DuraLev® 2000

4.1 bar (59 psi)
140 liters/min (37 gallons/min)

USER MANUAL

This manual contains information necessary for the safe and proper use of the DuraLev® 2000. Included are specifications for the standard configurations of the pump system and instructions regarding its use, installation, operation, adjustment, inspection and maintenance. For special configurations of the pump system refer to accompanying information. If the system must be configured for other parameter settings, then the Levitronix® Service Software version V2.0.5.0 or higher (with according manual Levitronix® Doc.# PL-4046-00) is necessary. Familiarize yourself with the contents of the manual to ensure the safe and effective use of this product. After reading this manual, please store the manual where the personnel responsible for operating the pump system can readily refer to it at any time.
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1 Safety Precautions

The DuraLev® 2000 pump system is designed to be used in industrial production machines and equipment containing hydraulic circuits. Typical applications are industrial and chemical manufacturing equipment. Installation shall be done by qualified personnel only. Following safety precautions and all “CAUTION”, “WARNING” and “DANGER” indications in the relevant sections shall be followed.

**CAUTION**
Do not under any circumstances open the controller or motor. Levitronix® does not assume responsibility for any damage, which occurs under such circumstances.

**CAUTION**
High magnetic field strength of pump impeller.
The pump system contains a rotor magnet with high field strength. This may alter or damage the calibration of sensitive electronic devices and measuring instruments in the immediate surroundings. Keep at a safe distance from the rotor, computers, monitors and all magnetic data storage media (e.g. disks, credit cards, audio, video tapes etc.)

**WARNING**
Hazardous voltage may be present.
The controller must be grounded and placed in a spill protected electrical cabinet. Do not under any circumstances open the powered controller. Always isolate the electrical power supply before making or changing connections to the unit. To remove the power it is recommended to use an isolating device. Hazardous voltage is present until 20 sec after switch off. Do not handle the controller during this time.

**WARNING**
High magnetic field strength of pump impeller.
The pump system contains a rotor magnet with high field strength. Pace maker may be influenced and magnetic forces may lead to contusions. Keep distance to pace makers and handle impeller with care.

**WARNING**
TOXIC CHEMICALS may be present.
When using the system to pump chemicals skin contact and toxic gases may be hazardous to your health. Wear safety gloves and other appropriate safety equipment.

**WARNING**
Motors for ATEX / IECEx applications: only specific types of motors LPM-2000 are classified for the use in ATEX Zone 2 classified locations. Refer to the corresponding section in the manual.

**WARNING**
Do not miss-match the power extension cables for connection of the motor to the controller of the BPS-4 pump system with the one’s of the BPS-2000 as this may destroy the controller. The BPS-4 power extension cables are designated with “MCAP-4.x” and the one’s of the DuraLev® 2000 with “MCAP-2000.x”.
2 Specifications

2.1 Specification of Components

Figure 1 shows the main system components (motor, controllers, and pump head) and Figure 2 illustrates the accessories.

Figure 1: Pump system with standard components

Figure 2: Pump system accessories
Table 1: Standard system configurations

<table>
<thead>
<tr>
<th>Pos.</th>
<th>Component</th>
<th>Article Name</th>
<th>Article #</th>
<th>Characteristics</th>
<th>Value / Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>Pump Head</td>
<td>LPP-2000.2</td>
<td>100-90414</td>
<td>Impeller, Pump Housing, Sealing Ring, Fittings</td>
<td>PFA, PVDF or PP (+GF30), NPT 1&quot;</td>
</tr>
<tr>
<td>1b</td>
<td></td>
<td>LPP-2000.4</td>
<td>100-90416</td>
<td>Max. Flow, Max. Diff.-Pressure, Max. Viscosity, Max. Liquid Temperature</td>
<td>140 liters/min / 37 gallons/min, 4.1 bar / 58 psi (3 % lower for PP pump head LPP-2000.2)</td>
</tr>
<tr>
<td>2a</td>
<td>Motor</td>
<td>LPM-2000.1</td>
<td>100-10049</td>
<td>Housing</td>
<td>Epoxy (antioxidative) coated Aluminum waterproofed (IP67 without connectors)</td>
</tr>
<tr>
<td>2b</td>
<td>(ATEX, IECEx)</td>
<td>LPM-2000.7</td>
<td>100-10059</td>
<td>ATEX / IECEx Marking</td>
<td>III 3G Ex ic H II T6 Gc, III 3D Ex h T12 T6 Gc</td>
</tr>
<tr>
<td>3a</td>
<td>Standalone Controller (User Panel)</td>
<td>LPM-2000.1-01</td>
<td>100-30018</td>
<td>Voltage / Power, Housing, Voltage / Power, Panel to set speed (automatic storage on internal EEPROM)</td>
<td>IP20</td>
</tr>
<tr>
<td>3b</td>
<td>Extended Controller (PLC and USB)</td>
<td>LPM-2000.2-01</td>
<td>100-30021</td>
<td>Interface for Extended Controller, Interface for Extended Controller, PLC with digital inputs, Panel to set speed (automatic storage on internal EEPROM)</td>
<td>Standard Firmware &quot;High Flow&quot;</td>
</tr>
</tbody>
</table>

Table 2: Specification of standard components

<table>
<thead>
<tr>
<th>Pos.</th>
<th>Component</th>
<th>Article Name</th>
<th>Article #</th>
<th>Characteristics</th>
<th>Value / Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>4a</td>
<td>Extension Adaptor</td>
<td>MAC-600-1-05 (5m)</td>
<td>190-10105</td>
<td>Sensor Cable</td>
<td>PVC</td>
</tr>
<tr>
<td>4b</td>
<td>Cable for Sensor (a) and Power (b) Wires</td>
<td>MAC-600-1-09 (10m)</td>
<td>190-10109</td>
<td>Power Cable</td>
<td>PVC</td>
</tr>
<tr>
<td>5a</td>
<td>Extension Adaptor</td>
<td>MAC-600-3-30 (5m)</td>
<td>190-10219</td>
<td>Jacket Material</td>
<td>Circular AMP to D-SUB</td>
</tr>
<tr>
<td>5b</td>
<td>Cable for Sensor (a) and Power (b) Wires</td>
<td>MAC-600-3-70 (7m)</td>
<td>190-10223</td>
<td>Connector Material</td>
<td>Metalic – Nickel coated</td>
</tr>
</tbody>
</table>

Table 3: Specification of adaptor/extension cables

<table>
<thead>
<tr>
<th>Pos.</th>
<th>Component</th>
<th>Article Name</th>
<th>Article #</th>
<th>Characteristics</th>
<th>Value / Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>6a</td>
<td>Air Cooling Module</td>
<td>ACM-4.2</td>
<td>190-10139</td>
<td>Material / Connection Port</td>
<td>PP / 40% Tutuklu / NPT 1/4&quot;</td>
</tr>
<tr>
<td>6b</td>
<td>Air Cooling Module</td>
<td>ACM-4.3</td>
<td>190-10243</td>
<td>Material</td>
<td>PP-EL-S with conductive additive for operation with ATEX motor</td>
</tr>
<tr>
<td>7a</td>
<td>Fan Cooling Module</td>
<td>FCM-2000.1</td>
<td>190-10390</td>
<td>Housing / Cable Spec., Supply Spec.</td>
<td>PP (20% Tutuklu) / PP jacket, 3m, circum, sealed M12 connector (PP), 24 VDC, 33.5 W / IP-45 (fan is IP68 rated)</td>
</tr>
<tr>
<td>7b</td>
<td>Fan Cool. Module Cable</td>
<td>FCC-1.1-50 (5 m)</td>
<td>190-10467</td>
<td>Specification</td>
<td>PP cable jacket with circular M12 connector (PP) to open wires</td>
</tr>
</tbody>
</table>

Table 4: Specification of accessories

<table>
<thead>
<tr>
<th>Pos.</th>
<th>Component</th>
<th>Article Name</th>
<th>Article #</th>
<th>Characteristics</th>
<th>Value / Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>8a</td>
<td>ATEX Cable Sealing System</td>
<td>ACS-2 (Roxtec)</td>
<td>100-90292</td>
<td>Stainless Steel and EPDM Rotor (EPDM rubber)</td>
<td>Note: Lubricant (E) and measurement probes (F) are included.</td>
</tr>
</tbody>
</table>
2.2 Standard System Configurations

2.2.1 Stand-Alone System Configuration

The stand-alone configuration of the DuraLev® 2000 pump system (see Figure 3) consists of a controller with an integrated user panel to set the speed manually. The speed is automatically stored in the internal EEPROM of the controller. As an option, the speed can also be set with an analog signal.

