Knowles MEMS Microphones in Apple iPhone 7 Plus

Patent-to-Product Mapping

March 2017
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INTRODUCTION</strong></td>
<td>6</td>
</tr>
<tr>
<td>Company profile</td>
<td>7</td>
</tr>
<tr>
<td>Scope of the report</td>
<td>9</td>
</tr>
<tr>
<td>Key features of the report</td>
<td>11</td>
</tr>
<tr>
<td>Related reports</td>
<td>12</td>
</tr>
<tr>
<td><strong>METHODOLOGY</strong></td>
<td>13</td>
</tr>
<tr>
<td>Teardown analysis and patent mapping</td>
<td>14</td>
</tr>
<tr>
<td>Patent database and tools</td>
<td>15</td>
</tr>
<tr>
<td>Terminology for patent analysis</td>
<td>16</td>
</tr>
<tr>
<td><strong>TEAR DOWN</strong></td>
<td>18</td>
</tr>
<tr>
<td><strong>PATENT LANDSCAPE OVERVIEW</strong></td>
<td>22</td>
</tr>
<tr>
<td>Knowles IP portfolio</td>
<td>23</td>
</tr>
<tr>
<td>Time evolution of patent publications</td>
<td>25</td>
</tr>
<tr>
<td>Patent distribution by legal status</td>
<td>26</td>
</tr>
<tr>
<td>Mapping of granted patents and pending applications</td>
<td>27</td>
</tr>
<tr>
<td>Patent List</td>
<td>28</td>
</tr>
<tr>
<td>Inventors</td>
<td>33</td>
</tr>
<tr>
<td>Patent citations analysis</td>
<td>34</td>
</tr>
<tr>
<td>IP blocking potential of the patent families</td>
<td>35</td>
</tr>
<tr>
<td><strong>PATENT-TO-PRODUCT MAPPING</strong></td>
<td>36</td>
</tr>
<tr>
<td>Packaging: Housing &amp; RF shielding</td>
<td>37</td>
</tr>
<tr>
<td>Embedded capacitance</td>
<td>44</td>
</tr>
<tr>
<td>MEMS die</td>
<td>51</td>
</tr>
<tr>
<td>Diaphragm</td>
<td>54</td>
</tr>
<tr>
<td>Backplate: Perforation &amp; support structure</td>
<td>63</td>
</tr>
<tr>
<td>MEMS cavity &amp; bottom acoustic port</td>
<td>77</td>
</tr>
<tr>
<td><strong>PATENT LITIGATIONS</strong></td>
<td>87</td>
</tr>
<tr>
<td>Introduction</td>
<td>88</td>
</tr>
<tr>
<td>Knowles vs Company A</td>
<td>90</td>
</tr>
<tr>
<td>Knowles vs Company B</td>
<td>91</td>
</tr>
<tr>
<td>Knowles vs Company C</td>
<td>94</td>
</tr>
<tr>
<td>Knowles vs Akustica</td>
<td>95</td>
</tr>
<tr>
<td>Knowles vs Company D</td>
<td>96</td>
</tr>
<tr>
<td>Knowles vs Company E</td>
<td>98</td>
</tr>
<tr>
<td><strong>CONCLUSION</strong></td>
<td>99</td>
</tr>
<tr>
<td><strong>KNOWMADE PRESENTATION</strong></td>
<td>102</td>
</tr>
</tbody>
</table>
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Coralie Le Greneur

Romain Fraux

Brice Sagot
RELATED REPORTS

You may also be interested in those market analysis reports of our partners System Plus Consulting and Yole Développement:

- Apple iPhone 7 Plus: MEMS Microphones (2016) ([link](#))
- Vesper VM1000 Piezoelectric Microphone (2017) ([link](#))
- Acoustic MEMS (Microphone, Microspeaker) and Audio Solutions (2017) (to be published)
INTRODUCTION
INTRODUCTION
Scope of the Report

This report provides a patent-to-product mapping of the recent MEMS Microphones supplied by Knowles for the iPhone 7 Plus of Apple.
INTRODUCTION
Scope of the Report

This report provides a patent-to-product mapping of the recent MEMS Microphones supplied by Knowles for the iPhone 7 Plus of Apple.

