DMX3 Micro 100781

ENG Instructions for use
Revision history

<table>
<thead>
<tr>
<th>Doc. version</th>
<th>Date</th>
<th>Author</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>25.11.2015</td>
<td>CZ</td>
<td>First version</td>
</tr>
<tr>
<td>1.1</td>
<td>06.03.2017</td>
<td>CZ</td>
<td>Updated for new hardware: single PCB, compliant with IEC 60601-1-2 ed. 4.0, supply voltage range of 32 VDC ±10%</td>
</tr>
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</tr>
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<td>endodontic auto-forward mode</td>
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<td>9</td>
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</tbody>
</table>
1 Symbols & abbreviations

1.1 Description of symbols

<table>
<thead>
<tr>
<th>Sign</th>
<th>Description</th>
<th>Sign</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>🚧</td>
<td>Manufacturer</td>
<td>![Recyclable]</td>
<td>Recyclable electrical and electronic materials</td>
</tr>
<tr>
<td>⚠</td>
<td>CAUTION!</td>
<td>⚠</td>
<td>ESD sensitive device</td>
</tr>
<tr>
<td>📡</td>
<td>Interference</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1: symbols

1.2 Description of abbreviations

- ADC Ampere Direct Current
- AM Amplitude Modulation
- CCW Counter Clockwise
- CW Clockwise
- DC Direct Current
- EEPROM Electrically-Erasable Programmable Read-Only Memory
- EMC ElectroMagnetic Compatibility
- ESD Electrostatic Discharge
- ISM Industrial, Scientific and Medical (radio bands)
- LED Light Emitting Diode
- PCB Printed Circuit Board
- REF Reference Number
- RF Radio Frequency
- RMS Root Mean Square
- rpm Revolutions Per Minute
- SN Serial Number
- SW Software
- VAC Voltage Alternative Current
- VDC Voltage Direct Current
2 Identification & intended use

2.1 Identification

The present document describes the Bien-Air Dental DMX3 Micro 100781 (hereafter DMX3 Micro) brushless and sensorless motor drive and its functionalities. The DMX3 Micro is the simplified and miniaturized version of the DMX3 board, controlling one of the three Bien-Air Dental brushless motors MCX, MX2 or MX-i. The board is exclusively controlled through the serial interface.

This document is applicable for the DMX3 Micro hardware and software version shown in table 2.

<table>
<thead>
<tr>
<th>Board version</th>
<th>Hardware REF</th>
<th>SW version</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMX3 Micro 100781, version with opto-isolated RS-232 interface and single-wire mode</td>
<td>1502116</td>
<td>1.02</td>
</tr>
</tbody>
</table>

**table 2: references and versions**

2.2 Intended use

This product is intended solely for professional use in dental office environments. It is intended for use in dentistry for the equipment that can perform restorative, endodontics and implantology procedures. Any use other than that for which this product is intended is prohibited and may prove dangerous.

The intended EM environment (per IEC 60601-1-2 ed. 4.0) is *Professional healthcare facility environment*. 
3 Warnings & precautions of use

3.1 Precautions of use

This electronic control is in compliance with electrical safety standards in line with standard IEC 60601-1, edition 3.1, and those governing electromagnetic compatibility in line with standard IEC 60601-1-2, fourth edition.

CAUTION!

The device must be used by a competent person, in particular in compliance with the legal provisions in force regarding occupational safety, health and accident prevention measures, and the current instruction for use. According to these measures, the user has the following obligations:

- to only use devices that are in perfect working order
- to make sure that the board is used solely for the purpose for which it is intended
- avoid contact with liquids.

3.2 Precautions to be taken during integration

- During integration, only use a medical supply that conforms to standards EN/IEC 60601-1, third edition, respecting the required withstand voltage, creepage distances and distances in air.
- Following integration, the complete assembly becomes an EM (electromedical) system.
- Connect the earths (GND) of all the electronic controls connected to the DMX3 Micro. This also applies to digital interfaces.
- Only use accessories and cables specified by Bien-Air Dental SA.

For more information about the integration or programming of the DMX3 Micro, please refer to the RS-232 specifications [1].

3.3 Electromagnetic compatibility warnings

CAUTION!

The DMX3 Micro complies with the EMC requirements according to IEC 60601-1-2. Radio transmitting equipment, cellular phones, etc., should not be used in the immediate vicinity of the device, since this could affect its operation. Special precautions should be taken when using strong emission sources such as high-frequency surgical equipment and other similar devices, to ensure that HF cables are not routed above or near the device. If in doubt, please contact a qualified technician or Bien-Air.

Portable RF communications equipment (including peripherals such as antenna cables and external antennas) should be used no closer than 30 cm (12 inches) to any part of the DMX3 Micro, including cables specified by the manufacturer. Otherwise, degradation of the performance of this equipment could result.

CAUTION!

The use of accessories, transducers and cables other than those specified, with the exception of transducers and cables sold by Bien-Air as spare parts for internal components, may result in increased emissions or decreased immunity.

CAUTION!

