**PT**

# Check items off your to-do list faster with Dell OptiPlex small and micro form-factor desktops powered by Intel Core processors

## vs. comparable Lenovo ThinkCentre M Series desktops powered by AMD Ryzen PRO processors

Choosing the right Windows 10 Pro desktop can feel like throwing a dart at a dartboard. You know you want something compact, but how will the choice of processor affect your experience? To find out, we ran performance, system responsiveness, productivity, and content creation comparisons on Dell™ OptiPlex™ desktops powered by Intel® Core™ i3, i5, and i7 processors versus comparable Lenovo® ThinkCentre® M Series desktops powered by AMD Ryzen™ 3, 5, and 7 PRO processors.

Notice up to 41% better system responsiveness during day-to-day tasks based on higher SYSMark 2018 overall scores*

Open large Excel spreadsheets in up to 36% less time*

Render 4K Adobe® Premiere® Pro videos in up to 37% less time**

Gain up to 134% better processing power to run AI operations locally based on higher AIXPRT ML inference scores*

*Dell OptiPlex 5080 Micro Desktop with a 10th Gen Intel Core i5-10600T vPro® processor vs. Lenovo ThinkCentre M75q Tiny Desktop with an AMD Ryzen 5 PRO 3400GE processor

**Dell OptiPlex 3080 Micro Desktop with a 10th Gen Intel Core i3-10100T processor vs. Lenovo ThinkCentre M75q Tiny Desktop with an AMD Ryzen 3 PRO 3200GE processor

## What we tested

In this study, we combined benchmark and scenario-based testing to compare performance, system responsiveness, productivity, and content creation on the following devices.

### Space-saving desktops with <u>entry-level</u> CPU specs

- 8 GB of memory
- 256 GB of PCIe® SSD storage

**Dell OptiPlex 3080 Micro Desktop** powered by a 10th Gen Intel Core i3-10100T processor with integrated Intel UHD Graphics 630

vs.

**Lenovo ThinkCentre M75q Tiny Desktop** powered by an AMD Ryzen 3 PRO 3200GE processor with integrated AMD Radeon Vega 8 Graphics

### Space-saving desktops with <u>mid-range</u> CPU specs

- 8 GB of memory
- 256 GB of PCIe SSD storage

**Dell OptiPlex 5080 Micro Desktop** powered by a 10th Gen Intel Core i5-10600T vPro processor with integrated Intel UHD Graphics 630

vs.

**Lenovo ThinkCentre M75q Tiny Desktop** powered by an AMD Ryzen 5 PRO 3400GE processor with integrated AMD Radeon-RX Vega 11 Graphics

### Space-saving desktops with <u>high-end</u> CPU specs

- 16 GB of memory
- 512 GB of PCIe SSD storage

**Dell OptiPlex 7080 Small Form Factor Desktop** powered by a 10th Gen Intel Core i7-10700 processor with NVIDIA® GeForce® GT 730 dedicated graphics

vs.

**Lenovo ThinkCentre M75s Small Form Factor Compact PC** powered by an AMD Ryzen 7 PRO 3700 processor with dedicated AMD Radeon 520 Graphics

## Performance

On all six desktops, we ran three real-world benchmarks: SYSmark 2018, WebXPRT 3, and AIXPRT. SYSmark 2018 workloads reflect day-to-day application usage patterns; WebXPRT 3 evaluates browser performance; and AIXPRT determines machine learning inference performance.[1,2,3]
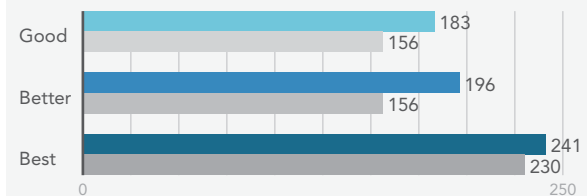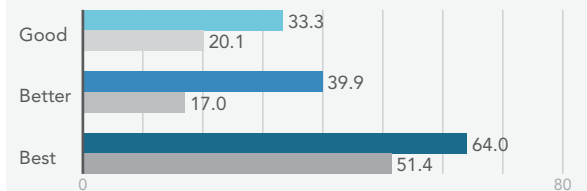


**SYSmark 2018 overall score**
Higher is better

| | |
|---|---|
| Good | 1,234 / 971 |
| Better | 1,418 / 1,000 |
| Best | 1,832 / 1,513 |

(0 – 2,000)
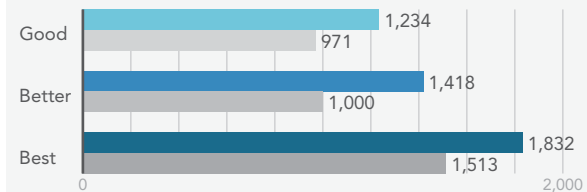
**WebXPRT 3 overall score**
Higher is better

| | |
|---|---|
| Good | 183 / 156 |
| Better | 196 / 156 |
| Best | 241 / 230 |

(0 – 250)

**AIXPRT ResNet-50 maximum inference throughput**
Images per second | Higher is better

| | |
|---|---|
| Good | 33.3 / 20.1 |
| Better | 39.9 / 17.0 |
| Best | 64.0 / 51.4 |

(0 – 80)

**Good**
- Dell OptiPlex 3080 Micro with a 10th Gen Intel Core i3-10100T processor
- Lenovo ThinkCentre M75q Tiny with an AMD Ryzen 3 PRO 3200GE processor

**Better**
- Dell OptiPlex 5080 Micro with a 10th Gen Intel Core i5-10600T vPro processor
- Lenovo ThinkCentre M75q Tiny with an AMD Ryzen 5 PRO 3400GE processor

**Best**
- Dell OptiPlex 7080 SFF with a 10th Gen Intel Core i7-10700 processor
- Lenovo ThinkCentre M75s SFF with an AMD Ryzen 7 PRO 3700 processor

Figure 1: SYSmark 2018 overall performance qualification scores, WebXPRT 3 Microsoft Edge browser overall scores, and AIXPRT ResNet-50 max inference throughput scores. Higher is better. Source: Principled Technologies.