The patent-to-product mapping study is focused on following features:

- **Process**: Diaphragm Structure, Anti-Stiction Bumps
- **Design**: Acoustic Holes Shape, Transducer Number & Shape
- **Packaging**: Port Structure, Housing, Embedded Capacitance, RF Shielding

The patent-to-product mapping study is **not related** to the following features:

- **ASIC Die**
- **Dicing**
- **Wire Bonding**
INTRODUCTION

Key Features of the Report

• **Essential IP analysis** of Knowles’ patent portfolio related to KSM1/KSM2 and KMM1 MEMS microphones found in Apple iPhone 7 Plus, including:

  • Time evolution of patent publications and countries of patent filings
  • Current legal status of patents
  • Citation network and competitive IP networks
  • Inventor identification

• **Deep insight on technology data**, including teardown analysis, of the Knowles microphone’s components

• **Key patents related to Knowles** microphone’s features and held by Knowles
METHODOLOGY
METHODOLOGY

Teardown Analysis and Patent Mapping

Teardown Analysis
- Package is analyzed and measured
- The dies are extracted in order to get overall data: dimensions, main blocks, pad number and pin out, die marking

Comparative Study
- A set of product features and manufacturing processes is selected regarding their interest in terms of IP study

Patent Search
- Patents are extracted from Questel-Orbit worldwide patent database by using keyword-based queries
- The selection of relevant patents is done manually by expert review of the subject-matter of inventions
- The patents are manually categorized regarding the selected product features

Patent Mapping
- The links between the patented technologies and the target product features are established
METHODOLOGY

Patent Database and Tools

• The data were extracted from the FamPat worldwide database (Questel-ORBIT) which provides 90+ million patent documents from 95 offices.
• The patents search was performed in January and February 2017, hence patents published after this date will not be available in this report.
• The patent selection was done manually.

Number of selected patent families related to KSM1/KSM2 and KMM1 MEMS Microphones developed by Knowles and found in Apple iPhone 7 Plus:
20 patent families

• The statistical analysis was performed with Questel Orbit IP Business Intelligence software.
• The patents were manually categorized using keyword analysis of patent title, abstract and claims, in conjunction with expert review of the subject-matter of inventions.
• The patents were organized according to FamPat’s family rules (variation of EPO strict family): A Patent Family comprises patents linked by exactly same priority numbers (strict family), plus comparison of priority and application numbers, specific rules by country and information gathered from other sources (national files, legal status ...).

Disclaimer: KnowMade is a research firm that provides technical analysis and technical opinions. The research, technical analysis and/or work contained herein is not a legal opinion and should not be construed as such.
PATENT LANDSCAPE OVERVIEW
Knowles IP Portfolio

Patent-to-Product Mapping

XX families related to the MEMS microphones of Knowles (KSM1/2 and KMM1) found in Apple iPhone 7 Plus have been identified in this Patent-to-Product Mapping

The MEMS portfolio of Knowles is mainly turn toward MEMS microphones (120 families out of 150)

Over 150 families of Knowles portfolio are related to MEMS

Knowles owns over 500 patent families worldwide. USA are by far the major country of filings, before China and Europe. The portfolio of Knowles is dedicated to audio and acoustic technologies, for examples: hearing aids, microphones, MEMS microphones,...
Knowles owns more than 500 patent families and over 120 families are dedicated to MEMS microphones. In this Patent-to-Product Mapping, we identified 20 patent families of Knowles related to the MEMS microphones of the company found in the iPhone 7 Plus (KMM1/KSM1/KSM2 microphones) which represents over 150 patents or applications.

