mSATA
3SE4 Series

Customer: __________________________
Customer Part Number: __________________________
Innodisk Part Number: __________________________
Innodisk Model Name: __________________________
Date: __________________________

<table>
<thead>
<tr>
<th>Innodisk Approver</th>
<th>Customer Approver</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<tr>
<td></td>
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</tr>
</tbody>
</table>
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# Revision History

<table>
<thead>
<tr>
<th>Revision</th>
<th>Description</th>
<th>Date</th>
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<tr>
<td>1.0</td>
<td>First Released</td>
<td>Sep., 2017</td>
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1. Product Overview

1.1 Introduction of Innodisk mSATA 3SE4

Innodisk mSATA 3SE4 which is designed with mSATA form factor by JEDEC MO-300/MO-300B, supporting SATA III standard (6.0Gb/s), achieves excellent performance up to 4CH standard by cost effective controller with 2CH. Regarding of mechanical interference, Innodisk mSATA 3SE4 absolutely replaces the traditional hard disk and makes personal computer, in any field, smaller and easier.

With Innodisk L³ FW architecture, combining our signature 4K mapping algorithm L² FW architecture with powerful LDPC technology, 3SE4 series has outstanding high IOPS, better data integrity and extended lifespan through reducing the bad block number happening.

For real industrial application, 3SE4 series is built in thermal sensor to monitor the environment temperature. iData Guard, the power loss management mechanism developed by Innodisk, ensures data integrity while power sudden loss happened.

1.2 Product View and Models

Innodisk mSATA 3SE4 is available in follow capacities within MLC flash ICs.

mSATA 3SE4 08GB  mSATA 3SE4 16GB  mSATA 3SE4 32GB  mSATA 3SE4 64GB

1.3 SATA Interface

Innodisk mSATA 3SE4 supports SATA III(6.0Gb/s) interface, and compliant with SATA I (1.5Gb/s) and SATA II(3.0Gb/s).
2. Product Specifications

2.1 Capacity and Device Parameters
mSATA 3SE4 device parameters are shown in Table 1.

Table 1: Device parameters

<table>
<thead>
<tr>
<th>Capacity</th>
<th>Cylinders</th>
<th>Heads</th>
<th>Sectors</th>
<th>LBA</th>
<th>User Capacity(MB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>08GB</td>
<td>15525</td>
<td>16</td>
<td>63</td>
<td>15649200</td>
<td>7,641</td>
</tr>
<tr>
<td>16GB</td>
<td>16383</td>
<td>16</td>
<td>63</td>
<td>31277232</td>
<td>15,272</td>
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<tr>
<td>32GB</td>
<td>16383</td>
<td>16</td>
<td>63</td>
<td>62533296</td>
<td>30,533</td>
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<tr>
<td>64GB</td>
<td>16383</td>
<td>16</td>
<td>63</td>
<td>125045424</td>
<td>61,057</td>
</tr>
</tbody>
</table>

2.2 Performance
Burst Transfer Rate: 6.0Gbps

Table 2: Performance

<table>
<thead>
<tr>
<th>Capacity</th>
<th>08GB</th>
<th>16GB</th>
<th>32GB</th>
<th>64GB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sequential Read (max.)</td>
<td>375 MB/sec</td>
<td>520 MB/sec</td>
<td>525 MB/sec</td>
<td>525 MB/sec</td>
</tr>
<tr>
<td>Sequential Write (max.)</td>
<td>75 MB/sec</td>
<td>150 MB/sec</td>
<td>290 MB/sec</td>
<td>345 MB/sec</td>
</tr>
<tr>
<td>4KB Random** Read (QD32)</td>
<td>23,000 IOPS</td>
<td>24,000 IOPS</td>
<td>31,000 IOPS</td>
<td>31,000 IOPS</td>
</tr>
<tr>
<td>4KB Random** Write (QD32)</td>
<td>13,000 IOPS</td>
<td>25,000 IOPS</td>
<td>28,000 IOPS</td>
<td>28,000 IOPS</td>
</tr>
</tbody>
</table>

Note: the information is based on CrystalDiskMark 5.1.2 with file size 1000MB test pattern