## System responsiveness

Desktops that take too long to start can be frustrating, so we hand-timed how long it took for each desktop to come up to speed in three difference scenarios.
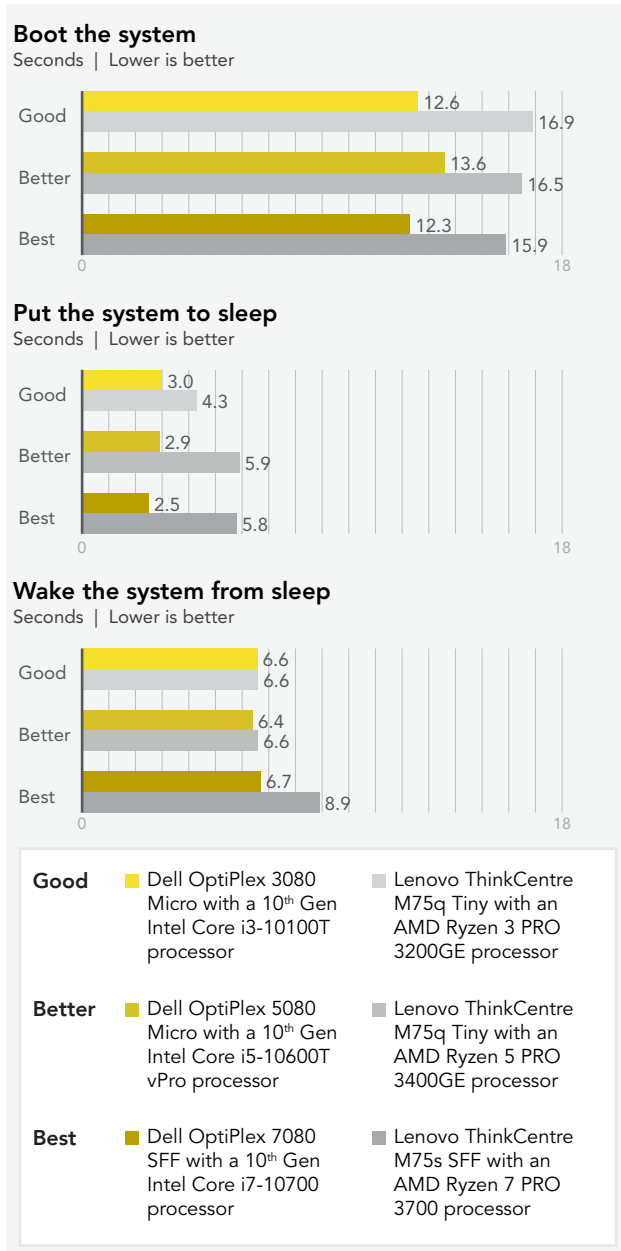
## Productivity

Whether you're using Microsoft 365 tools for business or pleasure, the faster you can knock things off your to-do list, the more time you have for the rest of your life. We hand-timed how long it took for each desktop to complete a few simple Microsoft 365 workflows.
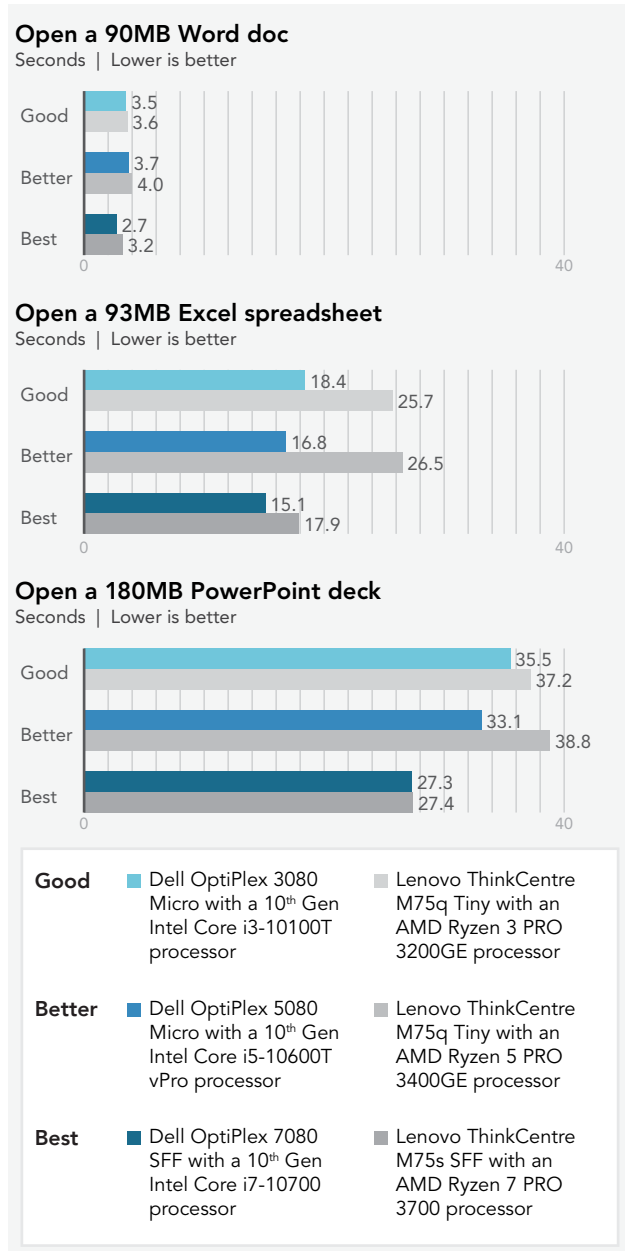
### Boot the system
Seconds | Lower is better

| | |
|---|---|
| Good | 12.6 / 16.9 |
| Better | 13.6 / 16.5 |
| Best | 12.3 / 15.9 |

0 — 18

### Put the system to sleep
Seconds | Lower is better

| | |
|---|---|
| Good | 3.0 / 4.3 |
| Better | 2.9 / 5.9 |
| Best | 2.5 / 5.8 |

0 — 18

### Wake the system from sleep
Seconds | Lower is better

| | |
|---|---|
| Good | 6.6 / 6.6 |
| Better | 6.4 / 6.6 |
| Best | 6.7 / 8.9 |

0 — 18

**Good** — Dell OptiPlex 3080 Micro with a 10th Gen Intel Core i3-10100T processor / Lenovo ThinkCentre M75q Tiny with an AMD Ryzen 3 PRO 3200GE processor

**Better** — Dell OptiPlex 5080 Micro with a 10th Gen Intel Core i5-10600T vPro processor / Lenovo ThinkCentre M75q Tiny with an AMD Ryzen 5 PRO 3400GE processor

**Best** — Dell OptiPlex 7080 SFF with a 10th Gen Intel Core i7-10700 processor / Lenovo ThinkCentre M75s SFF with an AMD Ryzen 7 PRO 3700 processor

Figure 2: Time (in seconds) to boot, sleep, and return from sleep. Lower (faster) is better. Source: Principled Technologies.