Note: Due to the delay between the filing of patents and the publications by patent offices, usually 18 months, the data corresponding to the year 2016 and 2017 may not be complete since most patents filed during these years are not published yet.
Knowles has filed the patents related to the features identified for the KMM1/KSM1/KSM2 microphones worldwide.

Number of patent families* containing pending patent applications or granted patents in the corresponding country.

* A patent family is a set of patents filed in multiple countries by a common inventor(s) to protect a single invention.

4 PCT applications pending
PATENT LANDSCAPE OVERVIEW
Patent Citation Analysis

Main companies cited in selected Knowles patents

Main companies citing selected Knowles patents

Knowles MEMS Microphone in Apple iPhone 7 Plus – Patent-to-Product Mapping | March 2017 | Ref. : KM17004

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The patent USxxxxxxx and its associated family show a very high IP blocking potential. This patent and other US members of the family have been the subject of different patent litigations filed by Knowles against several competitors. Thus, it represents a key technology for Knowles. Over 35 patents of this family are currently granted in the US. Patents are also granted in Europe, Korea and Japan. Patent USxxxxxxx also has a high IP blocking potential. It has also been subject to patent litigations. Both patent families are related to the packaging of MEMS microphone and the RF shielding.

Note: The more the number of forward citations from different patent applicants is high, the more the capacity to hamper the other firms’ attempts to patent a related invention is important. Note, however, that the identification of a “blocking patent” requires an in-depth specific analysis of each patent.

*These patents have been the subject of patent litigations.
Packaging: The device is covered with a metal lid, which is removed in the optical view. The housing and RF shielding are identified in the patent families. Note: This patent and other members of the family have been part of infringement litigations introduced by Knowles (see Patent Litigations section).

**Identified Patent Families**

<table>
<thead>
<tr>
<th>Patent family</th>
<th>Claims</th>
<th>Description</th>
<th>Legal</th>
</tr>
</thead>
<tbody>
<tr>
<td>US20010100000</td>
<td>Claim 1: A mems transducer comprising: a printed circuit board comprising a plurality of layers comprising a conductive layer and an insulating layer covered by a cover comprising a printed circuit, a print portion of an aperture for the transducer and an liner comprising an electrode comprising a material of a conductor between the printed wire and the inside of the printed circuit comprising a conductive insulating, the printed wire is covered by a layer at least a portion of the printed material, the inner lining should include a conductive material, and the printed image against the commodity such as a faraday cage.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Selected Images**

16: amplifier
42: 
44: 
nor 
52: 
54: port
56: chamber
58: transducer
60: 
61: 
62: 
64: 
68: 
70: solder pads
74: side walls
**TEARDOWN**

**Packaging:**
The device is covered with a metal lid. The metal lid was removed for the optical view.

**Selected images**
- Metal Lid removed – Optical View
- Cross-Section Overview – SEM View

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**IDENTIFIED PATENT FAMILIES**

<table>
<thead>
<tr>
<th>Patent family</th>
<th>Claims</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>US 6,436,195 (2002)</td>
<td><strong>Claim 1:</strong> A microelectromechanical system package comprising: a microelectromechanical system microphone; a substrate comprising a surface for supporting the microphone; and a housing formed by connecting the peripheral edge portion of the cover to the substrate, the substrate being a supporting member for the microphone.</td>
<td>The housing 22 includes a top portion and a bottom portion, and the housing 22 is provided with a through hole 40 for passing the microphone through the housing 22. The housing 22 includes an outer ring 12 that is formed to be connected to the peripheral edge portion of the cover 14.</td>
</tr>
</tbody>
</table>
## Embedded Capacitance

### Identified Patent Families

<table>
<thead>
<tr>
<th>Patent family</th>
<th>Claims</th>
<th>Description</th>
<th>Legal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>152, a first metal layer 154, a first core layer 156, a second</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>156, a second metal layer 158, a second core layer 160, a</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>third core layer 162, and a bottom metal layer 164.</td>
<td></td>
</tr>
</tbody>
</table>