2.2.2 Extended System Configuration

The extended version of the DuraLev® 2000 pump system (Figure 4) consists of a controller with an extended PLC interface. This allows setting the speed by an external signal (see Position 3b in Figure 4) and enables precise closed-loop flow or pressure control in connection with either a flow or a pressure sensor. A USB interface allows communication with a PC in connection with the Levitonix® Service Software. Hence parameterization, firmware updates and failure analysis are possible.

Figure 3: System configuration for standalone operation
(Speed setting with integrated user panel)

Figure 4: Extended operation (flow or pressure control) with extended controller
2.2.3 ATEX / IECEx System Configuration

Together with the standard pump-head and controllers an ATEX / IECEx certified motor allows installation of motor and pump-head within an ATEX Zone 2 area (see Figure 5). The ATEX / IECEx motor (Pos. 2b in Figure 5) comes delivered with special connectors and according extension cables (Pos. 5a and 5b in Figure 5). One option to lead the cables outside of the ATEX area is an ATEX certified cable sealing system as listed in Table 4 (see Pos. 8) and shown in Figure 2.

Figure 5: System configuration for ATEX / IECEx applications

2.3 General Environmental Conditions

<table>
<thead>
<tr>
<th>Usage</th>
<th>Indoor 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Altitude</td>
<td>Up to 2000 m</td>
</tr>
<tr>
<td>Operating ambient temperature</td>
<td>0 to 40 °C</td>
</tr>
<tr>
<td>Storage ambient temperature (Extremes for Transportation)</td>
<td>-20 to 80 °C</td>
</tr>
<tr>
<td>Operating humidity range (relative humidity)</td>
<td>15 – 95% (non-condensing)</td>
</tr>
<tr>
<td>Storage humidity range (relative humidity) (Extremes for Transportation)</td>
<td>15 – 95% (non-condensing)</td>
</tr>
<tr>
<td>Normal storage conditions</td>
<td>Ambient temp.: 20 to 30 °C Relative humidity: 50% (non-condensing)</td>
</tr>
<tr>
<td>AC supply fluctuations</td>
<td>± 10% of nominal voltage</td>
</tr>
<tr>
<td>Transient over-voltages typically present on the mains supply</td>
<td>Surge immunity according to EN 61000-4-5</td>
</tr>
<tr>
<td>Pollution degree</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 5: Environmental conditions for pump system

Note 1: Contact Levitrinix® technical department (see Section 7) for outdoor usage.
2.4 Pressure-Flow Curves

Figure 6: Pressure/flow curves for “High Flow” pump head for aqueous solutions
(Measured with PVDF pump-head LPP-2000.4, pressure for PP pump head LPP-2000.2 is ~3% lower)

The linearly increasing cavitation effects for the “High Flow” system for flows > 100 lpm and liquid temperature range of 40 – 90 °C was measured for water. This can be different for other liquids and depends on the hydraulic circuit design. For example: higher inlet pressure reduces cavitation effects.

2.5 NPSHr Curves

Figure 7: NPSHr curves for “High Flow” pump head
(Measured with pump-head LPP-2000.4)
2.6 Maximum Static Pressure for Pump Heads

![Graph showing maximum static pressure for pump heads LPP-2000.2 and LPP-2000.4 in psi and bar versus liquid temperature in °C.

Safety Factor = 1.3 (according to EN12162)
Limitation: Given by deformation. Burst pressure is significantly higher.
Ambient Temp = 25 °C
Note: Pressure limit only valid for pumphead mounted on motor.]

Figure 8: Specification for maximum static pressure of pump heads LPP-2000.2/4
(Pressure limits only valid for pump head mounted on motor)
2.7 Basic Dimensions of Main Components

Figure 9: Basic dimensions (in mm and [inch])
- LPP-2000.2 pump head (PP+GF30) with motor LPM-2000
- Same dimensions apply to LPP-2000.4 pump head (PVDF) with motor LPM-2000
**Figure 10:** Basic dimensions (in mm and [inch]) Motor LPM-2000 with Air Cooling Module ACM-4.2
(Same basic dimensions for ACM-4.3)

<table>
<thead>
<tr>
<th>Cable Jacket</th>
<th>Cable OD Motor Sensor</th>
<th>Cable OD Motor Power</th>
<th>Minimum Bending Radius Permanent Installation</th>
<th>Minimum Bending Radius Sometimes Moved</th>
</tr>
</thead>
<tbody>
<tr>
<td>PVC</td>
<td>7.20 mm</td>
<td>11.1 mm</td>
<td>5x Cable OD</td>
<td>11 x Cable OD</td>
</tr>
</tbody>
</table>

Table 6: Specifications for min. bending radius of motor and adaptor cables for LPM-2000

Note: If not mentioned explicitly all the cables are not suited for constant dynamic bending and movement!

**Figure 11:** Basic dimensions (in mm and [inch]) of LPC-2000.1-xx and LPC-2000.2-xx controllers
3 Engineering Information

3.1 Sealing and Material Concept

![Sealing and material concept for “High Pressure” system](image)

**Figure 12: Sealing and material concept for “High Pressure” system**

(LPM-2000.1 motor with pump head LPP-2000.2)

<table>
<thead>
<tr>
<th>System Component</th>
<th>Item No</th>
<th>Description</th>
<th>Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pump-Heads LPP-2000.2/4</td>
<td>1</td>
<td>Pump casing (lid and bottom, 1” NPT)</td>
<td>PP+GF30 for pump head LPP-2000.2, PVDF for pump head LPP-2000.4</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Static sealing O-ring of pump housing</td>
<td>FPM/FKM</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>8 M8x40mm screws for pump housing</td>
<td>Stainless steel (Inox)</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Impeller LPI-2000.1</td>
<td>PFA</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Rotor magnet</td>
<td>Rare-earth material</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>4 M8x30mm screws for pump/motor mounting</td>
<td>Stainless steel (Inox)</td>
</tr>
<tr>
<td>Motor LPM-2000.2</td>
<td>7</td>
<td>Flat gasket for motor housing</td>
<td>FPM (= FKM)</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>Cable bushing</td>
<td>PA, cable jacket is PVC</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Motor housing</td>
<td>Epoxy coating, waterproof (IP-67), Coils and electromagnetic circuit potted with an epoxy compound (UL94 V0).</td>
</tr>
</tbody>
</table>

**Table 7: Materials used in the LPM-2000.1 motor and LPP-2000.2/4 pump heads**
3.2 AC Supply and Power Consumption

3.2.1 Power Consumption

![Figure 13: Electrical power consumption with “High-Flow” system for aqueous liquids](image)

(Controller LPC-2000.x with pump-head LPP-2000.2/4)

3.2.2 AC Input Voltage and Grid Currents

The input grid currents depend on the operational point and the input voltage. As shown in Table 8 maximum input grid currents are achieved at highest power and lowest voltage. Note that the grid currents also depend on the impedance of the grid, therefore below values are only typical values.

