VIRTUAL GPU SOFTWARE

QSG-07847-001 _v7.0 through 7.2 | March 2019

Quick Start Guide
# TABLE OF CONTENTS

About this Guide ........................................................................................................ iii

Chapter 1. Getting Your NVIDIA vGPU Software ......................................................... 1
1.1. Before You Begin ................................................................................. 1
1.2. Your Order Confirmation Message .................................................... 1
1.3. Creating Your NVIDIA Enterprise Account ........................................ 5
1.4. Redeeming Your Product Activation Keys and Downloading Your NVIDIA vGPU Software ............................................................. 8

Chapter 2. Installing Your NVIDIA vGPU Software License Server and License Files .... 15
2.1. Overview of NVIDIA vGPU software Licensing ........................................ 15
2.2. Platform Configuration Requirements ............................................... 16
2.3. Installing the Java Runtime Environment ........................................... 16
2.4. Installing the License Server Software ............................................. 17
2.5. Obtaining the License Server’s MAC Address .................................... 21
2.6. Registering Your License Server and Getting License Files ..................... 22
2.7. Installing a License ........................................................................ 24

Chapter 3. Installing and Configuring NVIDIA vGPU Manager and the Guest Driver ...... 26
3.1. Switching the Mode of a Tesla M60 or M6 GPU ...................................... 26
3.2. Installing the NVIDIA Virtual GPU Manager ....................................... 26
  3.2.1. Installing the NVIDIA Virtual GPU Manager on VMware vSphere ......... 27
  3.2.2. Installing the NVIDIA Virtual GPU Manager on Citrix Hypervisor ........ 27
3.3. Disabling ECC Memory .................................................................... 28
3.4. Attaching an NVIDIA vGPU Profile to a VM ........................................ 29
  3.4.1. Configuring a vSphere VM with NVIDIA vGPU ................................. 29
  3.4.2. Configuring a Citrix Hypervisor VM with Virtual GPU ..................... 31
3.5. Installing the NVIDIA vGPU Software Graphics Driver ......................... 31
3.6. Licensing an NVIDIA vGPU ................................................................ 33
Virtual GPU Software Quick Start Guide provides minimal instructions for installing and configuring NVIDIA® virtual GPU software on the Citrix Hypervisor or VMware vSphere hypervisor and for installing and configuring a single-instance NVIDIA virtual GPU License Server on Windows. If you need complete instructions, are using other platforms, or require high availability for the license server, refer to Virtual GPU Software User Guide and Virtual GPU License Server User Guide.
Chapter 1.
GETTING YOUR NVIDIA VGPU SOFTWARE

After your order for NVIDIA vGPU software is processed, you will receive an order confirmation message from NVIDIA. This message contains information that you need for getting your NVIDIA vGPU software from the NVIDIA Software Licensing Center. To log in to the NVIDIA Software Licensing Center, you must have an NVIDIA Enterprise Account.

1.1. Before You Begin

Before following the procedures in this guide, ensure that the following prerequisites are met:

‣ You have a server platform that is capable of hosting your chosen hypervisor and NVIDIA GPUs that support NVIDIA vGPU software. For a list of validated server platforms, refer to NVIDIA GRID Certified Servers.
‣ One or more NVIDIA GPUs that support NVIDIA vGPU software is installed in your server platform.
‣ A supported virtualization software stack is installed according to the instructions in the software vendor’s documentation.
‣ A virtual machine (VM) running a supported Windows guest operating system (OS) is configured in your chosen hypervisor.

For information about supported hardware and software, and any known issues for this release of NVIDIA vGPU software software, refer to the Release Notes for your chosen hypervisor:

‣ Virtual GPU Software for Citrix Hypervisor Release Notes
‣ Virtual GPU Software for VMware vSphere Release Notes

1.2. Your Order Confirmation Message

After your order for NVIDIA vGPU software is processed, you will receive an order confirmation message to which your NVIDIA Entitlement Certificate is attached.
Dear Customer,

Thank you for your software and services order!

Please find enclosed your Entitlement Certificate for the Software and/or Support products you ordered.

Please refer to the attached Entitlement Certificate to register for your software and services.

The following is your order information:

<table>
<thead>
<tr>
<th>PO Number</th>
<th>NVIDIA Sales Order</th>
<th>NVIDIA Delivery Number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Questions?
Please contact us at enterprisesupport@nvidia.com

Your NVIDIA Entitlement Certificate contains your product activation keys.
Your NVIDIA Entitlement Certificate also provides instructions for using the certificate.
To redeem the product activation keys for your NVIDIA vGPU software, you must have an NVIDIA Enterprise Account.