### Open a 90MB Word doc
Seconds | Lower is better

| | |
|---|---|
| Good | 3.5 / 3.6 |
| Better | 3.7 / 4.0 |
| Best | 2.7 / 3.2 |

0 — 40

### Open a 93MB Excel spreadsheet
Seconds | Lower is better

| | |
|---|---|
| Good | 18.4 / 25.7 |
| Better | 16.8 / 26.5 |
| Best | 15.1 / 17.9 |

0 — 40

### Open a 180MB PowerPoint deck
Seconds | Lower is better

| | |
|---|---|
| Good | 35.5 / 37.2 |
| Better | 33.1 / 38.8 |
| Best | 27.3 / 27.4 |

0 — 40

**Good** — Dell OptiPlex 3080 Micro with a 10th Gen Intel Core i3-10100T processor / Lenovo ThinkCentre M75q Tiny with an AMD Ryzen 3 PRO 3200GE processor

**Better** — Dell OptiPlex 5080 Micro with a 10th Gen Intel Core i5-10600T vPro processor / Lenovo ThinkCentre M75q Tiny with an AMD Ryzen 5 PRO 3400GE processor

**Best** — Dell OptiPlex 7080 SFF with a 10th Gen Intel Core i7-10700 processor / Lenovo ThinkCentre M75s SFF with an AMD Ryzen 7 PRO 3700 processor

Figure 3: Time (in seconds) to perform tasks in Microsoft 365 applications. Lower (faster) is better. Source: Principled Technologies.

## Content creation

The faster you can knock out projects, the better. We hand-timed how long it took for each desktop to complete a few simple Adobe Creative Cloud® workflows.
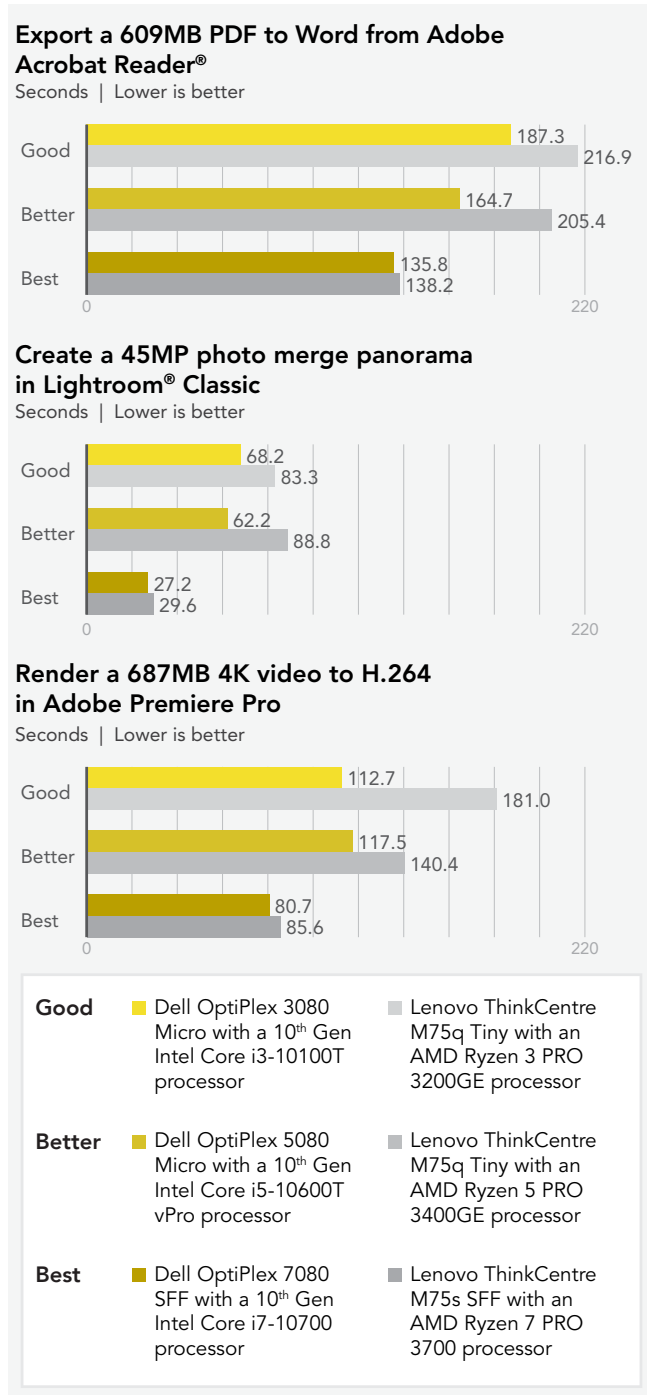
### Export a 609MB PDF to Word from Adobe Acrobat Reader®
Seconds | Lower is better

| | |
|---|---|
| Good | 187.3 / 216.9 |
| Better | 164.7 / 205.4 |
| Best | 135.8 / 138.2 |

0 — 220

### Create a 45MP photo merge panorama in Lightroom® Classic
Seconds | Lower is better

| | |
|---|---|
| Good | 68.2 / 83.3 |
| Better | 62.2 / 88.8 |
| Best | 27.2 / 29.6 |

0 — 220

### Render a 687MB 4K video to H.264 in Adobe Premiere Pro
Seconds | Lower is better

| | |
|---|---|
| Good | 112.7 / 181.0 |
| Better | 117.5 / 140.4 |
| Best | 80.7 / 85.6 |

0 — 220

**Good** — Dell OptiPlex 3080 Micro with a 10th Gen Intel Core i3-10100T processor — Lenovo ThinkCentre M75q Tiny with an AMD Ryzen 3 PRO 3200GE processor

**Better** — Dell OptiPlex 5080 Micro with a 10th Gen Intel Core i5-10600T vPro processor — Lenovo ThinkCentre M75q Tiny with an AMD Ryzen 5 PRO 3400GE processor

**Best** — Dell OptiPlex 7080 SFF with a 10th Gen Intel Core i7-10700 processor — Lenovo ThinkCentre M75s SFF with an AMD Ryzen 7 PRO 3700 processor

Figure 4: Time (in seconds) to perform tasks in Adobe Creative Cloud applications. Lower (faster) is better. Source: Principled Technologies.