<table>
<thead>
<tr>
<th>Phase Type</th>
<th>AC Voltage</th>
<th>AC Input Current</th>
<th>Performance Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-phase</td>
<td>200 – 240 VAC ±10%</td>
<td>Typical: 12 – 8.5 Arms ±10%</td>
<td>Continuous speed and pressure with maximum active power.</td>
</tr>
<tr>
<td>50/60Hz</td>
<td></td>
<td>Max. 13.3 – 11.1 Arms ±10%</td>
<td></td>
</tr>
<tr>
<td>Three-phase</td>
<td>Delta voltage 1: 200 – 240 VAC ±10% (180 – 264 VAC)</td>
<td>Typical: 3x 7 – 5 Arms ±10%</td>
<td>Continuous speed and pressure with maximum active power.</td>
</tr>
<tr>
<td>50/60Hz</td>
<td>Star voltage 2: 115 – 139 VAC ±10% (104 – 153 VAC)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 8: Voltage and grid current specifications

Note 1: See Figure 23 for visualization of delta and star voltages.

Note 2: Values depend on impedance of grid.

3.2.3 Inrush Current

Various situations have to be considered for the inrush current. The controller has integrated inrush current limiters, which limit the current during switch-on of the AC power. However, these limiters are not active if the controller is not completely discharged Table 8 shows the inrush currents during these situations. It has to be emphasized that these are absolute worst case currents measured with a rigid mains supply at highest input voltage. In reality these inrush currents might be much smaller.
### 3.2.4 Earth Leakage Current

Earth leakage currents have been measured under worst case situation and are $\leq 5$ mA.

### 3.2.5 Recommendations for Circuit Breaker Design

The controller contains fuses in all power input lines, which are configured for 20 A (time lag $T$).

For the selection of external breakers above considerations about AC voltage, grid currents, inrush current and earth leakage current have to be considered. It is recommended to test the reliability and sensitivity of the selected breakers with the pump system in the context of the tool, where it is operated.

Circuit breaker types full-filling above considerations have following basic specifications:

- 16 A and D or K tripping characteristics

### 3.3 Temperature Monitoring

To avoid overheating of the system, the controller and motor temperatures are monitored. If the controller temperature exceeds 70°C (158°F) or the motor temperature 90°C (194°F) for a duration of more than 10 minutes, the system goes into an error state and the pump stops. At 80°C (176 F) controller temperature or 100°C (212°F) motor temperature, the system stops immediately.

#### Figure 14: Controller temp. monitoring

#### Figure 15: Motor temp. monitoring
3.4 Thermal Management

3.4.1 Motor Temperature

The motor temperature depends on the ambient and liquid temperature, as well as on the hydraulic operation point and the characteristics (viscosity and density) of the liquid. Figure 16 illustrates the temperature characteristics for aqueous liquids at room temperature. For higher liquid temperatures and hydraulic operating points active cooling is recommended for example with the Air Cooling Module ACM-4.2 (see Figure 17).

Figure 16: Temperature curves for the LPM-2000.1 motor @ 25 C liquid temperature
(Temperature is measured inside of the motor, temperature of housing and sensor electronics is significantly below this temperature)

Figure 17: Temperature curves of motor LPM-2000.1 with Air Cooling Module ACM-4.2
(Temperature is measured inside of the motor, temperature of housing and sensor electronics is significantly below this temperature)
The above curves are measurements of the motor temperature at certain liquid and ambient temperatures. Equation (Eq. 1) shows how to calculate the motor temperature for other liquid and ambient temperatures based on these curves.

\[
T_M(T_L, T_A) \approx T_M(T_L = 25^\circ C, T_A = 25^\circ C) + (T_L - 25^\circ C) \cdot t_{LM} + (T_A - 25^\circ C)
\]

(Eq. 1)

\[
T_M = \text{Motor temperature} \quad T_L = \text{Liquid temperature} \\
T_A = \text{Ambient temperature} \quad t_{LM} = \text{Temperature gradient liquid/motor}
\]

All above presented thermal data are typical values, which are partly based on measurements and partly on interpolations with a simplified thermal model and are therefore only guideline values and are suitable for a first layout of the basic thermal concept. It is recommended to check the thermal values with the motor placed on the final location and under worst case performance conditions of the application.

In order to account for thermal variations (like ambient temperature, closed chemical cabinets or corners without ventilations) and to not significantly reduce the MTBF of the motor it is recommended to keep about 10 to 20°C safety distance to the absolute thermal limit of the motor (90°C) when designing the thermal concept of the pump system.

Figure 18: Influence of liquid temperature on motor temperature
(Measurement at 6000 rpm /50 l/min with LPP-2000.4, but gradients are representative for other operational points and the same for LPP-2000.2)
3.4.2 Controller Temperature

Depending on the ambient temperature and the placement of the controller additional cooling may be required (see Figure 19). To improve cooling of the controller, place the device into a moving air stream. If the controller is mounted in a compact area or adjacent to additional heat sources (e.g. a 2nd controller) ensure that there is sufficient ventilation.

![Figure 19: Temperature curves of controller LPC-2000 vs. flow and speed](image)

(see Figure 19)

The above curves are measurements of the controller temperature at 25°C ambient. Equation (Eq. 2) shows how to calculate the controller temperature for at other ambient temperatures based on this curve.

\[
T_C(T_A) \approx T_C(T_A = 25^\circ C) + (T_A - 25^\circ C)
\]

\[
T_C = \text{Controller temperature}
\]

\[
T_A = \text{Ambient temperature}
\]

(Eq. 2)
3.5 Hydraulic Circuit Design

Following general design rules for the hydraulic circuit shall be considered for a robust operation of the pump system and optimum priming behavior:

1. The general rule for optimum priming behavior is to minimize the pressure drop in the inlet circuit and avoid negative pressure at the inlet of the pump head.

2. Minimize tubing length at the inlet of the pump head and maximize the ID (not smaller than the pump head inlet ID of 22.2 mm is recommended). This reduces the pressure drop and the tendency of cavitation.

3. Avoid any restrictions, valves, elbows, bended tubing and sharp edges at the inlet circuit of the pump head, which potentially causes cavitation resulting in gas bubble collection in the pump head with the danger of priming loss.

4. Place the pump at the lowest point of the hydraulic circuit. Optimum is as much as possible below a tank or reservoir. This optimizes priming behavior and removal of gas bubbles.

5. Keep the liquid level in the reservoir tank or bag as high as possible, which increases the inlet pressure of the pump head and minimized heat up of the liquid.

6. In general the pump system placement and circuit shall be designed in a way that gas bubbles can leave the pump housing and that the pump head remains primed.

7. To minimize heat up of the liquid the overall pressure drop in the hydraulic circuit shall be reduced as much as possible.

8. It shall be avoided to pump longer times against a closed valve, which can cause heat-up of the liquid.

9. At higher liquid temperature above rules become more important due to higher cavitation tendency of the liquid.

10. Load and stress at the inlet and outlet by heavy tubing and inexact mounting alignment shall be avoided (see Figure 20) as this can cause leakage issues due to distortion of the plastic pump housing.

**Figure 20:** Avoidance of stress forces and torques at the inlet and outlet of the pump head

Contact the Levitronix® Technical Service department (see Section 7) for more detailed considerations and support on the design of the hydraulic circuit.
4 Installation

4.1 Electrical Installation of Controller

4.1.1 Overview

The LPC-2000 controllers have signal processor controlled power converters with switched inverters for the drive and the bearing windings of the motor. The signal processor allows precise control of pump speed and impeller position. Figure 21 shows the interfaces of the standalone controller LPC-2000.1 with stand-alone and minimal PLC functions and Figure 22 the interfaces of the controller LPC-2000.2 with extended PLC functions and USB interface for communication.