Since this device is intended to be used adjacent to or stacked with other equipment, the responsibility of verifying normal operation in the configuration in which it will be used falls onto the dental unit manufacturer.
3.4 Electromagnetic compatibility – emissions & immunity

Guidance and manufacturer’s declaration – Electromagnetic emissions

The DMX3 Micro is intended for use in the electromagnetic environment specified below. The customer or the user of the DMX3 Micro must ensure that it is actually used in such an environment.

<table>
<thead>
<tr>
<th>Emissions test</th>
<th>Compliance</th>
<th>Electromagnetic environment - guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF emissions CISPR 11</td>
<td>Group 1</td>
<td>The DMX3 Micro uses RF energy for its internal operation only. Therefore, its RF emissions are very low and are not likely to cause any interference in nearby electronic equipment.</td>
</tr>
<tr>
<td>RF emissions CISPR 11</td>
<td>Class B</td>
<td>The DMX3 Micro is suitable for use in any building, including residential buildings and those directly connected to the public low-voltage power supply network that supplies buildings used for residential purposes.</td>
</tr>
<tr>
<td>Harmonic emissions IEC 61000-3-2</td>
<td>N.A.</td>
<td></td>
</tr>
<tr>
<td>Emissions due to voltage fluctuations IEC 61000-3-3</td>
<td>N.A.</td>
<td></td>
</tr>
</tbody>
</table>

Table 3: electromagnetic emissions

Guidance and manufacturer’s declaration – Electromagnetic immunity

The DMX3 Micro is intended for use in the electromagnetic environment specified below. The customer or the user of the DMX3 Micro must ensure that it is actually used in such an environment.

<table>
<thead>
<tr>
<th>Immunity test</th>
<th>IEC 60601 test level</th>
<th>Compliance level</th>
<th>Electromagnetic environment - guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrostatic discharge (ESD) IEC 61000-4-2</td>
<td>±8 kV contact</td>
<td>±8 kV contact</td>
<td>Floors should be wood, concrete or ceramic tile. If floors are covered with synthetic material, the relative humidity should be at least 30%.</td>
</tr>
<tr>
<td></td>
<td>±2 kV air</td>
<td>±2 kV air</td>
<td></td>
</tr>
<tr>
<td></td>
<td>±4 kV air</td>
<td>±4 kV air</td>
<td></td>
</tr>
<tr>
<td></td>
<td>±8 kV air</td>
<td>±8 kV air</td>
<td></td>
</tr>
<tr>
<td></td>
<td>±15 kV air</td>
<td>±15 kV air</td>
<td></td>
</tr>
<tr>
<td>Electrical fast transient/burst IEC 61000-4-4</td>
<td>±2 kV for power supply lines</td>
<td>±2 kV for power supply lines</td>
<td>Mains power quality should be that of a commercial or hospital environment.</td>
</tr>
<tr>
<td></td>
<td>±1 kV for other lines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surge IEC 61000-4-5</td>
<td>±0.5 kV line to line</td>
<td>±0.5 kV line to line</td>
<td>Mains power quality should be that of a commercial or hospital environment.</td>
</tr>
<tr>
<td></td>
<td>±1 kV line to line</td>
<td>±1 kV line to line</td>
<td></td>
</tr>
<tr>
<td></td>
<td>±0.5 kV line to earth</td>
<td>±0.5 kV line to earth</td>
<td></td>
</tr>
<tr>
<td></td>
<td>±1 kV line to earth</td>
<td>±1 kV line to earth</td>
<td></td>
</tr>
<tr>
<td></td>
<td>±2 kV line to earth</td>
<td>±2 kV line to earth</td>
<td></td>
</tr>
<tr>
<td>Voltage dips, short interruptions and voltage variations on power supply input lines IEC 61000-4-11</td>
<td>0% Uₜ for 0.5 cycle, at 0°, 45°, 90°, 135°, 180°, 225°, 270° and 315°</td>
<td>0% Uₜ for 0.5 cycle, at 0°, 45°, 90°, 135°, 180°, 225°, 270° and 315°</td>
<td>Mains power quality should be that of a commercial or hospital environment. If the user of the DMX3 Micro requires continued operation during mains power interruptions, it is recommended that the DMX3 Micro be powered from an uninterruptible power supply or a battery.</td>
</tr>
<tr>
<td></td>
<td>0% Uₜ for 1 cycle and 70% Uₜ for 25/30 cycles at 0°</td>
<td>0% Uₜ for 1 cycle and 70% Uₜ for 25/30 cycles at 0°</td>
<td></td>
</tr>
</tbody>
</table>

Table 4: electromagnetic immunity
### Magnetic field due to mains frequency (50/60 Hz) IEC 61000-4-8

<table>
<thead>
<tr>
<th>Field Strength</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conducted disturbances induced by RF fields IEC 61000-4-6</td>
<td>3 V RMS 0,15 MHz – 80 MHz 6 V RMS in ISM bands 0,15 MHz – 80 MHz 80% AM at 1 kHz</td>
</tr>
<tr>
<td>Radiated RF EM fields IEC 61000-4-3</td>
<td>3 V/m 80 MHz – 2,7 GHz 80% AM at 1 kHz</td>
</tr>
</tbody>
</table>

### Conducted disturbances induced by RF fields IEC 61000-4-6

Field strengths from fixed RF transmitters, as determined by an electromagnetic site survey should be less than the compliance level in each frequency range. Interference may occur in the vicinity of equipment marked with the following symbol:

![RF symbol]

### Radiated RF EM fields IEC 61000-4-3

Field strengths from fixed transmitters, such as base stations for radio (cellular/cordless) telephones and mobile field radios, amateur radios, AM and FM radio broadcasts and TV broadcasts cannot be predicted theoretically with accuracy. To assess the electromagnetic environment due to fixed RF transmitters, an electromagnetic site survey should be considered. If the measured field strength in the location in which the DMX3 Micro is used exceeds the RF compliance level mentioned above, the DMX3 Micro should be observed to verify that it is operating normally. If abnormal operation is observed, additional measures may be necessary, such as reorienting or relocating the DMX3 Micro.