2.3 Electrical Specifications

2.3.1 Power Requirement

Table 3: Innodisk mSATA 3SE4 Power Requirement
### 2.3.2 Power Consumption

<table>
<thead>
<tr>
<th>Mode</th>
<th>Power Consumption (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Read</td>
<td>442 (max.)</td>
</tr>
<tr>
<td>Write</td>
<td>473 (max.)</td>
</tr>
<tr>
<td>Idle</td>
<td>139 (max.)</td>
</tr>
</tbody>
</table>

* Target: 64GB mSATA 3SE4

### 2.4 Environmental Specifications

#### 2.4.1 Temperature Ranges

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Range</th>
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</thead>
<tbody>
<tr>
<td>Operating</td>
<td>Standard Grade: 0°C to +70°C</td>
</tr>
<tr>
<td></td>
<td>Industrial Grade: -40°C to +85°C</td>
</tr>
<tr>
<td>Storage</td>
<td>-55°C to +95°C</td>
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</tbody>
</table>

#### 2.4.2 Humidity

Relative Humidity: 10-95%, non-condensing

#### 2.4.3 Shock and Vibration

<table>
<thead>
<tr>
<th>Reliability</th>
<th>Test Conditions</th>
<th>Reference Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vibration</td>
<td>7 Hz to 2K Hz, 20G, 3 axes</td>
<td>IEC 68-2-6</td>
</tr>
<tr>
<td>Mechanical Shock</td>
<td>Duration: 0.5ms, 1500 G, 3 axes</td>
<td>IEC 68-2-27</td>
</tr>
</tbody>
</table>

#### 2.4.4 Mean Time between Failures (MTBF)

Table 7 summarizes the MTBF prediction results for various mSATA 3SE4 configurations. The analysis was performed using a RAM Commander™ failure rate prediction.

- **Failure Rate**: The total number of failures within an item population, divided by the total number of life units expended by that population, during a particular measurement interval under stated condition.

- **Mean Time between Failures (MTBF)**: A basic measure of reliability for repairable items: The mean number of life units during which all parts of the item perform within their specified limits, during a particular measurement interval under stated conditions.
2.5 CE and FCC Compatibility

mSATA 3SE4 conforms to CE and FCC requirements.

2.6 RoHS Compliance

mSATA 3SE4 is fully compliant with RoHS directive.

2.7 Reliability

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Read Cycles</td>
<td>Unlimited Read Cycles</td>
</tr>
<tr>
<td>Flash endurance</td>
<td>60,000 P/E cycles</td>
</tr>
<tr>
<td>Wear-Leveling Algorithm</td>
<td>Support</td>
</tr>
<tr>
<td>Bad Blocks Management</td>
<td>Support</td>
</tr>
<tr>
<td>Error Correct Code</td>
<td>Support</td>
</tr>
</tbody>
</table>

**TBW* (Total Bytes Written)** Units: TB

<table>
<thead>
<tr>
<th>Capacity</th>
<th>Sequential workload</th>
<th>Client workload</th>
</tr>
</thead>
<tbody>
<tr>
<td>08GB</td>
<td>468.75</td>
<td>312.5</td>
</tr>
<tr>
<td>16GB</td>
<td>937.5</td>
<td>585.93</td>
</tr>
<tr>
<td>32GB</td>
<td>1,875</td>
<td>1,171.88</td>
</tr>
<tr>
<td>64GB</td>
<td>3,750</td>
<td>2,343.75</td>
</tr>
</tbody>
</table>

* Note:
1. Sequential: Mainly sequential write, tested by Vdbench.
2. Client: Follow JESD218 Test method and JESD219A Workload, tested by ULINK. (The capacity lower than 64GB client workload is not specified in JEDEC219A, the values are estimated.)