## Conclusion

In our hands-on benchmark and scenario-based comparisons, we found Dell OptiPlex desktops powered by Intel Core i3, i5, and i7 processors outperformed comparable Lenovo ThinkCentre M Series desktops powered by AMD Ryzen 3, 5, and 7 PRO processors.

1   BAPCo, "SYSmark 2018 white paper," accessed October 28, 2020, https://bapco.com/wp-content/uploads/2018/08/SYSmark_2018_White_Paper_1.0.pdf.

2   Principled Technologies, "WebXPRT 3," accessed October 28, 2020, https://www.principledtechnologies.com/benchmarkxprt/webxprt/.

3   Principled Technologies, "AIXPRT" accessed October 28, 2020, https://www.principledtechnologies.com/benchmarkxprt/aixprt/.

# Science

We concluded our hands-on testing on October 13, 2020. During testing, we determined the appropriate hardware and software configurations and applied updates as they became available. The results in this report reflect configurations that we finalized on September 4, 2020 or earlier. Unavoidably, these configurations may not represent the latest versions available when this report appears.

## Our results

While the report highlights benchmark overall scores and hand-timed results for individual tasks, the science show granular results from all benchmark and scenario-based testing.

Table 1: Results of our benchmark testing. These scores are the median of three runs.

| | Entry-level | | Mid-range | | High-end | |
|---|---|---|---|---|---|---|
| | Dell OptiPlex 3080 Micro Desktop with a 10th Gen Intel Core i3-10100T processor | Lenovo ThinkCentre M75s Small Form Factor Compact PC with an AMD Ryzen 7 PRO 3700 processor | Dell OptiPlex 5080 Micro Desktop with a 10th Gen Intel Core i5-10600T vPro processor | Lenovo ThinkCentre M75q Tiny Desktop with an AMD Ryzen 3 PRO 3200GE processor | Dell OptiPlex 7080 Small Form Factor Desktop with a 10th Gen Intel Core i7-10700 processor | Lenovo ThinkCentre M75s Small Form Factor Compact PC with an AMD Ryzen 7 PRO 3700 processor |
| **Sysmark 2018** | | | | | | |
| Overall rating (Higher is better) | 1,234 | 971 | 1,418 | 1,000 | 1,832 | 1,513 |
| **AIXPRT** | | | | | | |
| ResNet-50 maximum inference throughput, images/sec (Higher is better) | 33.3 | 20.1 | 39.9 | 17.0 | 64.0 | 51.4 |
| ResNet-50 minimum inference latency per image (90th percentile), ms (Lower is better) | 48.4 | 78.1 | 46.9 | 84.6 | 31.2 | 46.9 |
| SSD-MobileNet-v1 maximum inference throughput, images/sec (Higher is better) | 21.0 | 12.5 | 27.2 | 15.1 | 40.3 | 32.4 |
| SSD-MobileNet-v1 minimum inference latency per image (90th percentile), ms (Lower is better) | 62.5 | 93.7 | 46.9 | 84.6 | 31.2 | 47.1 |
| **WebXPRT 3 (Microsoft Edge browser)** | | | | | | |
| Overall (Higher is better) | 183 | 156 | 196 | 156 | 241 | 230 |

Table 2: Results (in seconds) of our hand-timed testing. These scores are the median of three runs. Lower is better.

| | Entry-level | | Mid-range | | High-end | |
|---|---|---|---|---|---|---|
| | Dell OptiPlex 3080 Micro Desktop with a 10th Gen Intel Core i3-10100T processor | Lenovo ThinkCentre M75s Small Form Factor Compact PC with an AMD Ryzen 7 PRO 3700 processor | Dell OptiPlex 5080 Micro Desktop with a 10th Gen Intel Core i5-10600T vPro processor | Lenovo ThinkCentre M75q Tiny Desktop with an AMD Ryzen 3 PRO 3200GE processor | Dell OptiPlex 7080 Small Form Factor Desktop with a 10th Gen Intel Core i7-10700 processor | Lenovo ThinkCentre M75s Small Form Factor Compact PC with an AMD Ryzen 7 PRO 3700 processor |
| **System responsiveness** | | | | | | |
| Boot | 12.6 | 16.9 | 13.6 | 16.5 | 12.3 | 15.9 |
| Sleep | 3.0 | 4.3 | 2.9 | 5.9 | 2.5 | 5.8 |
| Resume from sleep | 6.6 | 6.6 | 6.4 | 6.6 | 6.7 | 8.9 |
| **Productivity** | | | | | | |
| Microsoft Word | | | | | | |
| Open a Word document | 3.5 | 3.6 | 3.7 | 4.0 | 2.7 | 3.2 |
| Perform a word replacement | 1.5 | 1.8 | 1.5 | 1.7 | 1.3 | 1.4 |
| Microsoft Excel | | | | | | |
| Open an Excel spreadsheet | 18.4 | 25.7 | 16.8 | 26.5 | 15.1 | 17.9 |
| Perform a number-crunch calculation | 2.4 | 3.2 | 2.4 | 3.3 | 2.2 | 2.8 |
| Microsoft PowerPoint | | | | | | |
| Open a PowerPoint slide deck | 35.5 | 37.2 | 33.1 | 38.8 | 27.3 | 27.4 |
| Export to PDF | 9.0 | 10.0 | 8.5 | 10.4 | 7.3 | 7.8 |
| Microsoft OneNote | | | | | | |
| Open OneNote | 1.7 | 1.7 | 1.3 | 1.5 | 1.2 | 1.3 |
| Insert a spreadsheet | 19.3 | 27.0 | 17.5 | 25.7 | 15.3 | 17.7 |
| **Content creation** | | | | | | |
| Adobe Acrobat | | | | | | |
| Open an Adobe Acrobat Reader PDF | 1.0 | 1.0 | 0.9 | 1.0 | 0.8 | 0.9 |
| Export to Word | 187.3 | 216.9 | 164.7 | 205.4 | 135.8 | 138.2 |
| Adobe Lightroom | | | | | | |
| Open Adobe Lightroom Classic | 13.8 | 18.1 | 12.5 | 18.2 | 11.2 | 11.9 |
| Create a Photo Merge panorama | 68.2 | 83.3 | 62.2 | 88.8 | 27.2 | 29.6 |
| Adobe Premiere Pro | | | | | | |
| Open Adobe Premiere Pro | 10.7 | 12.6 | 12.3 | 12.3 | 10.5 | 11.8 |
| Render a RED 4K video file to H.264 | 112.7 | 181.0 | 117.5 | 140.4 | 80.7 | 85.6 |