### Proximity fields from RF wireless communications equipment IEC 61000-4-3

<table>
<thead>
<tr>
<th>Test freq. [MHz]</th>
<th>Max. power [W]</th>
<th>Immunity test level [V/m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>385</td>
<td>1.8</td>
<td>27</td>
</tr>
<tr>
<td>450</td>
<td>2</td>
<td>28</td>
</tr>
<tr>
<td>710, 745, 780</td>
<td>0.2</td>
<td>9</td>
</tr>
<tr>
<td>810, 870, 930</td>
<td>2</td>
<td>28</td>
</tr>
<tr>
<td>1720, 1845, 1970</td>
<td>2</td>
<td>28</td>
</tr>
<tr>
<td>2450</td>
<td>2</td>
<td>28</td>
</tr>
<tr>
<td>5240, 5500, 5785</td>
<td>0.2</td>
<td>9</td>
</tr>
</tbody>
</table>

Distance: 0.3 m

NOTE: U_T is the AC mains voltage prior to application of the test level. Essential performance per IEC 60601-1: The essential performance is to maintain the visual luminous intensity of the LED and the motor speed. The maximum speed deviation is ±5%.

### 3.5 Electrostatic precautions

The device contains ESD sensitive elements, appropriate handling precautions must be observed!

**CAUTION!**

This DMX3 Micro uses semiconductors that can be damaged by electrostatic discharge (ESD). When handling, care must be taken so that the device is not damaged. Damage due to inappropriate handling is not covered by the warranty. The following precautions must be taken:

- do not open the protective conductive packaging until you have read the following, and are at an approved anti-static work station
- use a conductive wrist strap attached to a good earth ground when handling the device
• always discharge yourself by touching a grounded bare metal surface or approved anti-static mat before touching the device
• use an approved anti-static mat to cover your work surface.

3.6 Environmental protection and information for disposal

This device must be recycled. Electrical and electronic equipment may contain dangerous substances which constitute health and environmental hazards. The user can return the device to their dealer or directly enlist the services of a firm accredited for the processing and recovery of this type of equipment (European Directive 2002/96/EC).
4 System description

4.1 System overview

The Bien-Air DMX3 Micro is an electronic device designed to control the Bien-Air brushless and sensorless motors MCX, MX2 or MX-i. Only the Bien-Air brushless motors brand can be controlled via the DMX3 Micro. The MX2 and MCX motors are exclusively intended for prophylaxis, restorative and endodontics procedures while MX-i is exclusively intended for implantology procedures where medium to high torque is needed. Each motor can integrate a LED lighting.

The DMX3 Micro is able to control all parameters of the motors types mentioned above, such as speed from 100 to 40000 rpm, torque value, rotation direction (CW, CCW) and LED light intensity (if available in the motor). The DMX3 Micro also integrates endodontic functions (auto-forward and auto-reverse); they are available with the MCX or MX2 motors.

A RS-232 communication link is required in order to control the board. The default baudrate of 9600 baud can be customized.
### 4.2 Optional accessories

<table>
<thead>
<tr>
<th>Designation &amp; references</th>
<th>Designation &amp; references</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCX LED micromotor * 1600751-001</td>
<td>MCX hose (L=1.7m) 1600756-001</td>
</tr>
<tr>
<td>MCX micromotor * 1600780-001</td>
<td></td>
</tr>
<tr>
<td>MCX hose (L=1.7m) 1600756-001</td>
<td></td>
</tr>
<tr>
<td>MX2 LED micromotor * 1600677-001</td>
<td>MX2 hose (L=1.7m) 1600700-001</td>
</tr>
<tr>
<td>MX2 hose (L=1.7m) 1600700-001</td>
<td></td>
</tr>
<tr>
<td>MX-i LED micromotor * 1600755-001</td>
<td>MX-i hose (L=1.7m) 1600606-001</td>
</tr>
<tr>
<td>MX-i hose (L=1.7m) 1600606-001</td>
<td></td>
</tr>
<tr>
<td>Internal power supply 1305350-001</td>
<td></td>
</tr>
</tbody>
</table>

* Applied parts (per IEC 60601-1)

**Table 6: Optional accessories**
4.3 Main functions

The DMX3 Micro controls the motors MCX, MX2 and MX-i through the serial interface (RS-232). The DMX3 Micro features are as follows:

- motor speed range: 100 to 40000 rpm
- progressive or ON/OFF mode speed adjustment
- maximum torque adjustable from 10% to 100% (MX-i motor: 10% to 75%) in 1% increments
- motor LED brightness control (16 levels) or light ON/OFF
- restorative mode (clockwise/counter-clockwise)
- endodontics mode:
  - auto-reverse mode: the direction of rotation is automatically reversed when the torque limit is reached (adjustable from 10% to 100% of the maximum torque)
  - auto-forward mode: the direction of rotation is reversed in a similar manner to auto-reverse mode; in addition, the motor switches automatically to clockwise rotation after an adjustable period of counter-clockwise rotation (from 0 to 25.4 seconds).