2.8 Transfer Mode

mSATA 3SE4 support following transfer mode:
- Serial ATA III 6.0Gbps
- Serial ATA II 3.0Gbps
- Serial ATA I 1.5Gbps

2.9 Pin Assignment

Innodisk mSATA 3SE4 uses a standard SATA pin-out. See Table 8 for mSATA 3SE4 pin assignment.
<table>
<thead>
<tr>
<th>Signal Name</th>
<th>Pin #</th>
<th>Pin #</th>
<th>Signal Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>GND</td>
<td>51</td>
<td>52</td>
<td>+3.3V</td>
</tr>
<tr>
<td>DAS</td>
<td>49</td>
<td>50</td>
<td>GND</td>
</tr>
<tr>
<td>NC</td>
<td>47</td>
<td>48</td>
<td>NC</td>
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<tr>
<td>NC</td>
<td>45</td>
<td>46</td>
<td>NC</td>
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<tr>
<td>NC</td>
<td>43</td>
<td>44</td>
<td>DEVSLP</td>
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<tr>
<td>+3.3V</td>
<td>41</td>
<td>42</td>
<td>NC</td>
</tr>
<tr>
<td>+3.3V</td>
<td>39</td>
<td>40</td>
<td>GND</td>
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<td>GND</td>
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<tr>
<td>GND</td>
<td>35</td>
<td>36</td>
<td>NC</td>
</tr>
<tr>
<td>RX+</td>
<td>33</td>
<td>34</td>
<td>GND</td>
</tr>
<tr>
<td>RX-</td>
<td>31</td>
<td>32</td>
<td>NC</td>
</tr>
<tr>
<td>GND</td>
<td>29</td>
<td>30</td>
<td>NC</td>
</tr>
<tr>
<td>GND</td>
<td>27</td>
<td>28</td>
<td>NC</td>
</tr>
<tr>
<td>TX-</td>
<td>25</td>
<td>26</td>
<td>GND</td>
</tr>
<tr>
<td>TX+</td>
<td>23</td>
<td>24</td>
<td>+3.3V</td>
</tr>
<tr>
<td>GND</td>
<td>21</td>
<td>22</td>
<td>NC</td>
</tr>
<tr>
<td>NC</td>
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<td>NC</td>
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<td>GND</td>
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<td>GND</td>
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<td>16</td>
<td>NC</td>
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<tr>
<td>NC</td>
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<td>NC</td>
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<td>12</td>
<td>NC</td>
</tr>
<tr>
<td>GND</td>
<td>9</td>
<td>10</td>
<td>NC</td>
</tr>
<tr>
<td>NC</td>
<td>7</td>
<td>8</td>
<td>NC</td>
</tr>
<tr>
<td>NC</td>
<td>5</td>
<td>6</td>
<td>NC</td>
</tr>
<tr>
<td>NC</td>
<td>3</td>
<td>4</td>
<td>GND</td>
</tr>
</tbody>
</table>
2.10 Mechanical Dimensions

2.11 Assembly Weight
An Innodisk mSATA 3SE4 within flash ICs, 32GB’s weight is 8 grams approximately.

2.12 Seek Time
Innodisk mSATA 3SE4 is not a magnetic rotating design. There is no seek or rotational latency required.

2.13 NAND Flash Memory
Innodisk mSATA 3SE4 uses Single Level Cell (SLC) NAND flash memory, which is non-volatility, high reliability and high speed memory storage. Read or Write data to flash memory for SSD is control by microprocessor.
3. Theory of Operation

3.1 Overview

Figure 2 shows the operation of Innodisk mSATA 3SE4 from the system level, including the major hardware blocks.

![Innodisk mSATA 3SE4 Block Diagram](image)

Figure 2: Innodisk mSATA 3SE4 Block Diagram

Innodisk mSATA 3SE4 integrates a SATA III controller and NAND flash memories. Communication with the host occurs through the host interface, using the standard ATA protocol. Communication with the flash device(s) occurs through the flash interface.

3.2 SATA III Controller

Innodisk mSATA 3SE4 is designed with 88NV1120, a SATA III 6.0Gbps (Gen. 3) controller. The Serial ATA physical, link and transport layers are compliant with Serial ATA Gen 1, Gen 2 and Gen 3 specification (Gen 3 supports 1.5Gbps/3.0Gbps/6.0Gbps data rate). The controller has 2 channels for flash interface.

3.3 Error Detection and Correction
Innodisk mSATA 3SE4 is designed with hardware LDPC ECC engine with hard-decision and Soft-decision decoding. Low-density parity-check (LDPC) codes have excellent error correcting performance close to the Shannon limit when decoded with the belief-propagation (BP) algorithm using soft-decision information.