# System configuration information

Table 3: Detailed information on the "Space-saving desktops with entry-level CPU specs" we tested.

| System configuration information | Dell OptiPlex 3080 Micro | Lenovo ThinkCentre M75q Tiny |
|---|---|---|
| Processor | | |
| Vendor | Intel | AMD |
| Name | Core i3 | Ryzen 3 Pro |
| Model number | 10100T | 3200GE |
| Core frequency (GHz) | 3.0-3.8 | 3.3-3.8 |
| Number of cores | 4 | 4 |
| Cache (MB) | 6 | 4 |
| Memory | | |
| Amount (GB) | 8 | 8 |
| Number of DIMMs | 2 x 4GB | 2 x 4GB |
| Type | DDR4 | DDR4 |
| Speed (MHz) | 2,933 | 2,666 |
| Graphics | | |
| Vendor | Intel | AMD |
| Model number | UHD Graphics 630 | Radeon Vega 8 |
| Storage | | |
| Amount (GB) | 256 | 256 |
| Type | M.2 PCIe NVMe | M.2 PCIe NVMe |
| Connectivity/expansion | | |
| Wired internet | Realtek PCIe Gbe | Realtek PCIe Gbe |
| Wireless internet | Qualcomm QCA61x4A | Intel Wireless-AC 9260 |
| Bluetooth | 5.0 | 5.0 |
| USB | **Front**<br>2 x USB-A ports (version 3.2 Gen 1)<br><br>**Rear**<br>2 x USB 2.0 ports (1 with Smart Power on)<br>2 x USB-A ports (version  3.2 Gen 1) | **Front**<br>1 x USB-A port (version 3.1 Gen 1 (always-on)<br>1 x USB-C port (version 3.1 Gen 1)<br><br>**Rear**<br>3 x USB-A 2.0 ports<br>1 x USB-A port (version 3.1 Gen 1) |
| Video | 1 x DisplayPort 1.4<br>1 x HDMI | 1 x DisplayPort 1.2<br>1 x HDMI |
| Operating system | | |
| Vendor | Microsoft | Microsoft |
| Name | Windows 10 Pro | Windows 10 Pro |
| Build number or version | 10.0.19041 | 10.0.19041 |

| System configuration information | Dell OptiPlex 3080 Micro | Lenovo ThinkCentre M75q Tiny |
| --- | --- | --- |
| BIOS | | |
| BIOS name and version | Dell 1.2.0 | Lenovo M2FKT24A |
| Dimensions | | |
| Height (in) | 1.4 | 1.4 |
| Width (in) | 7.0 | 7.0 |
| Depth (in) | 7.2 | 7.2 |

Table 4: Detailed information on the "Space-saving desktops with mid-range CPU specs" we tested.

| System configuration information | Dell OptiPlex 5080 Micro | Lenovo ThinkCentre M75q Tiny |
| --- | --- | --- |
| Processor | | |
| Vendor | Intel | AMD |
| Name | Core i5 | Ryzen 5 Pro |
| Model number | 10600T | 3400GE |
| Core frequency (GHz) | 2.4-4.0 | 3.3-4.0 |
| Number of cores | 6 | 4 |
| Cache (MB) | 12 | 4 |
| Memory | | |
| Amount (GB) | 8 | 8 |
| Number of DIMMs | 2 x 4GB | 2 x 4GB |
| Type | DDR4 | DDR4 |
| Speed (MHz) | 2,933 | 2,666 |
| Graphics | | |
| Vendor | Intel | AMD |
| Model number | UHD Graphics 630 | Radeon RX Vega 11 |
| Storage | | |
| Amount (GB) | 256 | 256 |
| Type | M.2 PCIe NVMe | M.2 PCIe NVMe |
| Connectivity/expansion | | |
| Wired internet | Intel I219-LM | Realtek PCIe Gbe |
| Wireless internet | Intel Wi-Fi 6 AX201 | Intel Wireless-AC 9260 |
| Bluetooth | 5.1 | 5.0 |

| System configuration information | Dell OptiPlex 5080 Micro | Lenovo ThinkCentre M75q Tiny |
|---|---|---|
| USB | **Front**<br>1 x USB-C port (version 3.2 Gen 2)<br>1 x USB-A port (version 3.2 Gen 1 (charging))<br><br>**Rear**<br>4 x USB-A ports (version 3.2 Gen1) | **Front**<br>1 x USB-A port (version 3.1 Gen 1 (always-on))<br>1 x USB-C port (version 3.1 Gen 1)<br><br>**Rear**<br>3 x USB-A 2.0 ports<br>1 x USB-A port (version  3.1 Gen 1) |
| Video | 2 x DisplayPort 1.4 | 2 x DisplayPort<br>1 x HDMI |
| Operating system | | |
| Vendor | Microsoft | Microsoft |
| Name | Windows 10 Pro | Windows 10 Pro |
| Build number or version | 10.0.19041 | 10.0.19041 |
| BIOS | | |
| BIOS name and version | Dell 1.1.7 | Lenovo M2FKT21A |
| Dimensions | | |
| Height (in) | 1.42 | 1.4 |
| Width (in) | 7.03 | 7.0 |
| Depth (in) | 7.16 | 7.2 |

Table 5: Detailed information on the "Space-saving desktops with high-end CPU specs" we tested.