### Selected Images

- PCB Cross-Section – SEM View
- Embedded Capacitor Cross-Section – SEM View
**Backplate: Support Structure**

**TEARDOWN**

Design and Packaging:
MEMS Microphone uses a

**IDENTIFIED PATENT FAMILIES**

<table>
<thead>
<tr>
<th>Patent family</th>
<th>Claims</th>
<th>Description</th>
<th>Legal</th>
</tr>
</thead>
<tbody>
<tr>
<td>US (2015)</td>
<td>Claim 1: A microelectromechanical system (MEMS) die comprising: a substrate; an insulation layer disposed adjacent to the substrate;</td>
<td>The back plate 108 includes a plurality of</td>
<td>US:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>EP:</td>
</tr>
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<td></td>
<td></td>
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<td>JP:</td>
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<td>CN:</td>
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<td>KR:</td>
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<td></td>
<td></td>
<td>TW:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>*WO:</td>
</tr>
</tbody>
</table>

**Selected images**

- Backplate – Optical View
- MEMS Cross-section – Optical View
### Identified Patent Families

<table>
<thead>
<tr>
<th>Patent family</th>
<th>Claims</th>
<th>Description</th>
<th>Legal</th>
</tr>
</thead>
<tbody>
<tr>
<td>US: 7916010  (2001)</td>
<td>Claim 1: A solid-state transducer comprising: a substrate forming a support structure and a free-standing diaphragm attached to the substrate</td>
<td>The transducer 10 comprises a semi-conductor substrate commonly found in bulk micro-machined silicon structures.</td>
<td>US:</td>
</tr>
</tbody>
</table>
PATENT LITIGATIONS
**PATENT LITIGATIONS**

**Introduction**

Knowles is the leader on the MEMS microphone market. According to our partner Yole Développement, Knowles represented over XX% of the market share for MEMS microphones in 2016*. On the IP side, the company defends its interests against potential infringement by its competitors. Indeed, several patents identified in this Patent-to-Product Mapping have been involved in lawsuits introduced by Knowles in the USA. These patents belong to 2 families: USxxxxxxxx and WOxxxxxxx. Defendants in these lawsuits are Company XXX, Company XXX, Company XXX, Company XXX and Company XXX.

GoerTek is the 2nd market player behind Knowles on the MEMS microphone market, it owned XX% of the market share in 2016*. Company XXX is shortly in front of Company XXX, 3rd market player. Company XXX(acquired by Bosch in 2005), Company XXX (acquired by InvenSense and then TDK), Company XXX and Company XXX represented each less than XX% of the market share in 2016*.

The patent litigations are mostly related to packaging technology for MEMS microphones. They were all settled by an agreement between Knowles and the defendants.

*Source: Yole Développement, Acoustic MEMS (Microphone, Microspeaker) and Audio Solutions 2017 report (to be published)
ORDER FORM

Knowles MEMS Microphones in Apple iPhone 7 Plus – Patent-to-Product Mapping

Ref.: KM17004

SHIP TO
Name (Mr/Ms/Dr/Pr):
_____________________________________________________
Job Title:
_____________________________________________________
Company:
_____________________________________________________
Address:
_____________________________________________________
City:
_____________________________________________________
State:
_____________________________________________________
Postcode/Zip:
_____________________________________________________
Country:
_____________________________________________________
VAT ID Number for EU members:
_____________________________________________________
Tel:
_____________________________________________________
Email:
_____________________________________________________
Date:
_____________________________________________________

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To pay your invoice using a check, please mail your check to the following address:
KnowMade S.A.R.L.
2405 route des Dolines, BP 65
06902 Valbonne Sophia Antipolis
FRANCE

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Bank: Banque populaire St Laurent du Var CAP 3000 - Quartier du lac - 06700 St Laurent du Var
IBAN: FR76 1560 7000 6360 6214 5695 126
BIC/SWIFT: CCBPFRPPNE

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Mail: KnowMade S.A.R.L. 2405 route des Dolines, 06902 Sophia Antipolis, FRANCE

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1.1 The Contracting Parties undertake to observe the following general conditions when agreed by the
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7 days from the date of order, to be sent either by email or to the Buyer’s address. In the absence of any
confirmation in writing, orders shall be deemed to have been accepted.