![Figure 21: Overview of the controller LPC-2000.1-xx for standalone operation](image)

### Table 10: Description of interfaces of LPC-2000.1-xx controller

<table>
<thead>
<tr>
<th>Interface (as labeled)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 “SENSORIC”</td>
<td>Position, field and temperature sensor signals from motor. Torque spec. for tightening of connector screws on motor side: Min. = 0.4 Nm, Max. = 0.6 Nm</td>
</tr>
<tr>
<td>2 “User Interface”</td>
<td>1 Digital Input - Galvanic isolation with optocoupler - Lowest input voltage for high level detection: min. 5 V - Typical 24 V / 16 mA, maximal 30 V / 20 mA - Highest input voltage for low level detection: max. 0.8 V - Minimum input resistance: $R_{\text{IN}} = 2.2 , \Omega$</td>
</tr>
<tr>
<td></td>
<td>1 Digital Output Galvanic isolation with relay - Relay: 1A / 30VDC, 0.3A / 125 VAC</td>
</tr>
<tr>
<td></td>
<td>1 Analog Input Analog current input: 4 – 20 mA 450 Ohm shunt input</td>
</tr>
<tr>
<td>3 “POWER OUTPUT”</td>
<td>Drive and bearing currents of the motor. Torque spec. for tightening of connector screws on motor side: Min. = 0.7 Nm, Max. = 0.8 Nm</td>
</tr>
<tr>
<td>4 “POWER INPUT”</td>
<td>AC power input. Torque spec. for tightening of connector screws on motor side: Min. = 0.5 Nm, Max. = 0.6 Nm</td>
</tr>
<tr>
<td>5 “Power on” Green LED</td>
<td>LED is on if supply voltage of signal electronics is present.</td>
</tr>
<tr>
<td>6 “Power Output not active” Red LED</td>
<td>Red LED is off if the switched output stage of the controller is enabled. If the LED is on, the bearing and drive coils of the motor carry no current.</td>
</tr>
<tr>
<td>7 “RESET” Button</td>
<td>Reset button of the controller stage. The button is sunk mounted and can be activated for example with a small screw driver.</td>
</tr>
<tr>
<td>8 2-Digit Display “Speed”</td>
<td>Rotational speed display in 100rpm</td>
</tr>
<tr>
<td>9 “UP” Button</td>
<td>Button for speed increasing</td>
</tr>
<tr>
<td>10 “DOWN” Button</td>
<td>Button for speed decreasing</td>
</tr>
<tr>
<td>11 “Firmware” Label</td>
<td>Firmware version and revision number</td>
</tr>
</tbody>
</table>

1: Connectors are not made for multiple connection cycles. Avoid connections cycles > 25.
**Figure 22: Overview of the controller LPC-2000.2-xx for extended operation**

<table>
<thead>
<tr>
<th>Interface (as labeled)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 &quot;SENSORIC&quot;</td>
<td>Position, field and temperature sensor signals from motor. Torque spec. for tightening of connector screws on motor side: Min. = 0.4 Nm, Max. = 0.6 Nm</td>
</tr>
<tr>
<td>2 &quot;PLC&quot; (User Interface)</td>
<td>2 Analog Input - Analog current input: 4 – 20 mA - 450 Ohm shunt input</td>
</tr>
<tr>
<td></td>
<td>2 Analog Input - Analog voltage input 0 – 10 V - Direct connection, no galvanic isolation - 7.8 kΩ input resistance</td>
</tr>
<tr>
<td></td>
<td>2 Analog Output - Analog voltage output: 0 – 5 V - Direct connection, no galvanic isolation - Max. Output current: 2mA</td>
</tr>
<tr>
<td></td>
<td>4 Digital Input - Galvanic isolation with optocoupler - Lowest input voltage for high level detection: min. 5 V Typical 24 V / 16 mA, maximal 30 V / 20 mA - Highest input voltage for low level detection: max. 0.8 V - Minimum input resistance: $R_{IN} = 2.2 , \text{kΩ}$</td>
</tr>
<tr>
<td></td>
<td>4 Digital Output - Galvanic isolation with relay - Relay: 1A / 30VDC, 0.3A / 125 VAC</td>
</tr>
<tr>
<td>3 &quot;USB&quot;</td>
<td>USB interface</td>
</tr>
<tr>
<td>4 &quot;POWER OUTPUT&quot;</td>
<td>Drive and bearing currents of the motor. Torque spec. for tightening of connector screws on motor side: Min. = 0.5 Nm, Max. = 0.6 Nm</td>
</tr>
<tr>
<td>5 &quot;POWER INPUT&quot;</td>
<td>AC power input. Torque spec. for tightening of connector screws on motor side: Min. = 0.5 Nm, Max. = 0.6 Nm</td>
</tr>
<tr>
<td>6 &quot;Power on&quot; Green LED</td>
<td>LED is on if supply voltage of signal electronics is present.</td>
</tr>
<tr>
<td>7 &quot;Power Output not active&quot; Red LED</td>
<td>LED is off if the switched output stage of the controller is enabled. If the LED is on, the bearing and drive coils of the motor carry no current.</td>
</tr>
<tr>
<td>8 &quot;RESET&quot; Button</td>
<td>Reset button of the controller stage</td>
</tr>
</tbody>
</table>

**Table 11: Description of interfaces of LPC-2000.2-xx controllers**

1: Connectors are not made for multiple connection cycles. Avoid connections cycles > 25.
4.1.2 General Installation Instructions

**WARNING**

Hazardous voltage may be present.
Always isolate the electrical power supply before making or changing connections to the unit. To remove the power it is recommended to use an isolating device. Hazardous voltage is present until 60 sec after switch off. Do not handle the controller during this time. The controller housing must be properly grounded. Use the specified screws on the feet of the controller housing.

**WARNING**

Incorrect assembling of the “POWER INPUT” connector ➔ short circuit possible.
Assure that the pin assignments of the “POWER INPUT” connector are correct before it is plugged in.

1. Connect the protective earth wire with a crimp-type end on the specified earth screw (see Figure 23) on the feet of the controller (see also protective earth labels on controller).
2. Connect the two motor connectors (sensor and power) to the controller. Assure that the “POWER OUTPUT” connector from the motor is correctly aligned with the connector of the controller before it is plugged in.
3. Connect the AC power input connector. Make sure that the pin connections are correct:
   - 1 x 200-240V (1-phase) ⇒ L1 (⇒ L), L2 (⇒ N), PE (= Protective Earth)
   - 3 x 200-240V (3-phase delta voltage) ⇒ L1,L2, L3, PE (lines can be switched), star-voltage = 115 – 139V AC
   - Minimum Wire Gauge = AWG 14 (cooper diameter = 1.63 mm, cross section = 2.08 mm²)
   - For usage of external circuit breakers consult Section Error! Reference source not found..
4. To secure the connectors, tighten all retaining screws according to the torque specifications in Table 10 (for LPC-2000.1) and Table 11 (for LPC-2000.2).

*Figure 23: Protective earth and AC power input connection of LPC-2000 controller*
4.1.3 Electrical Installation of Controller LPC-2000.1 for Standalone Operation
For standalone operation the LPC-2000.1 is disabled when power is turned on. It can be enabled manually by using the “UP” button on the display. If the controller shall be enabled automatically, when power is applied the “ENABLE” pin on the “User Interface” connector (see Table 12) has to be active (typically 24V).

4.1.4 Electrical Installation of Controller LPC-2000.1 for Extended Operation
If the LPC-2000.1 shall to be controlled with external signals the “User Interface” can be used with the PIN designations described in Table 12.

<table>
<thead>
<tr>
<th>Pin Name</th>
<th>Connector Pin #</th>
<th>Designation</th>
<th>Levels</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analog In, (Signal)</td>
<td>5</td>
<td>Reference Speed</td>
<td>4.20 mA = 0..10000 rpm</td>
<td>Direct connection, no protection. Galvanic isolation on the user side is required.</td>
</tr>
<tr>
<td>Ground Analog In</td>
<td>6</td>
<td>Speed</td>
<td>- Speed Limit = 8000 rpm ± 16.8 mA</td>
<td></td>
</tr>
<tr>
<td>Digital In, (Signal)</td>
<td>3</td>
<td>Enable</td>
<td>24 V ⇒ active</td>
<td>Is needed to enable the system with an external signal.</td>
</tr>
<tr>
<td>Ground Digital In</td>
<td>4</td>
<td>0 V ⇒ not active</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digital Out</td>
<td>1</td>
<td>Status</td>
<td>Relay closed ⇒ active, system on</td>
<td>This signal indicates if the system is active.</td>
</tr>
<tr>
<td>Ground Digital Out</td>
<td>2</td>
<td>Relay open</td>
<td>⇒ not active, system off</td>
<td></td>
</tr>
</tbody>
</table>

Table 12: Description of „USER INTERFACE“ connector
(Description is for standard firmware, for other configurations refer to alternate firmware documentation)

Figure 24: „User Interface“ connector
- Delivered with controller LPC-2000.1
- Supplier: PTR Messtechnik GmbH, Germany
- Connector Type: AK1550/06-3.81-GREEN

Figure 25: Mounted “USER INTERFACE” connector and Pin numbering
4.1.5 Installation of PLC Interface for Extended Controller \textit{LPC-2000.2}

To operate the pump system with a PLC, a minimum set of two digital inputs and one analog input is needed. The digital and analog outputs can be used to monitor the pump status and operating parameters.

