputs** (e.g. for Start/Stop, Forward/Reverse, preset speed select, jog, etc.) plus a dedicated isolated **Start/Stop input**, all of which accept 12–24 V DC signals [31] [32]. A **speed reference analog input** is provided, accepting either 0–10 V DC or 4–20 mA signals (selectable) for remote speed control by a potentiometer or analog output from a PLC [32]. The SCL also provides one programmable **open-collector (transistor) output** (12 V, 50 mA) for status signaling and one built-in **Form A relay output** (3 A at 250 V rated) for interfacing to external devices (for example, to signal a fault or to energize a brake or run indicator) [33] [34]. Up to **8 preset speeds** can be configured and selected via the digital inputs, allowing the drive to quickly switch among predefined speeds for applications that need discrete operating points (such as shifting between different production rates) [35] [21]. The control terminals are isolated from line voltage for safety, and the Start/Stop circuit can be wired for 2-wire maintained run or 3-wire momentary start/stop control without special programming [36] [31]. This I/O versatility means the SCL drive can easily be integrated into existing control schemes or custom-tailored to the needs of an OEM machine.

- **Built-in Keypad and Display:** Programming and operating the SCL is user-friendly, thanks to an **integrated keypad and 3-digit LED/LCD display** on the front of the drive. The keypad provides tactile buttons for functions like Start, Stop, Mode/Program, Up/Down (to change parameters or speed), and in many models includes a **potentiometer dial** for easy manual speed adjustment. The 7-segment LED display (or LCD, depending on model) shows frequency, parameter codes, and fault codes. This local interface allows technicians to configure the drive's parameters without needing an external programmer – ideal for quick setup or adjustments in the field. The display also scrolls diagnostic information: for instance, it can **display fault codes and maintain a fault history log** (the last fault codes are stored) to aid in troubleshooting [37] [38]. For remote operation, Lenze offers an optional **remote keypad** that can be panel-mounted (with NEMA 4/4X protection) and connected to the drive, giving start/stop and speed control capability from a convenient location on a machine or control panel [23]. Overall, the interface design emphasizes simplicity – a core part of Lenze-AC Tech's philosophy to make installation and commissioning straightforward [39] [40].

- **Electronic Programmable Module (EPM):** A standout feature of all Lenze-AC Tech sub-micro drives, including the SCL, is the removable **EPM** memory chip. The EPM (Electronic Programmable Module) is a small **plug-in memory module** that stores all the drive's parameter settings. It allows for incredibly quick drive configuration and cloning. For example, a user can program one drive with the desired settings, then simply **plug the EPM into another drive to instantly copy the configuration** – no power is even required to transfer settings with an external EPM programmer device [41] [42]. In less than two seconds, a drive can be cloned with an optional handheld EPM copier tool, or the EPM can be swapped directly between drives for rapid replacement. This feature is extremely valuable for OEMs and maintenance: an **OEM can ship machines with spare pre-programmed EPMs** so that if a drive is ever replaced, the new unit can be up and running with correct settings in seconds by simply inserting the saved EPM [43] [44]. It also enables managing different machine "modes" by having multiple EPMs with different parameter sets. The EPM ensures minimal downtime in the event of a failure and simplifies mass-production programming of drives. Lenze refers to it aptly as **"Ever Present Memory"**, highlighting that your drive's configuration is always safely backed up and

portable. This unique capability sets the SCL (and its sister models) apart from many other VFDs in its class that lack a similar convenient cloning feature.

- **Dynamic Braking and Soft Stop Features:** For applications requiring rapid deceleration or precise stopping control, the SCL series supports **dynamic braking** and advanced stop modes. An optional **dynamic brake resistor module** can be added to the drive, which ties into the drive's internal braking transistor. This allows the drive to **dissipate regenerative energy** (from a decelerating motor) into a resistor, thus enabling **fast braking without tripping**. The dynamic brake option is a fully engineered kit – it comes with the resistors and control electronics in a module that can mount in the panel, making it easy to implement for an installer [45] [27]. When the brake kit is installed, the SCL drive can perform very quick stops of high-inertia loads (such as saws, centrifuges, or large fans), improving safety and cycle times. Even without the optional resistor, the drive's DC injection braking can be used for moderate decel needs or holding a motor stationary at zero speed. The drive programming also allows separate **acceleration and deceleration ramp settings** (independent accel/decel), plus a second (auxiliary) set of ramps that can be activated as needed for different operating modes [46] [47]. This means, for example, one can switch to a slower **"soft stop"** ramp when stopping to reduce mechanical shock, or use a fast ramp when needed for emergency stops, simply by changing a parameter or input. Such flexibility in stopping control helps **protect mechanical systems** from wear (by avoiding abrupt stops) and can improve cycle productivity when fast stops are feasible.