2. MAILINGS OF THE PRODUCTS

2.1 Products are sent by mail to the Buyer: within [1] month from the order for Products already released; or
within a reasonable time for Products ordered prior to their effective release. In this case, the Seller shall
use its best endeavours to inform the Buyer of an indicative release date and the evolution of the work in
progress.

2.2 Some weeks prior to the release date the Seller can propose a pre-release discount to the Buyer.

2.3 The Seller shall by no means be responsible for any delay in respects of article 2.2 above, and including
in cases where a new event or access to new informational database would require for the analyst extra
time to complete or compute the data in order to enable the Seller to deliver a high quality products.

2.3 The mailing of the Product will occur only upon payment by the Buyer, in accordance with the conditions
contained in article 8.1 above.

2.4 The mailing is operated through electronic means either by email via the sales department. If the
Product’s electronic format is defective, the Seller undertakes to replace it at no charge to the Buyer
provided that it is informed of the defective formatting within 90 days from the date of the original
download or receipt of the Product.

2.5 The person receiving the Products on behalf of the Buyer shall immediately verify the quality of the
Products and their conformity to the order. Any claim for apparent defects or for non-conformity shall be
sent in writing to the Seller within 8 days of receipt of the Products. For this purpose, the Buyer agrees to
produce sufficient evidence of such defects.

3. PRICE, INVOICING AND PAYMENT

3.1 Prices are given in the orders corresponding to each Product sold on a unit basis or corresponding to
annual subscriptions. They are expressed to be inclusive of all taxes. The prices may be reevaluated from
the moment of delivery of the Product the next time a new one is to be the one applied at the time of the order.

3.2 Payments due by the Buyer shall be sent by cheque payable to Knowmadia, PayPal or by electronic
bank transfer in the following manner: Banque populaire St Laurent du Var CAP 3000 - Quartier du lac: 0670 St Laurent du Var
BIC or SWIFT code: CBPFRPPPC

IBAN: FR76 5560 0000 5310 6214 6505 126

To ensure the payments, the Seller reserves the right to demand payments from the Buyer. In this case
there are no delays. These delays are to be the one applied at the time of the order.

3.3 Payment is due by the Buyer to the Seller within 30 days from invoice date, except in the case of a
particular written agreement. If the Buyer fails to pay within this time and fails to contact the Seller, the
amount due is considered as not paid and becomes due on the order.

3.4 In the event of termination of the contract, or of misconduct, during the contract, the Seller will have
the right to invoice the stage in progress, and to take legal action for damages.

4. LIABILITIES

4.1 The Seller shall compensate or any other individual or legal person acting on its behalf, being a business user buying
the Products for its business activities, shall be solely responsible for choosing the Products and for the use and
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acts it deduces thereof.

4.2 The Seller shall only be liable for: (i) direct and (ii) foreseeable pecuniary loss caused by the Products or any
event arising as a result of the Seller’s negligence.

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obligation; (ii) any damage resulting from a lack of compliance with contractual conditions (by the same
way, not limited to, damages for loss of profit, business interruption and loss of programs or information)
resulting from the use of a Product or to the Seller’s website or the Products, or any information provided
by the Seller, or in the event of the Seller’s malfeasance and fraud.

4.4 All the information contained in the Products has been obtained from sources believed to be reliable.
The Seller does not warrant the accuracy, completeness adequacy or reliability of such information, which
are all the Seller’s own responsibility and are therefore exclusively bear.

4.5 All the Products that the Seller sells may, upon prior notice to the Buyer from time to time be modified
by updating the Product with the latest information available at the time of this notice. This modification
shall not lead to the liability of the Seller, provided that the Seller ensures the substituted Product is similar to the Product
initially ordered.