### 3.4 Wear-Leveling

Flash memory can be erased within a limited number of times. This number is called the erase cycle limit or write endurance limit and is defined by the flash array vendor. The erase cycle limit applies to each individual erase block in the flash device.

Innodisk mSATA 3SE4 uses a static wear-leveling algorithm to ensure that consecutive writes of a specific sector are not written physically to the same page/block in the flash. This spreads flash media usage evenly across all pages, thereby extending flash lifetime.

### 3.5 Bad Blocks Management

Bad Blocks are blocks that contain one or more invalid bits whose reliability are not guaranteed. The Bad Blocks may be presented while the SSD is shipped, or may develop during the life time of the SSD. When the Bad Blocks is detected, it will be flagged, and not be used anymore. The SSD implement Bad Blocks management, Bad Blocks replacement, Error Correct Code to avoid data error occurred. The functions will be enabled automatically to transfer data from Bad Blocks to spare blocks, and correct error bit.

### 3.6 iData Guard

Innodisk’s iData Guard is a comprehensive data protection mechanism that functions before and after a sudden power outage to SSD. Low-power detection terminates data writing before an abnormal power-off, while table-remapping after power-on deletes corrupt data and maintains data integrity. Innodisk’s iData Guard provides effective power cycling management, preventing data stored in flash from degrading with use.

### 3.7 Garbage Collection

Garbage collection is used to maintain data consistency and perform continual data cleansing on SSDs. It runs as a background process, freeing up valuable controller resources while sorting good data into available blocks, and deleting bad blocks. It also significantly reduces write operations to the drive, thereby increasing the SSD’s speed and lifespan.

### 3.8 Trim

The Trim command is designed to enable the operating system to notify the SSD which pages no
longer contain valid data due to erases either by the user or operating system itself. During a delete operation, the OS will mark the sectors as free for new data and send a Trim command to the SSD to mark them as not containing valid data. After that the SSD knows not to preserve the contents of the block when writing a page, resulting in less write amplification with fewer writes to the flash, higher write speed, and increased drive life.

4. Installation Requirements

4.1 mSATA 3SE4 Pin Directions

Figure 3: Signal Segment and Power Segment

4.2 Electrical Connections for mSATA 3SE4

A Serial ATA device may be either directly connected to a host or connected to a host through an adaptor card. The SATA interface has a separate connector for the power supply. Please refer to the pin description for further details.

4.3 Device Drive

No additional device drives are required. The Innodisk mSATA 3SE4 can be configured as a boot device.
## 5. Part Number Rule

<table>
<thead>
<tr>
<th>CODE</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
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<th>9</th>
<th>10</th>
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<th>16</th>
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<th>18</th>
<th>19</th>
<th>20</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Disk</td>
<td>Capacity</td>
<td>Controller</td>
<td>Flash Mode</td>
<td>Operation Temp.</td>
<td>Internal Control</td>
<td>CH.</td>
<td>Flash Type</td>
<td>-</td>
<td>Customized Code</td>
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</tr>
<tr>
<td>Code 1st (Disk)</td>
<td>Code 13th (Flash Mode)</td>
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</tr>
<tr>
<td>D : Disk</td>
<td>S: Synchronous Flash</td>
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</tr>
<tr>
<td>Code 2nd ~ 5th (Form Factor)</td>
<td>Code 14th (Operation Temperature)</td>
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</tr>
<tr>
<td>EMSR: mSATA Regular</td>
<td>C: Standard Grade (0°C ~ +70°C)</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>W: Industrial Grade (-40°C ~ +85°C)</td>
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<td></td>
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<td>Code 7th ~ 9th (Capacity)</td>
<td>Code 15th (Internal control)</td>
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<td></td>
</tr>
<tr>
<td>08G: 08GB</td>
<td>A~Z: BGA PCB version</td>
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<tr>
<td>16G: 16GB</td>
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<td>32G: 32GB</td>
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<td>64G: 64GB</td>
<td>S: Single Channel</td>
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<td>D: Dual Channels</td>
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<td>Code 10th ~ 12th (Controller)</td>
<td>B: Toshiba SLC</td>
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<td>M41: 88NV1120</td>
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<td>Code 16th (Channel of data transfer)</td>
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<td>Code 17th (Flash Type)</td>
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<td>Code 19th~21th (Customized Code)</td>
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RoHS 自我宣告書 (RoHS Declaration of Conformity)