Although the board can drive several motor types, the board is intended to be used with a single motor at a time. If the board is used to drive more than one motor (one after another), an external multiplexing is required. The Bien-Air “Dual motor switch” accessory cannot be driven directly from the DMX3 Micro.
5 Installation information

This chapter describes how to install a DMX3 Micro into a dental unit.

5.1 Power supply description

The DMX3 Micro has to be supplied with 32 VDC ± 10% \(^1\) in order to meet the specified performances such as motor speed and torque. If these tolerances are not respected, the performances cannot be guaranteed.

The DMX3 Micro power supply must be suited to the type of motor used, since the power requirements are different from a motor type to another. The use of an under powered power supply could lead to under-voltage errors when the motor is loaded or abnormal motor behaviour (sudden stop). Bien-Air Dental strongly recommends the use of a medical power supply that complies with the medical applicable standards.

The following conditions have to be fulfilled:

- supply voltage: 32 VDC ± 10% (min. 28.8 VDC, max. 35.2 VDC)
- nominal power input rating: 60 W at 32 VDC for MX2 and MCX motors
  120 W at 32 VDC for MX-i motor
- peak power input rating: 160 W at 32 VDC for MX2 and MCX motors
  320 W at 32 VDC for MX-i motor
- power supply approval standards: IEC 60601-1

\(^1\) The maximum motor speed of 40000 rpm CANNOT be maintained if the power supply voltage drops below 32 VDC – 10 \%(i.e. below 28.8 VDC): for instance, when driving an MX2 motor at 27.2 VDC, the maximum speed drops to about 39’800 rpm.

The power supply has to be thermally designed to withstand the nominal ratings and also needs to be able to supply the peak power during at least 3 seconds.

⚠️ CAUTION!

In order to comply with IEC 60601-1-2, the power supply line overall length must be shorter than 3 m. The use of ferrite beads is strongly recommended.

5.2 Serial commands

5.2.1 Functional description

The serial commands allow controlling the DMX3 Micro through the RS-232 communication interface. All parameters such as motor speed, motor torque, and motor LED light intensity can be set through RS-232. For more details, please refer to the RS-232 specifications [1].

Furthermore, the serial commands are used to define the motor working modes as summarized in table 7.

<table>
<thead>
<tr>
<th>Drive mode</th>
<th>Mode</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dec</td>
<td>Hex</td>
<td></td>
</tr>
<tr>
<td>00</td>
<td>0x00</td>
<td>Standby</td>
</tr>
<tr>
<td>01</td>
<td>0x01</td>
<td>Standard serial</td>
</tr>
<tr>
<td>06</td>
<td>0x06</td>
<td>Endodontic</td>
</tr>
<tr>
<td>09</td>
<td>0x09</td>
<td>Endodontic</td>
</tr>
<tr>
<td>12</td>
<td>0x0C</td>
<td>Endodontic</td>
</tr>
<tr>
<td>15</td>
<td>0x0F</td>
<td>Endodontic</td>
</tr>
</tbody>
</table>

| table 7: drive modes |
5.2.2 RS-232 interface information

The DMX3 Micro RS-232 communication interface is based on the Bien-Air Dental protocol.

The TX/RX lines of the DMX3 Micro are opto-isolated and do not match the standard RS-232 levels. Therefore, the board can NOT be connected to a computer without any suitable level translator.

The DMX3 Micro features a single wire RS-232 line option, which can be enabled by changing the device parameters. Once enabled, the single wire RS-232 line option allows communicating with a common TX/RX line, working as half-duplex communication. This protocol and the single wire RS-232 mode are fully described in the RS-232 protocol specification [1].

The default configuration is the following:

- baud rate: 9600 bauds (configurable through RS-232 commands)
- parity: none
- flow control: none
- character size: 8 bits
- stop bit: 1 bit
- duplex: full (single wire line inactive)
- TX line polarity: default LOW on the DMX3 Micro input connector
- RX line polarity: default LOW on the DMX3 Micro input connector
- timeout: one second when the motor runs or the light is turned on (can be customized).

⚠️ CAUTION!

The overall RS-232 cable length must be shorter than 3 meters. The use of a shielded RS-232 cable is strongly recommended.

5.3 DIP-switch for single wire RS-232 mode

The DIP-switch placed next to the input connector is used to connect both RX and TX lines together when the single wire RS-232 mode is active. The switch must be set as shown in the table 8.

<table>
<thead>
<tr>
<th>Position</th>
<th>RX/TX lines</th>
<th>Used for RS-232 mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON</td>
<td>Shorted</td>
<td>Single wire</td>
</tr>
<tr>
<td>OFF</td>
<td>Independent</td>
<td>Standard</td>
</tr>
</tbody>
</table>

table 8: DIP-switch configuration

The "ON" position is labelled on the switch.