4.6 In the case where, after inspection, it is acknowledged that the Products contain defects, the Seller
undertakes to replace the defective products as far as the supplies allow and without indemnities or
compensation of any kind for labor costs, delays, loss caused or any other reason. The replacement is
guaranteed for a maximum of 2 months starting from the delivery date. Any replacement is excluded
from the warranty.

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compensation of any kind. If any cause of force majeure prevents the delivery of the Products, the Seller is
authorized to contest the information from the Seller. In such case only, the Buyer shall be entitled to ask for a reimbursement of its
first down payment on the exclusion of any further damages.

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saleability and fitness for a particular purpose, with respect to the Products. Although the Seller shall take
reasonable steps to screen Products for infection of viruses, worms, Trojan horses or other codes
which have the potential to cause harm before making the Products available, the Seller cannot
 guarantee that any Product will be free from infection.

5. FORCE MAJEURE

The Seller shall not be liable for any delay in performance directly or indirectly caused by or resulting from
acts of nature, fire, flood, accident, riot, war, government intervention, embargoes, strikes, labor
difficulties, equipment failure, late deliveries by suppliers or other difficulties which are beyond the control
of the Seller, which renders the Seller unable to fulfill its obligations under this sales agreement.

6. PROTECTION OF THE SELLER’S IPR

6.1 All the IPR attached to the Products are and remain the property of the Seller and are protected under
French and international copyright law and conventions.

6.2 The Buyer agrees not to disclose, copy, reproduce, redistribute, resell or publish the Product, or any
part of it to any other party other than employees of its company. The Buyer shall have the right to use the
Product for internal purposes, for the specific use for which the Product is designed and in any other case
for personal use.

6.3 The Buyer shall therefore not use the Product for purposes such as:

- Information storage and retrieval systems;

- Recordings and transmissions over any network (including any local area network);

- use in any timesharing, service bulletin, bulletin board or similar arrangement or public display;

- resale, are delivered only to the registered users in the order and

- Licensing, leasing, selling, offering for sale or assigning the Product.

6.4 The Buyer shall define within its company point of contact for the needs of the contract. This person will
be the recipient of each new report in PDF format. This person shall also be responsible for respecting
of the copyrights and will guaranty that the Products are not disseminated out of the company.

6.5 The Buyer shall define within the company point of contact the needs of the contract. This person will
be the recipient of each new report in PDF format. This person shall also be responsible for respecting
of the copyrights and will guaranty that the Products are not disseminated out of the company.

7. TERMINATION

7.1 If the Buyer cancels the order in whole or in part postpones the date of mailing, the Buyer shall
accept and concur any damages resulting from the termination or cancellation of such delay or cancellation. This may also apply for any other direct or indirect consequent loss that may be borne by the Seller, following this decision.

7.2 In the event of breach by one Party under these conditions or the order, the non-breaching Party
may send a notification to the other by recorded delivery letter upon which, after a period of thirty (30)
days without solving the problem, the non-breaching Party shall be entitled to terminate all the pending
orders, without being liable for any compensation.

8. MISCELLANEOUS

8.1 All the provisions of these Terms and Conditions are for the benefit of the Seller itself, but also for its
agents and employees. Each of them is entitled to assert and enforce these provisions against the
Buyer.

8.2 Changes in prices under these Terms and Conditions shall be given in writing. They shall be effective
upon receipt by the other Party.

8.3 The Seller may, from time to time, update these Terms and Conditions and the Buyer, is deemed to
have accepted the latest version of these terms and conditions, provided they have been communicated to him
in due time.

8.4 Governing Law and Jurisdiction

8.5 Any dispute arising out or linked to these Terms and Conditions or to any contract (orders) entered
into between the Parties shall be subject to the exclusive jurisdiction of the French courts, which shall have exclusive jurisdiction upon such issues.

8.6 The Parties shall not have any control over the relation between the Buyer and the Seller, in accordance with
these Terms and Conditions.