| System configuration information | Dell OptiPlex 7080 SFF | Lenovo ThinkCentre M75s SFF |
|---|---|---|
| Processor | | |
| Vendor | Intel | AMD |
| Name | Core i7 | Ryzen 7 Pro |
| Model number | 10700 | 3700 |
| Core frequency (GHz) | 2.9-4.8 | 3.6-4.4 |
| Number of cores | 8 | 8 |
| Cache (MB) | 16 | 32 |
| Memory | | |
| Amount (GB) | 16 | 16 |
| Number of DIMMs | 2 x 8GB | 2 x 8GB |
| Type | DDR4 | DDR4 |
| Speed (MHz) | 2,933 | 2,666 |
| Graphics | | |
| Vendor | NVIDIA | AMD |
| Model number | NVIDIA GeForce GT 730 | Radeon 520 |
| Video RAM | 2GB GDDR5 | 2GB GDDR5 |

| System configuration information | Dell OptiPlex 7080 SFF | Lenovo ThinkCentre M75s SFF |
|---|---|---|
| Storage | | |
| Amount (GB) | 512 | 512 |
| Type | M.2 PCIe NVMe | M.2 PCIe NVMe |
| Connectivity/expansion | | |
| Wired internet | Intel I219-LM | Realtek PCIe Gbe |
| Wireless internet | Intel Wi-Fi 6 AX201 | Realtek 8822CE |
| Bluetooth | 5.1 | 5.0 |
| USB | **Front**<br>2 x USB 2.0 ports (1 with PowerShare)<br>1 x USB A port (version 3.2 Gen 2)<br>1 x USB-C port (version 3.2 Gen 2)<br><br>**Rear**<br>1 x USB-A port (version 3.2 Gen 2)<br>3 x USB -A ports (version 3.2 Gen 1)<br>2 x USB 2.0 ports with Power On | **Front**<br>2 x USB-A ports (version  3.1 Gen 2)<br>2 x USB-A ports (version 3.1 Gen 1)<br><br>**Rear**<br>2 x USB 2.0 Type-A<br>2 x USB 3.1 Gen 1 Type-A |
| Video | 4 x DisplayPort 1.4 | 2 x DisplayPort |
| Operating system | | |
| Vendor | Microsoft | Microsoft |
| Name | Windows 10 Pro | Windows 10 Pro |
| Build number or version | 10.0.19041 | 10.0.19041 |
| BIOS | | |
| BIOS name and version | Dell 1.1.5 | Lenovo M2CKT38A |
| Dimensions | | |
| Height (in) | 3.6 | 3.6 |
| Width (in) | 11.4 | 11.4 |
| Depth (in) | 11.53 | 13.5 |

# How we tested

## Setting up the desktops

### Creating and updating the OEM Windows 10 Pro Image

1. Boot the system.
2. To complete installation, follow the on-screen instructions using the default selections when appropriate.
3. Run Windows Update, and install all updates available.
4. Launch the Windows Store app, and install all Store app updates.
5. Launch each vendor-proprietary utility app installed on each system, and update any drivers or BIOS files. For Dell, run the Dell Command Update utility. For Lenovo, run the Lenovo Vantage utility.
6. To install the latest chipset and graphics drivers available, depending on the hardware of each system, go to either https://www.intel.com/content/www/us/en/support.html, https://www.amd.com/en/support or https://www.nvidia.com/en-us/geforce/drivers/ to install the latest chipset and graphics drivers available.
7. Verify the date and time are correct, and synchronize the system clock with the time server.
8. Disable Automatic Windows Update.
    a. Right-click the Windows Start button.
    b. Select Computer Management.
    c. Select Services and Applications.
    d. Select Services.
    e. Scroll down, and double-click Windows Update.
    f. Click Stop.
    g. From the Startup drop down menu, select Disabled.

### Capturing an image

1. Connect an external HDD to the system.
2. Right-click the desktop, and select Personalize→Home→Update & security→Backup→More options→See advanced settings→System Image Backup→Create a system image.
3. Verify that the external HDD is selected as the save drive, and click Next.
4. Verify that all drives are selected to back up, and click Next.
5. Click Start backup.
6. At Do you want to create a system repair disc, select No, and close the dialogs.

### Restoring an image

1. Connect an external HDD to the system.
2. Press and hold the Shift key while restarting the system.
3. Select Troubleshoot.
4. Select Advanced options.
5. Select System image recovery.
6. Select the User account.
7. Enter the system password, and click Continue.
8. Verify that the external HDD is selected, and click Next.
9. Once the recovery has completed, click Finish.

# Measuring performance with benchmarks

**SYSmark 2018**

**Avoiding antivirus software conflicts**

SYSmark 2018 is not compatible with any virus-scanning software, so we uninstalled any such software present on the desktop PCs before we installed the benchmark.

**Avoiding pre-installed software conflicts**

- SYSmark 2018 installs the following applications, which its test scripts employ:

**Productivity**

- Adobe Acrobat Pro DC
- AutoIT 3.3.14.2
- BowPad64-2.3.3 installer
- Google® Chrome®
- Microsoft Excel 2016
- Microsoft OneNote 2016
- Microsoft Outlook 2016
- Microsoft PowerPoint 2016
- Microsoft Word 2016
- Windows Zip

**Creativity**

- Adobe Photoshop CC 2017
- Adobe Lightroom Classic CC
- CyberLink PowerDirector® 2015

**Responsiveness**

- Adobe Acrobat Pro DC
- Adobe Lightroom Classic CC
- Adobe Photoshop CC 2017
- CyberLink PowerDirector 2015
- Google Chrome
- Microsoft Excel 2016
- Microsoft OneNote 2016
- Microsoft Outlook 2016
- Microsoft PowerPoint 2016
- Microsoft Word 2016

If any of these applications already exist on the system under test, they could cause problems with the benchmark due to software conflicts. To avoid any such issues, we uninstalled all conflicting pre-installed software applications—including different versions of any of the programs SYSmark 2018 uses—before we installed the benchmark.

**Using the SYSmark built-in configuration tool**

This tool supports three levels of configuration:

1. Only makes changes that are REQUIRED for the benchmark to run.
2. Additionally, makes changes that are RECOMMENDED for repeatable results.
3. Additionally, makes OPTIONAL changes that help ensure best results.

The Configuration tool makes the following configuration changes at each of the three levels:

*Level 1 - Required*

- Disables User Account Control (UAC)
- Set DPI Scaling to 100%
- Disables Low Battery Actions
- Disables Network Proxies
- Disables System Sleep and Hibernate
- Disables Windows Update

*Level 2 - Recommended*

- Disables User Account Control (UAC)
- Set DPI Scaling to 100%
- Disables Low Battery Actions
- Disables Network Proxies
- Disables System Sleep and Hibernate
- Disables Windows Update
- Create BAPCo power scheme
- Set Power Plan Type to High Performance
- Set CPU High Performance
- Disables Disk Defrag
- Disables Windows Error Reporting
- Disables Windows Lock Screen
- Disables Windows Pop-ups
- Disables Screen Saver and Monitor Timeout
- Disables Windows Sidebar/Gadgets
- Disables Desktop Slideshow
- Disables Windows Defender
- Disables Windows Firewall
- Set Font Smoothing

*Level 3 - Optional*

- Disables Hard Disk Timeout
- Disables System Restore
- Ignores Laptop Lid Close

We chose the official BAPCo 'Run Benchmark' default as outlined in the BAPCo SYSmark2018 User Guide http://bapco.com/wp-content/uploads/2018/10/BAPCo_SYSmark2018_user_guide.pdf, which runs the benchmark using the Required and Recommended options.