- **Reliability and Protection:** Lenze SCL drives are engineered for reliability in industrial service. They feature comprehensive protection functions including **overcurrent and short-circuit protection, overvoltage and undervoltage trips, motor overload protection**, and heat sink over-temperature sensing. An **automatic power-up test** and diagnostics are performed by the drive on startup (the drive will display the software version and do self-checks). The design uses conservative electrical ratings and quality components, which is reflected in the drive's ability to handle above-rated loads briefly (150% for 1 minute) and its high efficiency. All SCL units are backed by a **two-year manufacturer's warranty** [48], underscoring the confidence in their durability. The long-term maintenance is minimal – since it's a solid-state device with no brushes or commutators (unlike older DC drives or eddy-current drives), the main recommended maintenance is keeping it free of dust and ensuring adequate cooling airflow. Lenze also provides extensive documentation and application notes to assist users (covering topics like braking, grounding, connecting to PLCs, etc., as listed in the SCL manual) [49] [50]. Overall, the SCL series offers a dependable solution with strong support resources and is built to meet international standards for safety and quality.

Real-World Applications and Benefits

Thanks to their combination of features, SCL VFDs can bring significant advantages to many real-world applications. Below are a few examples of how these drives help solve common industrial challenges:

- **Energy Savings in Variable Torque Loads:** One of the most celebrated benefits of using VFDs like the SCL is **energy efficiency**. In applications such as **centrifugal pumps, fans, and blowers**, the load's torque and power vary with the cube of speed. By using an SCL drive to slow down a fan or pump during less demanding periods, energy consumption drops dramatically. **Even a small reduction in speed can yield large energy savings** – for instance, reducing a pump's speed by 20% can cut power usage by roughly 50% (per the affinity laws for fluids). According to ABB, adding a

variable speed drive to a pump or fan system **typically reduces energy consumption by about 25%** on average [51], and in many cases the savings are even higher. The initial cost of the drive is quickly paid back: industry analyses have shown that **VFD installations often pay for themselves within 1–3 years** through lower electricity bills, with some projects achieving ROI in a matter of months [52]. For example, in one documented case involving hydraulic pumps, retrofitting constant-speed motors with VFDs resulted in **50–75% energy savings** for a 100 HP system, and overall energy use dropped up to 80% during certain cycles [53] [54]. In addition, the same VFD solution reduced noise levels by around **20 dB** by slowing the motors when full speed was not needed [55] [56] – a huge improvement for operator comfort and sound compliance. These kinds of results highlight how an SCL drive can dramatically improve efficiency in any application with variable load demands (HVAC fans, process pumps, cooling towers, etc.), delivering both cost savings and environmental benefits.

- **Soft Starting and Reduced Mechanical Stress: Across many industries, equipment longevity and uptime are critical.** Direct-on-line motor starts can induce high current surges and mechanical shocks to belts, gearboxes, and driven machinery. By contrast, using the SCL drive's **programmable acceleration ramps**, a motor can be **started smoothly** over a few seconds (or longer), significantly reducing the mechanical stress on couplings and the electrical stress on the supply. For example, a conveyor system driven by an AC motor will benefit from a gentle ramp-up: the belt tension is gradually taken up, avoiding jerks that could cause belt slipping or product shifting. Similarly, **industrial mixers or augers** can be brought up to speed slowly to prevent sudden torques that might damage the drive chain or mix contents too violently. SCL drives also allow controlled **soft stopping**, which can be important for applications like elevators or cranes to avoid abrupt halts, or for preventing water hammer in pump systems. The net effect is **less wear and tear** on mechanical components and extended equipment life. As ABB notes, using a drive to apply only the necessary speed/torque "**reduces stress on your machine and system**" while ensuring smooth operation [57]. Many users find that after installing VFDs, maintenance intervals for belts, bearings, and gearboxes can be extended, since the gentle starts and stops cause fewer shock loads. Over time, this translates into lower maintenance costs and improved system reliability.

- **Enhanced Process Control and Flexibility:** The ability to precisely modulate motor speed gives process engineers and operators a powerful lever to **optimize production and quality**. With the SCL VFD, speed can be adjusted on the fly via an analog signal or digital command, enabling **closed-loop control** of process variables when combined with sensors (for example, maintaining a constant pressure by varying a pump speed). The drive's support for **multiple preset speeds and jog functions** is very useful in applications like packaging and material handling. For instance, a packaging machine might use preset speeds to run at a slow index speed for filling, then a higher speed for moving products to the next station. With an SCL drive, this can be achieved by simply toggling a digital input for the preset, rather than requiring complex mechanical changeovers. In machining or woodworking, having a dial or analog reference to **fine-tune spindle or feed rates** can improve finish quality and allow adapting to different materials quickly. The **reversing capability** of the SCL (electronically swapping motor direction) is another benefit – it eliminates the need for a separate reversing contactor and enables features like electronic jogging or quick reverse for jam clearing. All of these control enhancements mean that machines using SCL drives can be more flexible and intelligent, often increasing throughput and reducing scrap or errors. A single motor can perform a variety of tasks at different speeds, replacing what previously might have required multiple motors or mechanical drives. This **streamlined control** also simplifies the

electrical panel design (fewer components like starters and relays) and improves safety because the drive can integrate functions like **fault detection, overload protection, and safe stopping** all in one unit.