**CAUTION**

The analog inputs and outputs are not galvanic isolated from the controller electronics. To avoid ground loops and malfunctions, use floating analog signals.

1. Detach the PLC connector from the controller
2. Connect the designated wires of a cable the pins of the detached connector according to Table 13. Assignment and functions of the I/Os can be changed with the controller firmware version (refer to according firmware documentation).
3. Connect the PLC connector (Figure 26) to the controller.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure26.png}
\caption{PLC connector}
\end{figure}

- Delivered with controller LPC-2000.2
- Supplier: Weidmüller, Connector Type: B2L 3.5/28 SN BK BX

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure27.png}
\caption{Mounted PLC connector and Pin numbering}
\end{figure}
### Table 13: Signals of the PLC connector for standard firmware

<table>
<thead>
<tr>
<th>Wire name</th>
<th>Connector Pin</th>
<th>Designation</th>
<th>Levels</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analog In1, (Signal)</td>
<td>18</td>
<td>Ref Value (Current Input)</td>
<td>4.20 mA = 0..10000 rpm (speed mode)</td>
<td>- Speed Limit: 8000 rpm = 16.8 mArms</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Cut-off (min.) speed = 300 rpm</td>
</tr>
<tr>
<td>Ground Analog In1</td>
<td>17</td>
<td></td>
<td></td>
<td>- Grounds are internally connected</td>
</tr>
<tr>
<td>Analog In2, (Signal)</td>
<td>20</td>
<td>Actual Process Control Value</td>
<td>4.20 mA = 0..100%</td>
<td>- Direct connection, no protection. Galvanic isolation on the user side is required.</td>
</tr>
<tr>
<td>Ground Analog In2</td>
<td>19</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analog In3, (Signal)</td>
<td>22</td>
<td>Ref Value (Voltage Input)</td>
<td>0..10 V = 0..10000 rpm</td>
<td>- Default input settings: Current inputs selected. Voltage input can be selected with EEPROM—editor in Levitronix® Service Software.</td>
</tr>
<tr>
<td>Ground Analog In3</td>
<td>21</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analog In4, (Signal)</td>
<td>24</td>
<td>Actual Process Control Value</td>
<td>0..10 V = 0..100%</td>
<td></td>
</tr>
<tr>
<td>Ground Analog In4</td>
<td>23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analog Out1, (Signal)</td>
<td>26</td>
<td>Actual Speed</td>
<td>0.5 V = 0..10000 rpm</td>
<td>- Direct connection, no protection. Galvanic isolation on the user side is required. 5V is given by firmware, hardware allows up to 10V output voltage.</td>
</tr>
<tr>
<td>Analog Out2, (Signal)</td>
<td>28</td>
<td>Actual Process Control Value</td>
<td>0.5 V = 0..100%</td>
<td></td>
</tr>
<tr>
<td>Com. Ground Analog Out</td>
<td>25, 27</td>
<td>--</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digital In1, (Signal)</td>
<td>2</td>
<td>Reset</td>
<td>24 V ⇒ active</td>
<td>Resets error state</td>
</tr>
<tr>
<td>Ground Digital In1</td>
<td>1</td>
<td></td>
<td>0 V ⇒ not active</td>
<td></td>
</tr>
<tr>
<td>Digital In2, (Signal)</td>
<td>4</td>
<td>Process mode</td>
<td>24 V ⇒ active</td>
<td>Switches between process mode and speed mode</td>
</tr>
<tr>
<td>Ground Digital In2</td>
<td>3</td>
<td></td>
<td>0 V ⇒ not active</td>
<td></td>
</tr>
<tr>
<td>Digital In3, (Signal)</td>
<td>6</td>
<td>Enable</td>
<td>24 V ⇒ active, system on</td>
<td>The Enable signal switches the pump system on and off.</td>
</tr>
<tr>
<td>Ground Digital In3</td>
<td>5</td>
<td></td>
<td>0 V ⇒ not active, system off</td>
<td></td>
</tr>
<tr>
<td>Digital In4, (Signal)</td>
<td>8</td>
<td>Not used</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>Ground Digital In4</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digital Out1</td>
<td>10</td>
<td>Status</td>
<td>Relay closed ⇒ active, system on</td>
<td>This signal indicates the state of the pump system.</td>
</tr>
<tr>
<td>Ground Digital Out1</td>
<td>9</td>
<td></td>
<td>Relay open ⇒ not active, system off</td>
<td></td>
</tr>
<tr>
<td>Digital Out2</td>
<td>12</td>
<td>Error</td>
<td>Relay closed ⇒ not active, system on</td>
<td>When active, the system drives the impeller to zero rpm and shuts down. With a reset pulse the system can be re-initialized.</td>
</tr>
<tr>
<td>Ground Digital Out2</td>
<td>11</td>
<td></td>
<td>Relay open ⇒ active, system off</td>
<td></td>
</tr>
<tr>
<td>Digital Out3</td>
<td>14</td>
<td>Warning</td>
<td>Relay closed ⇒ not active, system o.k.</td>
<td>The warning signal indicates if a system fault has been detected. The warning signal indicates a system fault but the system does not shut down</td>
</tr>
<tr>
<td>Ground Digital Out3</td>
<td>13</td>
<td></td>
<td>Relay open ⇒ active, system not o.k.</td>
<td></td>
</tr>
<tr>
<td>Digital Out4</td>
<td>16</td>
<td>Default Setting: Trend Warning</td>
<td>Relay closed ⇒ warning active</td>
<td>Default setting: Relay closed if trend warning is active. Can be changed in EEPROM with Levitronix® Service Software. Can be used to control a priming valve for priming of the pump. Feature can be activated and configured with Levitronix® Service Software.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Relay open ⇒ warning not active</td>
<td></td>
</tr>
<tr>
<td>Ground Digital Out4</td>
<td>15</td>
<td>Option: Priming Valve Signal</td>
<td>Relay closed ⇒ Priming valve active</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Relay open ⇒ Priming valve inactive</td>
<td></td>
</tr>
</tbody>
</table>

Note 1: For other configurations of PLC inputs and outputs refer to alternate firmware documentation.

Note 2: Configurations can be done with Levitronix® Service Software.

Note 3: All ground wires have to be connected.
4.2 Mechanical Installation of the Pump/Motor

4.2.1 Standard Installation Instructions and Information

**WARNING**

*Overheating of the Motor Power and Extension Power Cable*

To prevent an overheating of the motor power and extension power cables, do not roll-up or install several motor power cables in the same cable channel. This is has especially to be considered when long motor power cables are used.

- The motor can be fixed with four screws on the motor feet (see Figure 9)
- As an alternative the motor can be mounted with 12 screws on the back (see Figure 9)
- The motor can be mounted in either the horizontal or vertical position
- Minimum cable bending radius according Table 6 to shall be followed for the installation of the motor and extension/adaptor cables
- Each motor is identified with a unique serial number. This serial number consists of a series of 6 digits were the 5th and the 6th digit representing the manufacturing year.
- To prevent an overheating of > 90°C of the motor power cable in extension power cable, please don’t roll-up or install several motor power cables in the same cable channel.

4.2.2 Installation of ATEX / IECEx Motors

**WARNING**

Motors for ATEX / IECEx applications. Only specific types of motors LPM-2000 are classified for the use in ATEX Zone 2 classified locations. Refer to the corresponding section in the manual.