⚠️ CAUTION!

Setting the DIP-switch alone does NOT enable the single wire mode. The mode must be set through serial commands (see [1]).

5.4 Start-up and shutdown procedure

After powering up the board, the serial commands to send in order to bring the DMX3 Micro into operation must follow the procedure described in the RS-232 specifications [1]. This involves in particular setting the motor type and the drive mode.

Shutting down the DMX3 Micro can be done by turning off the power supply. However, it is strongly recommended to stop the motor and turn off the light before cutting off the power supply. Cutting off the power supply during motor and/or light operation may cause hardware damages.
6 Hardware detailed description

CAUTION!

The technical specifications, illustrations and dimensions contained in these instructions are given only as a guide. They may not be the subject of any claim. The manufacturer reserves the right to make technical improvements to its equipment, without amending these instructions. For all additional information, please contact Bien-Air Dental SA at the address indicated on the back cover.

6.1 Board dimensions

The most important dimensions are depicted on the figure 1. The board is viewed from the processor side ("top").

The dimensions as summarized in the table 9.

figure 1: main dimensions, top view
6.2 Connectors description

In order to facilitate the cabling in the enclosure, both input and output connectors are placed on the same side of the PCB.

6.2.1 Input connector

The “input” side comprises the power input and the RS-232 communication interface. The input connector has 6 pins, where the pin 1 is defined as the pin next to the DIP-switch. The input connector pinning is shown in table 10.

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Function</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Main ground</td>
<td>Either pin can be used</td>
</tr>
<tr>
<td>2</td>
<td>+32 VDC input</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Isolated RX</td>
<td>Unit to DMX3 Micro</td>
</tr>
<tr>
<td>4</td>
<td>Isolated TX or common RX/TX line</td>
<td>DMX3 Micro to unit</td>
</tr>
<tr>
<td>5</td>
<td>Isolated ground</td>
<td>No galvanic connection to the main ground</td>
</tr>
</tbody>
</table>

CAUTION!

The DMX3 Micro doesn’t feature any reverse-polarity protection on the +32 V input! Reversing +32 V and GND may cause permanent damages to the hardware!

6.2.2 Output connector

The “output” side comprises the motor phases and light outputs. The output connector has 5 pins, where the pin 1 is defined as the pin next to the other connector. The output connector pinning is shown in table 11.

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Function</th>
<th>Standard Bien-Air wire colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Motor phase A</td>
<td>Blue</td>
</tr>
<tr>
<td>2</td>
<td>Motor phase B</td>
<td>Red</td>
</tr>
<tr>
<td>3</td>
<td>Motor phase C</td>
<td>Black</td>
</tr>
<tr>
<td>4</td>
<td>Negative light output</td>
<td>Orange</td>
</tr>
<tr>
<td>5</td>
<td>Positive light output</td>
<td>Brown</td>
</tr>
</tbody>
</table>
6.3 Diagnostic LEDs
The DMX3 Micro includes two diagnostic LEDs located on the top side of the board:
- green LED (“PWR”): the green LED indicates that the board is powered and ready to receive RS-232 commands; short flashes indicate RS-232 frame acknowledgment
- red LED (“DIAG”): the red LED indicates a DMX3 Micro error; this LED blinks according to the error type, see §7.2 for further information.

6.4 EEPROM memory
The DMX3 Micro stores all the user definable functioning parameters in an EEPROM memory. These are accessible via the RS-232 interface (see [1]).

6.5 Braking resistor (ballast)
The DMX3 Micro contains power resistors intended to dissipate the excess energy during motor braking. The resistors are automatically activated when the power supply voltage rises above 37.6V and deactivated when the voltage drops under 37.1V. These resistors draw enough current to dissipate the excess energy from the motor.

Special precaution is taken not to make the resistors overheat. They are first driven at full power during 1 s and then the power is reduced by applying PWM pulses at 1/7 duty cycle. This 2-step procedure allows dissipating quickly the excess energy while the motor is slowing down.

6.6 LED drive output
Depending on the serial commands, the DMX3 Micro can generate 16 different current levels to supply the motor LED. To achieve this requirement, a 326 mA fixed current source is chopped by PWM pulses to modulate the current source into 16 current levels. The PWM period is fixed and the pulse width depends on light intensity level.

![figure 2: motor LED light output waveform](image)

The table 12 shows the motor LED current versus the light intensity level. The motor LED current depends on light intensity level. For each intensity level, a certain pulse width is generated. Each current level is individually configurable in the EEPROM.
### Motor LED current versus light intensity level