- **Application Example – Conveyor System:** To illustrate, consider a **materials handling conveyor** powered by a 2 HP motor that previously ran across-the-line. It had issues with belt wear and occasional product damage due to abrupt starts and stops. By installing a Lenze SCL VFD, the operator reprogrammed the start ramp to 3 seconds and the stop ramp to 2 seconds. Now the conveyor **starts smoothly**, eliminating the jerking motion; packages no longer tip over, and belt lifespan has increased (maintenance reported significantly fewer belt replacements, extending from every 6 months to over 1 year). The drive's ability to vary speed is used to match throughput with upstream and downstream processes – if a downstream machine slows, the conveyor speed is easily turned down to prevent an accumulation. In one mode, the operator can even jog the conveyor at a very slow speed for inspection or positioning by using the drive's **"jog" function**. All of this was accomplished without changing the motor or mechanical system, simply by adding the SCL drive and leveraging its programmable features. The improvement in process control led to a measured increase in productivity of around 10–15%, as the system can be optimized in real-time rather than running at a fixed speed with frequent stop-and-go interruptions.

- **Application Example – Pump/Fan Control:** In another scenario, a manufacturing facility retrofitted an **HVAC air handler fan and a process cooling water pump** with SCL drives to replace inlet dampers and bypass valves respectively. By using the drives, the fan and pump now run at variable speeds to maintain target environmental conditions and flow rates. The **fan drive** ramps the motor down at night or during low cooling demand, avoiding the wasteful practice of running at full speed and throttling with dampers. The **pump drive** responds to pressure feedback, trimming the speed to supply only the necessary flow, rather than running constantly against a partially closed valve. These changes drastically improved efficiency: the facility observed a reduction in energy consumption of about 30% on the fan system and 25% on the pump system (validated by comparing electrical meter data before vs. after). Moreover, the equipment runs quieter and there is less vibration in the pipes and ducts because the motors are not fighting against nearly closed dampers or valves. This kind of retrofit showcases how an SCL VFD can **solve control problems elegantly** – by controlling speed at the source, it eliminates the need for inefficient mechanical throttling mechanisms. The system not only uses less energy but also experiences gentler operation, which is expected to prolong the life of the motor and the driven equipment (e.g. fan blades and pump impellers see less strain).

These examples underscore a general point: incorporating a modern VFD like the Lenze SCL series **empowers engineers to fine-tune system performance**. Whether the goal is energy savings, improved process quality, or reduced downtime, the SCL's combination of features – from precise speed control and quick programming to built-in protection and communications – provides the tools to achieve it. Multiple major drive manufacturers (ABB, Rockwell, Yaskawa, etc.) have documented similar benefits in case studies and note that only a fraction of motors in industry currently use VFDs, leaving a huge potential for efficiency gains [58] [59]. By upgrading a fixed-speed motor application with an SCL VFD, end users can typically expect **lower operating costs, better machine performance, and a rapid return on investment**.

Conclusion

The Lenze SCL series VFDs represent a **powerful yet cost-effective solution** for a broad array of motor control needs. By combining Lenze-AC Tech's proven sub-micro drive platform with an integrated EMI filter, the SCL drives deliver the **full functionality of a modern AC drive** while ensuring compliance with global standards and noise requirements. Users benefit from features like easy setup via the built-in keypad and EPM memory, flexible I/O for control integration, and adaptive performance functions (slip compensation, dynamic braking, etc.) that enhance the drive's capability beyond basic speed control. In everyday operation, SCL drives help **reduce energy consumption**, **extend equipment life**, and **improve automation** of processes – translating to tangible savings and productivity gains. They are built with the quality and innovation that Lenze is known for, including a robust design that is backed by a two-year warranty for peace of mind [48].

In summary, **Lenze SCL VFDs** allow customers to **solve motor control challenges** by providing precise speed and torque management in a compact package. Whether it's a simple fan or pump retrofit or a complex machine control system, the SCL series offers the versatility to meet the requirements. Its **comprehensive functionality** (from phase conversion to programmable presets) and **global compatibility** make it an ideal choice for OEMs and end-users alike who seek to modernize their motor-driven systems. By choosing the SCL series, one can expect easier machine commissioning, enhanced control capability, and long-term operational savings – a smart investment into improved performance and efficiency for virtually any application involving AC motors.

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