**Setting up the test**
1. Install SYSmark 2018 with the default options.

**Running the test**

1. Launch SYSmark 2018.
2. Click the Settings gear icon.
3. For iterations, enter 3.
4. Verify that Conditioning Run is enabled.
5. Enable Process Idle Tasks.
6. Enter a name for the benchmark run.
7. To return to the main menu, click the Back button to return to the main menu.
8. Click Run Benchmark.
9. When the benchmark finishes, record the SYSmark 2018 benchmark results.

## WebXPRT 3

**Setting up the test**

1. Verify that the newest version of Microsoft Edge is installed. If it is not, go to https://www.microsoft.com/en-us/edge to download and install it.

**Running the test**

1. Boot the system.
2. Select Windows Start.
3. Type `cmd`, and press Ctrl+Shift+Enter.
4. Type `Cmd.exe /c start /wait Rundll32.exe advapi32.dll,ProcessIdleTasks` Do not interact with the system until the command completes.
5. After the command completes, wait five minutes before running the test.
6. Open the web browser under test and go to http://www.principledtechnologies.com/benchmarkxprt/webxprt/.
7. Click Run WebXPRT 3.
8. At the Ready to test your browser screen, click Continue.
9. Click Start.
10. When the test completes, record the results.
11. Click the option to rerun WebXPRT 3.
12. When the test completes, record the results.
13. Repeat steps 11 through 12 once more.

## AIXPRT

**Setting up the test**

1. Go to https://www.principledtechnologies.com/benchmarkxprt/aixprt/ and click on the Start here link.
2. For Operating System, choose Windows 10.
3. For Host hardware, choose Desktop.
4. For Toolkit, choose TensorFlow.
5. For Target hardware, choose CPUs.
6. For Workload, choose ResNet-50 and SSD MobileNet v1.
7. To download the AIXPRT_1.0_Tensorflow_Windows.zip installation package, click Download.
8. Unzip the AIXPRT_1.0_Tensorflow_Windows.zip file to C:\.
9. Download the Python v3.6.8 Windows x86-64 executable installer from https://www.python.org/downloads/windows/.
10. Click the Python executable file. Check the box next to Add Python 3.6 to path and click Install Python.
11. Navigate to the python3 install directory (default location is C:\Users\<name>\AppData\Local\Programs\Python\Python36) and duplicate python.exe file. Rename the duplicate file to python3.exe.
12. Open a administrative command prompt.
13. To install the necessary dependencies, type the following.

```
pip3 install pyreadline
pip3 install Pillow
pip3 install opencv-python
pip3 install --upgrade wmi
pip3 install --upgrade pypiwin32
pip3 install --upgrade setuptools==41.0.0
pip3 install tensorflow==1.14
```

**Running the test**

1. Boot the system.
2. Select Windows Start.
3. Type `cmd`, and press Ctrl+Shift+Enter.
4. Type `Cmd.exe /c start /wait Rundll32.exe advapi32.dll,ProcessIdleTasks`

   • Do not interact with the system until the command completes.

5. After the command completes, wait five minutes before running the test.
6. Type `cd C:\AIXPRT\Harness`.
7. Type `python3 index.py`.
8. When the test is complete, the benchmark saves the results to AIXPRT/Results in JSON format, and also generates CSV files with the name {ConfigName}_RESULTS_SUMMARY.csv.
9. By default, the AIXPRT config file is set to run 3 iterations. Record the results.

## Testing hand-timed tasks

### System responsiveness

**Running the "Time to boot" test**

1. Prepare the stopwatch.
2. Simultaneously start the timer and press the power button.
3. When taskbar loads, stop the stopwatch and record the results.
4. Select Windows Start.
5. Type `cmd`, and press Ctrl+Shift+Enter.
6. Type `Cmd.exe /c start /wait Rundll32.exe advapi32.dll,ProcessIdleTasks`

   • Do not interact with the system until the command completes.

7. After the command completes, wait five minutes before running the test.
8. Simultaneously start the timer and shut down the system.
9. When the power button light has turned off, stop the timer, and record the results.
10. Repeat steps 1 through 9 twice more.

**Setting up the "Time to sleep and time to resume from sleep" tests**

1. Disable Require a password when a computer wakes.
2. To bring up the Run command prompt, press Windows Key + R.
3. To open the Local Group Policy Editor, type `gpedit.msc`.
4. Browse to Computer Configuration→Administrative Templates→System→Power Management→Sleep Settings.
5. Double-click Require a password when a computer wakes (plugged in), and select Disable. Click Apply.
6. Close the Local Group Policy Editor and shut down the system.

**Running the "Time to sleep and time to resume from sleep" tests**

1. Boot the system.
2. Select Windows Start.
3. Type `cmd`, and press Ctrl+Shift+Enter.
4. Type `Cmd.exe /c start /wait Rundll32.exe advapi32.dll,ProcessIdleTasks`

   • Do not interact with the system until the command completes.

5. After the command completes, wait five minutes before running the test.
6. Simultaneously start the timer and put the system in Sleep.
7. When the power button light has turned off, stop the timer, and record the results.
8. Wait 30 seconds.
9. To wake the system out of Sleep, simultaneously start the timer and press the power button.
10. When the taskbar has loaded, stop the timer, and record the results.
11. Repeat steps 1 through 10 twice more.

## Productivity

### Running the "Opening a 90MB Microsoft Word document and performing a word replacement" test

1. Boot the system.
2. Select Windows Start.
3. Type `cmd`, and press Ctrl+Shift+Enter.
4. Type `Cmd.exe /c start /wait Rundll32.exe advapi32.dll,ProcessIdleTasks`
   - Do not interact with the system until the command completes.
5. After the command completes, wait five minutes before running the test.
6. Simultaneously start the timer and launch Word by clicking on the test Word document.
7. When the Word document has fully loaded, as indicated by the words Page 1 of 38 10473 words appearing, stop the timer, and record the results.
8. To bring up the Find/Replace dialog box, press CTRL + H.
9. In the Find What field type `I`.
10. In the Replace With field type `TEST`.
11. Simultaneously start the timer and select Replace All.
12. When every I has been replaced, stop the timer.
13. Close the Word document. Do not save changes.
14. Shut down the system.
15. Repeat steps 1 through 14 twice more.