**WARNING**

Motors for ATEX / IECEx applications. Use only, if necessary, the cooling module ACM-4.3 for motors installed in ATEX Zone 2 classified locations. The use of other materials for the air cooling module is not allowed.

An ATEX conform solution is needed for the motor cable to leave the ATEX area (see Figure 5). One option is an ATEX certified cable sealing system as listed in Table 4 (see Pos. 8) and shown in Figure 2.
A protective earth wire (minimum Wire Gauge AWG14, copper diameter 1.63mm, cross section 2.08mm²) shall be attached to the ATEX / IECEx specific motors by following the instructions outlined below.

1) Motors used without cooling module ACM-4.3

A protective earth wire shall be attached to the ATEX / IECEx specific motor housing by using one of the eight M4 threads on the backside of the motor.

- Remove one of the eight M4 screws on the backside of the motor.
- Use a crimp cable lug to connect the earth wire.
- Attach the crimp cable lug with a M4x10mm stainless steel screw, a washer disc, a spring lock washer and a spacer sleeve (6mm long) to the motor according to (Figure 28).

![Figure 28: Attachment of a protective earth wire to the backside of the motor](image)

2) Motors used with cooling module ACM-4.3

A protective earth wire shall be attached to the ATEX / IECEx specific motor housing by using one of the four M6 threads on the backside of the motor.

- Mount the cooling module ACM-4.3 to the motor according to Figure 10.
- Remove one of the four M6 screws on the mounted cooling module.
- Use a crimp cable lug to connect the earth wire.
- Attach the crimp cable lug with a M6x40mm stainless steel screw, a washer disc and a spring lock washer to the motor through the cooling module (see Figure 29).

![Figure 29: Attachment of a protective earth wire to the backside of the motor through ACM-4.3](image)
4.3 Mechanical Installation of the Controller

- The controller can be mounted with the 2 DIN rail brackets on the housing (see Figure 11).
- If no forced air-cooling is used, mount the controller in upright position and assure that the heat of the controller can dissipate. Avoid mounting the controller in a cabinet where heat is stagnated and accumulated.

![Figure 30: Din-rail bracket for mounting of the LPC-2000 controller](image)

---

**WARNING**

**Hazardous voltage may be present.**

In order to avoiding fluid spills shorting mains or other voltages within the controller, place the controller in a spill protected electronic cabinet.

If explosive flammable gases are present, place the controller in an explosion-proof cabinet.

---

**CAUTION**

Do not under any circumstances open the controller. Levitronix® does not assume responsibility for any damage, which occurs under such circumstances.

---

4.4 Mechanical Installation of Adaptor/Extension Cables

For connecting the motor to the controller the adaptor cables MCAP-2000.x (for power cable) and MCAS-600.x (for sensor cable) shall be used (see Table 3 for adaptor cables). For the cables which use an M23 threaded metallic Hummel connector type, check the connection according to the following pictures:

![Wrong Connection!](image)

**Wrong Connection!**

![Correct Connection!](image)

**Correct Connection!**

---

*Figure 31: Wrong and correct Hummel connector type assembly*
5 Operation

5.1 System Operation with LPC-2000.1 (Stand-Alone Version)

5.1.1 State Diagram of LPC-2000.1

The controller LPC-2000.1 allows stand-alone operation with manual speed setting ("Button Control Mode") as well as extended operation with analog speed setting (Analog Control Mode). Figure 32 shows the state diagram which can be controlled with the manual buttons and the signals on the “USER INTERFACE” connector. The operation mode can be chosen by pressing the “UP” and “DOWN” buttons simultaneously during 5 seconds. For the standard firmware default setting ex factory is “Button Control Mode”.

![State Diagram](image)

*Figure 32: State diagram for operation with LPC-2000.1 controller (Description is for standard firmware, for other configurations refer to alternate firmware documentation)*
5.1.2 Standalone Operation (Button Control Mode)

- When applying power the system defaults into the “Button Control Mode” and goes into the status “OFF ButtonControl” according to Figure 32. Levitation is disabled and the display indicates “OF”.

- Levitation can be enable by pressing the “UP” button during 1 second (display shortly indicates “ON”) or by activating (typically 24V) the “ENABLE” pin on the “User Interface” connector (see Table 12). The system goes then into the status “ON Button Control” and is running at the speed which is stored in the EEPROM.

- The speed can be changed by pressing accordingly the “UP” and “DOWN” buttons. As long as the digits on the display are blinking the set speed is shown. As soon as blinking stops the actual speed is shown and the set-speed is stored in the EEPROM of the controller after about 2 seconds.

- The system can be disabled by pressing the “DOWN” button until 0 rpm is achieved. Pressing further 1 second the “DOWN” button the system disables levitation and shows “OF” on the display. The system can also be disabled by deactivating (0 V) the “ENABLE” pin on the “USER INTERFACE” connector (see Table 12). Before disabling the system the speed is automatically reduced to 0 rpm and the impeller is properly touched down without grinding the wall.

- In case of an error the “RESET” button (see Table 10) can be used to restart the system or the power can be switch off and on. For detailed error analysis the codes described in Table 14 are shown on the two digit display (blinking between “Er” and the according code number).
5.1.3 Extended Operation ("Analog Control Mode")

- In order to be able to control the pump with external signals (PLC) the mode “Analog Control Mode” has to be set with the display buttons. The “UP” and “Down” buttons have to be pressed simultaneously during 5 seconds. The display should feedback the change by blinking between the stored speed value and “An”. The chosen mode is then stored in the EEPROM of the controller.
- The system and levitation can be enabled/disabled with the digital input on the “USER INTERFACE” connector (see Table 12). When disabling the running system, the speed is automatically reduced to 0 rpm and the impeller is smoothly touched down without grinding the wall.
- The speed can be set with an analog signal on the “USER INTERFACE” connector according to Table 12. It is strongly recommended to use galvanic separated signal values.
- For monitoring purposes a digital output on the “USER INTERFACE” connector (see Table 12) indicates an error. In case of an error the codes described in Table 14 are displayed (blinking between “An” and the according code number).

5.1.4 Error Display on the Integrated Panel

<table>
<thead>
<tr>
<th>Error Code</th>
<th>Error Description</th>
<th>Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Er 01</td>
<td>No motor connected to controller</td>
<td>Connect motor cables to controller and press reset.</td>
</tr>
<tr>
<td>Er 02</td>
<td>Motor power cable not connected with controller</td>
<td>Connect motor power cable to controller and press reset. In case it is an extension adapter cable check if its connectors are tightly screwed together. Check motor power cable for damages and bent connector pins.</td>
</tr>
<tr>
<td>Er 03</td>
<td>Motor sensor cable not connected with controller</td>
<td>Connect motor sensor cable to controller and press reset. In case it is an extension adapter cable check if its connectors are tightly screwed together. Check motor sensor cable for damages and bent connector pins.</td>
</tr>
<tr>
<td>Er 04</td>
<td>No pump head detected</td>
<td>Verify that a pump head is mounted on the motor. Check if the pump head is properly inserted into the motor socket. Check if the fixation disk on the bottom of the pump head has been removed.</td>
</tr>
<tr>
<td>Er 05</td>
<td>Detected a potential short-circuit situation in the pump</td>
<td>Check if motor cables are correctly connected to the controller and press reset. Check motor cables for damages and bent connector pins.</td>
</tr>
<tr>
<td>Er 06</td>
<td>The pump could not stabilize the position of the impeller</td>
<td>Check if the pump head is correctly mounted on motor. Check operating conditions (Flow, viscosity, density, priming, cavitation). Check if motor sensor cable is correctly connected to the controller. In case it is an extension adapter cable check if its connectors are tightly screwed together.</td>
</tr>
<tr>
<td>Er 08</td>
<td>Supply voltage out of range (Power input) (supply voltage &lt;64 VAC or &gt;267 VAC → DC link voltage &lt;90 or &gt;378 V DC)</td>
<td>Check if controller supply voltage is in range. (Power input) (Power input voltage &gt;64 VAC and &lt;267 VAC)</td>
</tr>
<tr>
<td>Er 09</td>
<td>Failed to access controller internal memory</td>
<td>Check if motor sensor cable is correctly connected to the controller. In case it is an extension adapter cable check if its connectors are tightly screwed together and reset system.</td>
</tr>
<tr>
<td>Er 10</td>
<td>Failed to access motor internal memory</td>
<td>Check if motor sensor cable is correctly connected to the controller. In case it is an extension adapter cable check if its connectors are tightly screwed together and reset system.</td>
</tr>
<tr>
<td>Er 11</td>
<td>Controller temperature was above 80°C or higher than 70°C for more than 10 min.</td>
<td>Cool motor. Consult the 'Thermal Management' chapter in the pump manual.</td>
</tr>
<tr>
<td>Er 12</td>
<td>Motor temperature was above 100°C or higher than 90°C for more than 10 min.</td>
<td>Cool controller. Consult the 'Thermal Management' chapter in the pump manual.</td>
</tr>
<tr>
<td>Er 13</td>
<td>Controller detected an incompatible motor</td>
<td>Connect a compatible motor.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Blinking dots on display</th>
<th>Dry Running Detection</th>
<th>Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pump keeps running on reduced speed (5000 rpm). The system accelerates to the set speed value when the pump is refilled with liquid. Note that the speed is only reduced during dry running if the pump speed was ≥ 6000 rpm.</td>
<td>Prime the pump head.</td>
</tr>
</tbody>
</table>