<table>
<thead>
<tr>
<th>Light level</th>
<th>EEPROM parameter No.</th>
<th>EEPROM value “E”</th>
<th>Pulse width [μs]</th>
<th>LED current [mA]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>44</td>
<td>60</td>
<td>0</td>
<td>960</td>
</tr>
<tr>
<td>1</td>
<td>45</td>
<td>81</td>
<td>0</td>
<td>960</td>
</tr>
<tr>
<td>2</td>
<td>46</td>
<td>108</td>
<td>0</td>
<td>960</td>
</tr>
<tr>
<td>3</td>
<td>47</td>
<td>141</td>
<td>0</td>
<td>960</td>
</tr>
<tr>
<td>4</td>
<td>48</td>
<td>179</td>
<td>0</td>
<td>960</td>
</tr>
<tr>
<td>5</td>
<td>49</td>
<td>222</td>
<td>0</td>
<td>960</td>
</tr>
<tr>
<td>6</td>
<td>50</td>
<td>271</td>
<td>0</td>
<td>960</td>
</tr>
<tr>
<td>7</td>
<td>51</td>
<td>326</td>
<td>0</td>
<td>960</td>
</tr>
<tr>
<td>8</td>
<td>52</td>
<td>386</td>
<td>0</td>
<td>960</td>
</tr>
<tr>
<td>9</td>
<td>53</td>
<td>451</td>
<td>0</td>
<td>960</td>
</tr>
<tr>
<td>10</td>
<td>54</td>
<td>522</td>
<td>0</td>
<td>960</td>
</tr>
<tr>
<td>11</td>
<td>55</td>
<td>599</td>
<td>0</td>
<td>960</td>
</tr>
<tr>
<td>12</td>
<td>56</td>
<td>681</td>
<td>0</td>
<td>960</td>
</tr>
<tr>
<td>13</td>
<td>57</td>
<td>768</td>
<td>0</td>
<td>960</td>
</tr>
<tr>
<td>14</td>
<td>58</td>
<td>861</td>
<td>0</td>
<td>960</td>
</tr>
<tr>
<td>15</td>
<td>59</td>
<td>960</td>
<td>0</td>
<td>960</td>
</tr>
</tbody>
</table>

The pulse width is calculated from the EEPROM value (“E”) as follows:
\[
\text{PulseWidth [μs]} = E \cdot 2.133\mu s - 60\mu s
\]

The RMS current value is proportional to the squared root of the PWM duty cycle:
\[
I_{\text{RMS}} = I_{\text{max}} \cdot \sqrt{\frac{\text{PulseWidth}}{3276.8\mu s}} [\text{mA}]
\]

Note: The LED turn on can be delayed using the parameter 39 of the EEPROM. The LED switch off can also be delayed when the light delay function is active (see §9.3).

### 6.7 Other hardware properties

**Weight:**
- Approx. 44 g

**Label:**
- REF XXXXXXX: Reference number
- SW VXXYY: Software version (X = major revision, Y = minor revision)
- XXXXXXXX-011: Drawing number
- Rev XXXX: Revision number
- SN XXYZZZZ: Serial number (X = year, Y = month, Z = incremental number)

**Environmental conditions – operating:**
- temperature: +10 °C to +40 °C
- relative humidity: 30% to 80%, including condensation
- atmospheric pressure: 700 hPa to 1060 hPa.

**Environmental conditions – transport and storage:**
- max. period: 15 weeks
- temperature: -25 °C to +70 °C
- relative humidity: 10% to 95%
- atmospheric pressure: 500 hPa to 1060 hPa.

The device is lead-free and RoHS compliant.
7 Error detection information

7.1 Introduction
The DMX3 Micro integrates error detection functions and warnings in order to protect the electronic board and the motor against unwanted behaviours.

The DMX3 Micro integrates different protections:
1. power protection (error No. 1)
2. motor phase missing (error No. 2)
3. serial communication timeout error (error No. 3)
4. invalid EEPROM protection (error No. 4)
5. over temperature protection (error No. 5)
6. under power supply voltage protection (error No. 6)
7. over power supply voltage protection (error No. 7)
8. motor jammed protection (error No. 8)

Errors and warnings are processed as follows:
- an error is displayed by means of the red LED; the motor is instantly stopped once the error appears and an error bit is set on the status frame
- a warning is sent through the serial interface with the status frame. The motor does not stop.

If several errors are present simultaneously, the error with the highest priority (i.e. the lowest number) will be displayed by the diagnostic LED.

7.2 Diagnostic LED behaviour
The DMX3 Micro errors are displayed on a red LED located on the top side of the board. Each error is displayed with a predefined error code flashed by the red LED. The LED flashes a predefined number of times corresponding to the error code. To know which error code is present, the user can count the number of flashes of the LED.

<table>
<thead>
<tr>
<th>Error No.</th>
<th>Red LED number of flashes</th>
<th>Error description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1 per period</td>
<td>Power protection</td>
</tr>
<tr>
<td>2</td>
<td>2 per period</td>
<td>Motor phase missing</td>
</tr>
<tr>
<td>3</td>
<td>3 per period</td>
<td>Serial communication timeout error</td>
</tr>
<tr>
<td>4</td>
<td>4 per period</td>
<td>Invalid EEPROM protection</td>
</tr>
<tr>
<td>5</td>
<td>5 per period</td>
<td>Over temperature protection</td>
</tr>
<tr>
<td>6</td>
<td>6 per period</td>
<td>Under power supply voltage protection</td>
</tr>
<tr>
<td>7</td>
<td>7 per period</td>
<td>Over power supply voltage protection</td>
</tr>
<tr>
<td>8</td>
<td>8 per period</td>
<td>Motor jammed protection</td>
</tr>
</tbody>
</table>

Table 13: error codes description

As long as the error is present, the red LED repeats the error code according to the following diagram.