Manufacturer Product: All Innodisk EM Flash and Dram products

一、宜鼎國際股份有限公司（以下稱本公司）特此聲明售予貴公司之所有產品，皆符合歐盟2011/65/EU及(EU) 2015/863 關於RoHS之規範要求。

Innodisk Corporation declares that all products sold to the company, are complied with European Union RoHS Directive (2011/65/EU) and (EU) 2015/863 requirement.

二、本公司同意因本保證書或與本保證書相關事宜有所爭議時，雙方宜友好協商，達成協議。

Innodisk Corporation agrees that both parties shall settle any dispute arising from or in connection with this Declaration of Conformity by friendly negotiations.

<table>
<thead>
<tr>
<th>Name of hazardous substance</th>
<th>Limited of RoHS</th>
<th>ppm (mg/kg)</th>
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</thead>
<tbody>
<tr>
<td>鎻 (Pb)</td>
<td>&lt; 1000 ppm</td>
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<tr>
<td>銅 (Cu)</td>
<td>&lt; 1000 ppm</td>
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<tr>
<td>銅 (Cd)</td>
<td>&lt; 100 ppm</td>
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<tr>
<td>六價鉻 (Cr VI)</td>
<td>&lt; 1000 ppm</td>
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<tr>
<td>多溴聯苯 (PBDEs)</td>
<td>&lt; 1000 ppm</td>
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<tr>
<td>多溴二苯醚 (PBDEs)</td>
<td>&lt; 1000 ppm</td>
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<tr>
<td>邻苯二甲酸二 (2-乙基己基)酯 (DEHP)</td>
<td>&lt; 1000 ppm</td>
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<tr>
<td>邻苯二甲酸丁酯苯甲酯 (DEP)</td>
<td>&lt; 1000 ppm</td>
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<tr>
<td>邻苯二甲酸二異丁酯 (DIBP)</td>
<td>&lt; 1000 ppm</td>
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</tbody>
</table>

立 證  人  (Guarantor)

Company name 公司名稱： Innodisk Corporation 宜鼎國際股份有限公司

Company Representative 公司代表人： Randy Chien 管川勝

Company Representative Title 公司代表人職稱： Chairman 董事長

Date 日期： 2017 / 01 / 18
REACH Declaration of Conformity

Manufacturer Product: All Innodisk EM Flash and Dram products

1. 宜鼎國際股份有限公司（以下稱本公司）特此聲明所售予貴公司之產品，皆符合歐盟化學品
法案 (Registration, Evaluation and Authorization of Chemicals: (EC) No 1907/2006 REACH)
以及附錄 XIV 中的限用物質之規定 (http://www.echa.europa.eu/de/candidate-list-table
last updated: 12/01/2017, SVHC’s 173).

所提供的產品包含：(1) 產品或產品所使用到的所有原物料；(2) 包裝材料；(3) 設計、生產
及重工過程中所使用到的所有原物料。

We Innodisk Corporation hereby declare that our products are in compliance with the
requirements according to the (EC) No 1907/2006 REACH Regulation and restricted
substances in Annex XIV (http://www.echa.europa.eu/de/candidate-list-table
last updated: 12/01/2017, SVHC’s 173).

Products include: 1) Product and raw material used by the product: 2) Packaging
material: 3) Raw material used in the process of design, production and rework.

2. 本公司同意因本保證書或與本保證書相關事宜有所爭議時，雙方宜友好協商，達成協議，
InnoDisk Corporation agrees that both parties shall settle any dispute arising from or in
connection with this Declaration of Conformity by friendly negotiations.