Table 14: Errors and warnings with indication on display of LPC-2000.1

Note 1: In case of an error the system can only be restarted with a reset or a power supply restart.
Note 2: Description is for standard firmware.
Note 3: For other configurations of error codes refer to alternate controller or firmware documentation.
5.2 System Operation with Controller *LPC-2000.2* (PLC version)

5.2.1 State Diagram of the PLC Interface

![State Diagram of the PLC Interface](image)

*Figure 34: PLC interface state diagram for standard firmware*  
(For other configurations refer to alternate firmware documentation)
State “Off”:
The pump system is switched off and the motor has no power. In this state, Levitronix® Service Software has full control.

State “ON” (speed control mode):
The pump system is switched ON and the impeller is rotating with the referenced speed. The motor has electrical power when in this state.

State “ON” (process control mode):
The pump system is switched ON and the impeller speed is controlled in order to get the referenced flow/pressure. The motor has electrical power when in this state.

State “Error”:
If an error according to Table 15 occurs in the pump system, the system defaults to the Error state. The designated digital output on the PLC Interface is activated. The pump system is switched OFF. By activating the “Reset” input the system gets back to the “Off” state.

<table>
<thead>
<tr>
<th>Error Source</th>
<th>Errors</th>
<th>Effect on designated Digital Output of the PLC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor</td>
<td>No pump head detected</td>
<td>Error = relay open</td>
</tr>
<tr>
<td>Motor</td>
<td>Temperature over 100°C</td>
<td>Error = relay open</td>
</tr>
<tr>
<td>Motor</td>
<td>Temperature was higher than 90°C for more than 10 minutes.</td>
<td>Error = relay open</td>
</tr>
<tr>
<td>Motor</td>
<td>Temperature more than 90°C</td>
<td>Warning = relay open</td>
</tr>
<tr>
<td>Motor</td>
<td>No motor temperature signal</td>
<td>Warning = relay open</td>
</tr>
<tr>
<td>Motor</td>
<td>Motor power cable not connected with controller</td>
<td>Error = relay open</td>
</tr>
<tr>
<td>Motor</td>
<td>Motor sensor cable not connected with controller</td>
<td>Error = relay open</td>
</tr>
<tr>
<td>Controller</td>
<td>Over-current</td>
<td>Error = relay open</td>
</tr>
<tr>
<td>Controller</td>
<td>Power channel interrupted</td>
<td>Error = relay open</td>
</tr>
<tr>
<td>Controller</td>
<td>Temperature over 80°C</td>
<td>Error = relay open</td>
</tr>
<tr>
<td>Controller</td>
<td>Temperature was higher than 70°C for more than 10 minutes.</td>
<td>Error = relay open</td>
</tr>
<tr>
<td>Controller</td>
<td>Supply voltage out of range (Power input)</td>
<td>Error = relay open</td>
</tr>
<tr>
<td></td>
<td>(Ext. range: &lt; 90 or &gt; 378 V DC corresponds to &lt; 64 VAC or &gt; 267 VAC Input)</td>
<td>If the voltage is out of extended range the system starts to reduce the speed and an error is generated. When reaching 0 rpm and the voltage is still out of extended range the system is disabled.</td>
</tr>
<tr>
<td>Controller</td>
<td>Supply voltage out of range (Nominal range: &lt; 130 VDC corresponds to 180 VAC Input)</td>
<td>Warning = relay open</td>
</tr>
<tr>
<td></td>
<td>If the voltage is below nominal range still within extended range than performance reduction may be possible at higher flows and speeds and warning is generated. For DC voltages &lt; 130 but &gt;90 VDC the speed is limited to 4000 rpm.</td>
<td></td>
</tr>
<tr>
<td>Controller</td>
<td>Dry running situation has been detected</td>
<td>Warning = relay open</td>
</tr>
<tr>
<td>Controller</td>
<td>Dry Running Detection</td>
<td>Warning = relay open</td>
</tr>
</tbody>
</table>

Table 15: Errors and warnings with indication on PLC interface
Note 1: Description is for standard firmware.
Note 2: For other configurations of error codes refer to alternate controller or firmware documentation
5.3 System Operation for ATEX IECEx Applications

5.3.1 General Safety Requirements

Specific precautions may be considered while using the pump system in potential explosive gas atmospheres according to ATEX category 3G/3D (Zone 2 and 22).

The user shall prevent priming issues during normal pump operation. Especially precautions have to be considered during installing and maintenance operations to prevent the occurrence of combustible atmospheres.

The user shall prevent electrostatic charging of the system at cleaning processes by using dry cleaning cloth. User shall use wet cleaning rags to avoid issues with charging during a cleaning process.

---

**CAUTION**

Precautions have to be considered to prevent priming issues during installation operation and maintenance of the pump head / motor.

**WARNING**

Operational Temperature 110°C (T4)
Maximum allowed pump liquid temperature is 90°C / 194°F for the use in ATEX Zone 2 applications.

**WARNING**

Do not operate the pump against closed valves
Refer to the corresponding section in the manual.
6 Troubleshooting

6.1 Troubleshooting for Operation with Controller LPC-2000.1
For troubleshooting and failure analysis with the stand-alone controller LPC-2000.1 the following procedure is recommended:

- Check the status of the LEDs. The specific LEDs are described in Table 10
- Use the ERROR codes on the display. The specific error codes are described in Table 14
- A digital output on the “USER INTERFACE” connector (“Status”) indicates if the system is active. However, the source of an error cannot be identified by this signal

6.2 Troubleshooting for Operation with Controller LPC-2000.2
The integrated PLC provides a Warning and an Error signals according to Table 15. However, the source of error cannot be identified by these signals.

For more detailed analysis the Levitronix® Service Software can be used with a PC and a USB interface to the controller.

6.3 Troubleshooting with Levitronix® Service Software
The Levitronix® Service Software allows communication with the pump system in connection with a PC and a USB interface. The software can be used for performing detailed troubleshooting.

Note: the Levitronix® Service Software can not be used with the standalone controller LPC-2000.1.

7 Technical Support
For troubleshooting, support and detailed technical information contact Levitronix® Technical Service Department:

Levitronix®
Technical Service Department
Technoparkstr. 1
CH-8005 Zurich
Switzerland

Phone for US: 888-569 07 18
Phone for outside US: +1 888-569 07 18
E-Mail: TechSupport@levitronix.com
8 Appendix

8.1 Regulatory Status

8.1.1 CE Marking
The Centrifugal Pump System DuraLev® 2000, in its various configurations, is in conformity with the below mentioned European Directives. The pump system is thought to be used in hydraulic circuits of production equipment of the Semiconductor, Chemical and general machinery applications.