![figure 3: diagnostic red LED behaviour](image-url)
7.3 Power protection (error No. 1)
To prevent any DMX3 Micro damage due to a short circuit on the motor wires, the DMX3 Micro integrates a motor line power protection. The DMX3 Micro continually monitors the motor current during operation. In case of a short circuit on the motor wires, the motor is instantly stopped and the light is turned off. The red LED starts blinking (one flash, two seconds on, and so on).

The red LED blinks as long as the speed reference value is different from zero. To clear the power protection error, the speed reference value must return to zero.

7.4 Motor phase missing (error No. 2)
The DMX3 Micro integrates a missing phase detection. It continually monitors the motor connection during operation. In case the DMX3 Micro detects a disconnected phase on the motor, the motor is instantly stopped and the light is turned OFF. The red LED starts blinking (2 flashes, two seconds on, and so on).

The red LED blinks as long as the speed reference value is different from zero. To clear the phase missing error, the speed reference value must return to zero.

7.5 Serial communication timeout error (error No. 3)
In serial mode, the DMX3 Micro integrates a timeout security on RS-232 frames when motor is running or/and light is turned ON. This means that at least one frame per timeout period must be sent on RS-232 line from the unit to the DMX3 Micro. In case this condition is not fulfilled, a timeout error occurs. Once timeout error has occurred, both motor and light are turned off. The red LED starts blinking (3 flashes, two seconds on, and so on).

To clear the timeout error, the RS-232 frame “reset communication timeout” must be sent to the DMX3 Micro.

The default timeout duration is set to 1 second. This duration can be configured by a specific RS-232 command (see the RS-232 the specification [1] for further information). The timeout security can also be deactivated with the same frame.

7.6 Invalid EEPROM protection (error No. 4)
The DMX3 Micro stores important operating parameters in an EEPROM located on the top side of board. To prevent any data corruption or data loss, the DMX3 Micro checks the EEPROM data integrity at each power up. If a data corruption is detected, the DMX3 Micro freezes, the motor cannot be started and the red LED starts blinking (4 flashes, two seconds on, and so on).

This error cannot be cleared by the user and the DMX3 Micro has to be returned to Bien-Air Dental for inspection.

7.7 Over temperature protection (error No. 5)
To prevent any DMX3 Micro damage due to an overload, the DMX3 Micro integrates an over temperature protection. The DMX3 Micro continually monitors the board temperature by means of a temperature sensor located on the top side of the PCB. In case the DMX3 Micro detects a temperature over 80°C, the motor is instantly stopped and the light is turned off. The red LED starts blinking (5 flashes, two seconds on, and so on).

The error is cleared as soon as the DMX3 Micro temperature drops below 60°C. However, the motor remains stopped as long as the speed reference value has not been set to zero (prevents the auto-restart of the motor).

The figure 4 shows the DMX3 Micro over temperature detection behaviour.
7.8 Under and over voltage protection (errors No. 6 and 7)
The DMX3 Micro must be powered with 32 VDC ± 10% (28.8 VDC to 35.2 VDC) to meet the specified performances. The supply voltage is continually monitored by the DMX3 Micro.

In case this voltage exceeds 39 VDC or falls below 20 VDC, an over voltage error, respectively under voltage error is generated. The motor is then instantly stopped and the light is turned off. The red LED starts blinking (6 flashes in case of under voltage or 7 flashes in case of over voltage, two seconds on, and so on).

The errors are cleared as soon as the supply voltage is back in the range between 21 VDC to 38 VDC. However the motor remains stopped as long as the speed reference value has not been set to 0 (prevents the auto-restart of the motor). The figure 5 shows the DMX3 Micro over voltage and under voltage detection behaviour.
7.9 Motor jammed (warning / error No. 8)

The DMX3 Micro integrates a protection against the motor jamming. As soon as the motor is rotating, the software controls the motor parameters and detects any abnormal behaviour. When the rotor is blocked during more than 500 milliseconds, the DMX3 Micro sets a warning bit in the RS-232 status frame (see [1]).

If the rotor is blocked for a longer time, an error is generated and the motor will be automatically stopped by the DMX3 Micro. This error can be disabled and the delay customized (see [1]).

The warning bit disappears as soon as the motor is no longer jammed or if the motor is stopped by the user. The error can be cleared by stopping the motor.

7.10 Motor \( I^2t \) and \( I_t \) protection (warning)

The DMX3 Micro integrates a protection against the motor overheat caused by an overload. The DMX3 Micro permanently monitors the motor current during the operation. When the DMX3 Micro calculates that the motor will be overloaded, it decreases the available current, causing the torque to drop. During the limitation, a warning bit is activated in the RS-232 status frame (see [1]).

As soon as the motor loaded decreases, the torque limitation is progressively deactivated. The full torque is recovered after a certain period of time depending on the load conditions.

This protection is needed to fulfil the safety standards about the maximum motor temperature during operation. The figure 6 shows the typical DMX3 Micro torque limitation curve for the MX2 motor.

![Figure 6: \( I^2t \) and \( I_t \) response to a 100% torque load on MX2 motor](image)
8 Endodontic modes

8.1 Introduction

The DMX3 Micro has two built-in modes allowing performing endodontic therapy. The endodontic therapy can only be performed with an MX2 or MCX motor. The use of an MX-i motor excludes endodontic modes.