立 證 書 人 (Guarantor)

Company name 公司名稱： Innodisk Corporation 宜鼎國際股份有限公司

Company Representative 公司代表人： Randy Chien 簡川勝

Company Representative Title 公司代表人職稱： Chairman 董事長

Date 日期： 2017/02/08
VERIFICATION OF COMPLIANCE

This Verification of Compliance is hereby issued to the below named company. The test results of this report relate only to the tested sample identified in this report.

Technical Standard: EMC DIRECTIVE 2014/30/EU (EN55022 / EN55024)

General Information
Applicant: Innodisk Corporation
5F., No. 237, Sec. 1, Datong Rd., Xizhi Dist.,
New Taipei City 22161, Taiwan (R.O.C.)

Product Description
EUT Description: mSATA
Brand Name: Innodisk
Model Number: mSATA 35*-&-
$-Flash type: (S:SLC, E:MLC, M:MLC, T:3D TLC)
*.:Product line: (E:Embedded, G:EverGreen, R:InnoRobust)
#:Product Generation: (empty, 0-9)
&:Product line: (empty, P:Plus)

Measurement Standard
EN 55022: 2010 / AC: 2011
EN 61000-3-2: 2014
EN 61000-3-3: 2013

Measurement Facilities
Xindian Lab.: Compliance Certification Services Inc.
No.163-1, Jhongsheng Rd., Xindian Dist., New Taipei City, 23131 Taiwan.
Tel: +886-2-22170964 / Fax: +886-2-22171029

This device has been shown to be in compliance with and was tested in accordance with the measurement procedures specified in the Standards & Specifications listed above and as indicated in the measurement report number: T161004D13-E

Sam Hsu / Assistant Manager
Date: October 11, 2016
VERIFICATION OF COMPLIANCE

This Verification of Compliance is hereby issued to the below named company. The test results of this report relate only to the tested sample identified in this report.

Technical Standard: EMC DIRECTIVE 2014/30/EU (EN55032)

General Information
Applicant: Innodisk Corporation
5F., No. 237, Sec. 1, Duzong Rd., Xizhi Dist., New Taipei City 22161, Taiwan (R.O.C.)

Product Description
EUT Description: mSATA
Brand Name: Innodisk
Model Number: mSATA 3S*#-&
S:Flash type: (S:SLC, HiSLC, M:MLC, T:3D TLC)
*:Product line: (E:Embedded, G:EverGreen, R:InnoRobust)
#:Product Generation: (empty, 0-9)
&:Product line: (empty, P:Plus)

Measurement Standard
EN 55032: 2012/AC: 2013
CISPR 32: 2012

Measurement Facilities
Xindian Lab.: Compliance Certification Services Inc.
No.163-1, Zhongsheng Rd., Xindian Dist., New Taipei City, 23151 Taiwan.
Tel: +886-2-22170894 / Fax: +886-2-22171029

This device has been shown to be in compliance with and was tested in accordance with the measurement procedures specified in the Standards & Specifications listed above and as indicated in the measurement report number: T16004DL3-E

Sam Hu / Assistant Manager
Date: October 11, 2016
VERIFICATION OF COMPLIANCE

This Verification of Compliance is hereby issued to the below named company. The test results of this report relate only to the tested sample identified in this report.

Technical Standard: FCC Part 15 Class B
IC ICES-003

General Information
Applicant: Innodisk Corporation
5F., No. 237, Sec. 1, Dazeng Rd., Xizhi Dist.,
New Taipei City 22161, Taiwan (R.O.C)

Product Description
EUT Description: mSATA
Brand Name: Innodisk
Model Number: mSATA 3S*# &
$Flash type: (S: SLC, P: SLC, M: MLC, T: 3D TLC)
+Product line: (E: Embedded, G: EverGreen, R: InnoRobust)
#Product Generation: (empty, 0-9)
&:Product line: (empty, P: Pico)

Measurement Facilities
Xindian Lab.: Compliance Certification Services Inc.
No.163-1, Jhongsheng Rd., Xindian Dist., New Taipei City, 23151 Taiwan.
Tel: +886-2-22170894 / Fax: +886-2-22171029

This device has been shown to be in compliance with and was tested in accordance with the measurement procedures specified in the Standards & Specifications listed above and as indicated in the measurement report number: T161004D13-D

Sam Hu / Assistant Manager
Date: October 11, 2016