### Setting up the "Opening a 93MB Microsoft Excel spreadsheet and performing a number crunch calculation" test

1. Launch Microsoft Excel.
2. Click File→Options→Trust Center→Trust Center Settings→Macro Settings. Select Enable all macros and click OK.
3. Close Microsoft Excel.
4. Shut down the system.

### Running the "Opening a 93MB Microsoft Excel spreadsheet and performing a number crunch calculation" test

1. Boot the system.
2. Select Windows Start.
3. Type `cmd`, and press Ctrl+Shift+Enter.
4. Type `Cmd.exe /c start /wait Rundll32.exe advapi32.dll,ProcessIdleTasks`
   - Do not interact with the system until the command completes.
5. After the command completes, wait five minutes before running the test.
6. Simultaneously start the timer and launch Excel by clicking on the test Excel spreadsheet.
7. When the Excel spreadsheet has fully loaded, stop the timer, and record the results.
8. Press CTRL + R to start the calculation.
9. Record the output.
10. Close the Excel spreadsheet.
11. Shut down the system.
12. Repeat steps 1 through 11 twice more.

### Running the "Opening a 180MB Microsoft PowerPoint slide deck and exporting to PDF" test

1. Boot the system.
2. Select Windows Start.
3. Type `cmd`, and press Ctrl+Shift+Enter.
4. Type `Cmd.exe /c start /wait Rundll32.exe advapi32.dll,ProcessIdleTasks`
   - Do not interact with the system until the command completes.
5. After the command completes, wait five minutes before running the test.
6. Simultaneously start the timer and launch PowerPoint by clicking on the test PowerPoint slide deck.
7. When the PowerPoint slide deck has loaded, as indicated by all 33 slides appearing in the side bar, stop the timer, and record the results.
8. Click File→Export→Create PDF/XPS.
9. Simultaneously start the timer and click Publish.
10. When the PDF has been created, stop the timer, and record the results.
11. Shut down the system.
12. Repeat steps 1 through 11 twice more.

**Running the "Launching Microsoft OneNote and inserting a 46MB spreadsheet" test**

1. Boot the system.
2. Select Windows Start.
3. Type `cmd`, and press Ctrl+Shift+Enter.
4. Type `Cmd.exe /c start /wait Rundll32.exe advapi32.dll,ProcessIdleTasks`

    • Do not interact with the system until the command completes.

5. After the command completes, wait five minutes before running the test.
6. Simultaneously start the timer and launch OneNote.
7. When OneNote has loaded, stop the timer, and record the results.
8. Click Add Page.
9. Click Insert➔Spreadsheet➔Existing Excel Spreadsheet.
10. Browse to the test Excel spreadsheet file, and click Insert.
11. Start the timer and click Insert spreadsheet.
12. When the Excel spreadsheet has been inserted, stop the timer, and record the results.
13. Shut down the system.
14. Repeat steps 1 through 13 twice more.

## Content creation

**Running the "Opening a 609MB Adobe Acrobat DC document and exporting to Microsoft Word" test**

1. Boot the system.
2. Select Windows Start.
3. Type `cmd`, and press Ctrl+Shift+Enter.
4. Type `Cmd.exe /c start /wait Rundll32.exe advapi32.dll,ProcessIdleTasks`

    • Do not interact with the system until the command completes.

5. After the command completes, wait five minutes before running the test.
6. Simultaneously start the timer and launch Acrobat DC by clicking on the test PDF document.
7. When the PDF document has fully loaded, stop the timer, and record the results.
8. In the right-hand column, expand the Export PDF option.
9. Verify that Microsoft Word is selected, and click Export.
10. Select the Save As directory.
11. Simultaneously start the timer and click Save.
12. When the PDF document has been converted to a Word document, stop the timer, and record the results.
13. Close the documents. Do not save changes.
14. Shut down the system.
15. Repeat steps 1 through 14 twice more.

**Running the "Launching Adobe Lightroom Classic and creating a photo merge panorama" test**

We used six 45 megapixel .NEF raw images. Each image was 95MB.

1. Boot the system.
2. Select Windows Start.
3. Type `cmd`, and press Ctrl+Shift+Enter.
4. Type `Cmd.exe /c start /wait Rundll32.exe advapi32.dll,ProcessIdleTasks`

    • Do not interact with the system until the command completes.

5. After the command completes, wait five minutes before running the test.
6. Simultaneously start the timer and launch Lightroom.
7. When Lightroom has fully loaded, Stop the timer, and record the results.
8. Click the Import button.
9. Select the test file directory and click Import.
10. Press Ctrl + A to select all the imported photos.
11. Click Photo➔Photo Merge➔Panorama.
12. Simultaneously start the stopwatch and click Merge.
13. Stop the stopwatch when the progress bar in the top left corner disappears and record the result.
14. Shut down the system.
15. Repeat steps 1 through 14 twice more.

**Running the "Launching Adobe Premiere Pro and rendering a 687MB RED camera 4K .R3D video file" test**

1. Boot the system.
2. Select Windows Start.
3. Type `cmd`, and press Ctrl+Shift+Enter.
4. Type `Cmd.exe /c start /wait Rundll32.exe advapi32.dll,ProcessIdleTasks`

   • Do not interact with the system until the command completes.

5. After the command completes, wait five minutes before running the test.
6. Simultaneously start the timer and launch Premiere.
7. When Premiere has fully loaded, stop the timer, and record the results.
8. Select New Project and give the project a name.
9. Press Ctrl + I to Import the test file.
10. Drag the imported file to the bottom timeline.
11. Select Effects➔Lumetri Pesets➔Filmstocks.
12. Select Fuji F125 Kodak 2393 (by Adobe) and drag it onto the video timeline.
13. To bring up the Export Media dialog, press Ctrl + M.
14. From the Format dropdown menu, choose H.264.
15. Simultaneously start the stopwatch and click Export.
16. When the progress bar disappears, stop the stopwatch, and record the result.
17. Shut down the system.
18. Repeat steps 1 through 17 twice more.

This project was commissioned by Dell Technologies.

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