Endodontic therapies use small files. To prevent them from breaking, the motor torque has to be limited.

The endodontic modes, called auto-reverse and auto-forward, are slightly different from each other. In auto-reverse mode, if the motor torque exceeds the torque limitation, the motor speed quickly drops to zero and then the motor rotation direction changes from CW to CCW until the user stops the motor.

The auto-forward mode behaviour is quite similar to the auto-reverse mode except that the motor stays in CCW direction only during a predefined period of time (default value is 25.4 seconds) and then starts again in CW direction. The duration mentioned above is configurable through the RS-232 interface (see [1]).

The default torque limitation set in CW direction is 10% of the maximal available torque with the MX2 or the MCX motor. The CW default torque limitation can be modified (see [1]). During the CCW rotation direction phase, 50% of the maximal torque is added to the CW torque limitation. For example, if the torque is limited to 20% in CW, the limit in CCW will be 70%.

8.2 Auto-reverse mode

The auto-reverse mode behaves as follows:

1. the DMX3 Micro waits for the user to start the motor
2. the motor is started at the speed reference value in CW direction
3. as soon as the torque limit is reached, the motor speed falls down to zero
4. the motor changes its rotation direction to CCW and, if the light is active, its intensity is modulated
5. the DMX3 Micro waits for the user to stop the motor.

The following diagram shows this behaviour.

![Figure 7: Endodontic auto-reverse mode](image-url)
8.3 Auto-forward mode

The auto-forward mode behaves as follows:

1. the DMX3 Micro waits for the user to start the motor
2. the motor is started at the speed reference value in CW direction
3. as soon as the torque limit is reached, the motor speed falls down to zero
4. the motor changes its rotation direction to CCW and, if the light is active, its intensity is modulated
5. as soon as the torque in CCW falls below 10%, the timer begins to count down (the default value is 25.4 seconds)
6. when the time has elapsed, the motor rotation direction is set to CW again and the light intensity is not modulated anymore. The procedure is repeated from step 3 until the user stops the motor.

The following diagram shows this behaviour.

![Diagram showing the Auto-forward mode behavior](image-url)
9 Additional functional information

9.1 Wake-up delay
After powering up, the DMX3 Micro needs a certain time to be ready for operation. During the wake-up phase, the DMX3 Micro cannot be used and it will not answer to any received RS-232 commands.

The DMX3 Micro wake-up delay (SW version 1.02) is about 0.30 second. The end of the delay is indicated by the turning on of the green LED (see §6.3).

9.2 Status frame auto-send function
If needed, the DMX3 Micro can automatically send the status frame through the RS-232 interface. The status frame includes information about the motor behaviour as speed, torque, rotation direction, etc. For further information about the status frame, please refer to the RS-232 specification [1].

When auto-send is active, the status frame is sent every 100ms. This feature can be activated/deactivated with a specific RS-232 frame, see [1].

9.3 Light delay function
The light delay function allows keeping the motor light active during a predefined period of time after the motor has stopped. The function can be activated or deactivated by means of a specific frame, see the RS-232 specification [1] for details.

The default value is 10 seconds. The light delay value can be modified in the EEPROM via the RS-232 interface, see [1].

The diagram below shows detailed behaviour of the light delay function.

![Light delay function diagram](image)

**Notes:**
- the default light status is off when the light delay function is active
- the light delay function described here concerns the delay after stopping the motor. This delay is also called "off delay". The delay after starting the motor ("on delay", not shown on the figure 9) can also be enabled and customized by means of the parameter 39 (see [1]).
10 Maintenance

CAUTION!

Use only genuine Bien-Air Dental maintenance products and parts. The use of other products or parts could void the warranty.

Servicing

Never dismantle the device.

For all servicing and repairs, it is recommended that you contact your usual supplier or Bien-Air Dental directly.
11 Terms of guarantee

Bien-Air Dental grants the user a guarantee covering all functional defects, material or production faults. The guarantee period for this device is 12 months from the date of invoicing.

In the event of a justified claim, Bien-Air Dental SA or its authorized representative will fulfil the company's obligations under this guarantee by repairing or replacing the product free of charge. Any other claims, of whatever nature, in particular in the form of a claim for damages and interest, are excluded.

Bien-Air Dental SA shall not be held liable for damage or injury and the consequences thereof, resulting from:

- excessive wear and tear
- improper use
- non-observance of the instructions for installation, operation and maintenance
- unusual chemical, electrical or electrolytic influences
- poor connections, whether of the air, water or electricity supply
- inappropriate ESD handling.

The guarantee does not cover flexible “fiber optic” type light conductors, or any parts made of synthetic materials. The guarantee shall become null and void if the damage and its consequences are due to improper manipulation of the product, or modifications to the product carried out by persons not authorized by Bien-Air Dental SA.

Claims under the terms of the guarantee will be considered only on presentation, together with the product, of the invoice or the consignment note, on which the date of purchase, the product reference and the serial no. should be clearly indicated.

⚠️

The guarantee shall become null and void if a device is returned to Bien-Air without ESD protective packaging.