Machinery Directive 2006/42/EC:
The machinery directive essentially has been followed by a risk analysis, according mitigation actions and a user manual for safe operation. For the design and testing the following standards are used as a guideline:

- EN809 Pumps for Fluids: basic requirements are followed.
- EN12162 Procedure for hydrostatic pressure testing in fluid pumps: used for max. pressure testing of pump head.
- ISO12100 Safety for machinery – principles for risk assessments: used for system risk analysis.

EMC Directive 2014/30/EC:
The following standards of the EMC directive are tested and confirmed at a certified laboratory:

- EN61000-6-2 Generic standards, Immunity for industrial environments
- EN61000-6-4 Generic standards, Emission standard for industrial environments

Low Voltage Directive 2014/35/EC:
The low voltage directive essentially has been followed by a risk analysis, according mitigation actions and a user manual for safe operation. For the design and testing the following standards are used as a guideline:

- EN61010-1 Safety requirements for electrical equipment: 3rd party tested.
- ISO12100 Safety for machinery – principles for risk assessments: used for system risk analysis.

8.1.2 IECEE CB Safety Certification
Specific motors with pump heads and controllers of the Centrifugal Pump System DuraLev® 2000 are 3rd party tested and certified by Electrosuisse following the IECEE CB Scheme according to the following safety standards:

- IEC61010-1 Safety requirements for electrical equipment for measurement, control and laboratory use.

The CB certification number is CH-7546.

8.1.3 Disposal of Equipment – WEEE Directive 2012/19/EU
Follow local legislation for disposal of equipment. In the European Union (EU) marked (Ε) devices are governed by the European WEEE Directive 2012/19/EU. Do not dispose with normal waste.

8.1.4 NRTL/ETL Safety Certification and Marking
Specific motors with pump heads and controllers of the Centrifugal Pump System DuraLev® 2000 are tested by the US national recognized laboratory (NRTL) Intertek according to the following safety standards:

- UL61010-1 Safety requirements for electrical equipment for measurement, control and laboratory (US Standard).
- CSA-C22.2 No. 61010-1-12 Safety requirements for electrical equipment for measurement, control and laboratory use (Canadian Standard).
- UL1004-1 Rotating Electrical Machines - General Requirements (US standard).

The ETL control number for the listing is 4010272.
8.1.5  ATEX / IECEx Marking
Specific motors together with the pump head of the DuraLev® 2000 pump system are in conformity with the requirements of the Directive 2014/34/EU and the applicable IEC standards. The following standards are tested and confirmed at a certified laboratory.

- IEC / EN 60079-0  Electrical apparatus for explosive gas atmospheres. General requirements.
- IEC / EN 60079-7  Explosive atmospheres – Part 7: Equipment protection by Increased safety "e".
- IEC / EN 60079-31 Explosive atmospheres – Part 31: Equipment dust ignition protection by enclosure "t".
- ISO 80079-36  Non-electrical equipment for explosive atmospheres – Basic method and requirements.
- ISO 80079-37  Non-electrical equipment for explosive atmospheres – Protection by constructional safety "c".

The Levitronix® Ex motors are marked clearly and in accordance to the ATEX / IECEx directives and standards. The protection Ex ec means increased safety, non sparking motor.

II 3G Ex ec h IIC T5 Gc
II 3D Ex h tc IIIC T100°C Dc

Classification:  Category 3GD (Zone 2 for Gas and Zone 22 for Dust)
Thermal Classification:  Thermal classification of motor is 100 °C (T5) (100 °C = 212 °F) for maximum full-load operating temperature at a maximum liquid temperature of 90 °C / 194 °F.

8.1.6  Immunity to Voltage Sags – Semi F47
Based on internally testing at Levitronix® the pump system DuraLev® 2000 in its various configurations is able to handle all the voltage sags defined in SEMI F47. Therefore the pump system BPS-2000 full fills the requirements of the SEMI F47 standard. The nominal voltage range is 200 – 240 VAC ±10% for operation without performance reduction. Based on this range the voltage sags specified in SEMI F47 have an influence on the maximum performance as following:

<table>
<thead>
<tr>
<th>Specified voltage sag</th>
<th>Impact on the system</th>
</tr>
</thead>
<tbody>
<tr>
<td>80% of Equipment Nominal Voltage, duration 1000 ms</td>
<td>No impact on the system operation mode since supply voltage is above the warning level. Slight power drop at high flow rate and speed is possible.</td>
</tr>
<tr>
<td>70% of Equipment Nominal Voltage, duration 500 ms</td>
<td>No impact on the system operation mode since supply voltage is above the warning level; slight power drop at high flow rate and speed is possible.</td>
</tr>
<tr>
<td>50% of Equipment Nominal Voltage, duration 200 ms</td>
<td>The system reduces the speed to 4000 rpm for save operation since supply voltage is below the warning level.</td>
</tr>
</tbody>
</table>

After the disappearing of the voltage drop, the system is returning to its full performance.
8.2 Symbols and Signal Words

<table>
<thead>
<tr>
<th>Symbol / Signal Word</th>
<th>Description</th>
<th>Type</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DANGER</strong></td>
<td>Indication of an imminently hazardous situation that, if not avoided, will result in death or severe injury. Limited to the most extreme situation</td>
<td>Signal word</td>
<td>SEMI S1-0701</td>
</tr>
<tr>
<td><strong>WARNING</strong></td>
<td>Indication of a potentially hazardous situation which, if not avoided, could result in death or severe injury.</td>
<td>Signal word</td>
<td>SEMI S1-0701</td>
</tr>
<tr>
<td><strong>CAUTION</strong></td>
<td>Indication of potentially hazardous situations which, if not avoided, could result in moderate or minor injury. Also alert against unsafe practice. Without safety alert indication of hazardous situation which, if not avoided, could result in property damage.</td>
<td>Signal word</td>
<td>SEMI S1-0701</td>
</tr>
<tr>
<td>!</td>
<td>Safety alert for “Warning” and “Caution”</td>
<td>Safety alert</td>
<td>SEMI S1-0701</td>
</tr>
<tr>
<td>!</td>
<td>Safety alert for “Danger”</td>
<td>Safety alert</td>
<td>SEMI S1-0701</td>
</tr>
<tr>
<td>!</td>
<td>Caution (refer to accompanying documents) (is used on article labels for reference to manual)</td>
<td>Refer to manual</td>
<td>ISO 3864</td>
</tr>
<tr>
<td>💥</td>
<td>Toxic material, poison</td>
<td>Hazard identification</td>
<td>IEC 61310</td>
</tr>
<tr>
<td>💥</td>
<td>Corrosive material, corrosion</td>
<td>Hazard identification</td>
<td>IEC 61310</td>
</tr>
<tr>
<td>💥</td>
<td>Cut/sever hand, sharp object</td>
<td>Hazard identification</td>
<td>ANSI Z535.3</td>
</tr>
<tr>
<td>💥</td>
<td>Strong magnetic field</td>
<td>Hazard identification</td>
<td>SEMI S1-0701</td>
</tr>
<tr>
<td>💥</td>
<td>Danger: electricity, electrical hazard</td>
<td>Hazard identification</td>
<td>IEC 61310, ISO 3864</td>
</tr>
<tr>
<td>🧟‍♀️</td>
<td>Wear safety gloves</td>
<td>Hazard avoidance, Mandatory action</td>
<td>IEC 61310</td>
</tr>
<tr>
<td>🧟‍♀️</td>
<td>Wear face shield</td>
<td>Hazard avoidance, Mandatory action</td>
<td>SEMI S1-0701</td>
</tr>
<tr>
<td>😷</td>
<td>No pacemakers</td>
<td>Hazard avoidance, Prohibition</td>
<td>SEMI S1-0701</td>
</tr>
<tr>
<td>Ex</td>
<td>ATEX Logo</td>
<td>Used for hazard identification in warnings</td>
<td>--</td>
</tr>
</tbody>
</table>

*Table 16: Safety symbols and signal words*