For a Support, Upgrade, and Maintenance Subscription (SUMS) renewal, no action is required. You do not need to redeem the product activation keys for a SUMS renewal.

- If you do not have an account, follow the Register link in the instructions for using the certificate to create your account. For details, see Creating Your NVIDIA Enterprise Account.
- If you already have an account, follow the Login link in the instructions for using the certificate to log in to the NVIDIA Enterprise Application Hub, go to the NVIDIA Software Licensing Center, and redeem your product activation keys. For details, see Redeeming Your Product Activation Keys and Downloading Your NVIDIA vGPU Software.
1.3. Creating Your NVIDIA Enterprise Account

If you do not have an NVIDIA Enterprise Account, you must create an account to be able to log in to the NVIDIA Software Licensing Center.

If you already have an account, skip this task and go to Redeeming Your Product Activation Keys and Downloading Your NVIDIA vGPU Software.

Before you begin, ensure that you have your order confirmation message.

1. In the instructions for using your NVIDIA Entitlement Certificate, follow the Register link.
2. Fill out the form on the Create Your NVIDIA Enterprise Account page and click Register.
CREATE YOUR NVIDIA ENTERPRISE ACCOUNT

If you need assistance with registration, please email enterprise-support@nvidia.com

*Required Fields

*Email address: Email

*Company: Select Company Name

*First name: Enter FirstName

*Last name: Enter LastName

*Job role: -- Please Choose One --

*Industry: -- Please Choose One --

*Phone: Ex: +1-222-333-4444

*Street 1: Enter street address

Street 2: Enter street address

*City: enter City

*State/Province: -- Please Choose One --

*Postal code: Enter Postal Code

*Country: United States

☑ Receive product updates and news from NVIDIA

CANCEL  REGISTER
A message confirming that an account has been created appears and an e-mail instructing you to set your NVIDIA password is sent to the e-mail address you provided.

3. Open the e-mail instructing you to set your password and click **SET PASSWORD**.

For your account security, the **SET PASSWORD** link in this e-mail is set to expire in 24 hours.

4. Enter and re-enter your new password, and click **SUBMIT**.
A message confirming that your password has been set successfully appears.

You are then automatically directed to log in to the NVIDIA Software Licensing Center with your new password.

1.4. Redeeming Your Product Activation Keys and Downloading Your NVIDIA vGPU Software

Before you begin, ensure that you have your order confirmation message and have created an NVIDIA Enterprise Account.
1. Visit the NVIDIA Software Licensing Center by following the Login link in the instructions for using your NVIDIA Entitlement Certificate.

2. When prompted, provide your e-mail address and password, and click LOGIN.

3. On the Redeem Product Activation Keys page that opens, do one of the following:
   - If the page is already populated with your product activation keys, click Redeem.
   - Otherwise, enter each product activation key in a separate text field and click Redeem.
4. On the **Register Product Activation Key** page that opens, provide the requested information about how you intend to use NVIDIA vGPU software and click **Submit**.
5. On the confirmation page that opens, follow the Please go to your products link.
The **Product Information** page opens with the **Current Releases** tab selected. Older versions of NVIDIA vGPU software are available from the **Archived Versions** tab.

6. On the **Product Information** page, follow the **NVIDIA Virtual GPU Software** link.
7. On the **Product Download** page that opens, follow the links to download the software that you require.

   a) Follow the link to the NVIDIA vGPU software download for the brand and version of your chosen hypervisor, for example, **NVIDIA vGPU for vSphere 6.5**.

   b) Follow the link to the NVIDIA vGPU software license server software for your license server host machine's operating system, for example, **License Manager for Windows**.

   c) If you are using an NVIDIA Tesla™ M60 or M6 GPU and think you might need to change its mode, follow the **Mode Change Utility** link.

   For details about when you need to change the mode, see **Switching the Mode of a Tesla M60 or M6 GPU**.
Product Download

NVIDIA Virtual GPU Software

- Please refer to the NVIDIA vGPU Quick Start Guide for download instructions. More NVIDIA vGPU resources are available here.
- Download appropriate version of the NVIDIA vGPU software below. You can refer to the Product Support Matrix to determine which software package is right for you.


- Download the GPU mount change utility here: Mode Change Utility
- Download the NVIDIA License Manager here: License Manager for Windows / License Manager for Linux
- Download the NVIDIA management pack for vRealize Operations: NVIDIA Virtual GPU Management Pack for vRealize Operations
- After you install the license server, read the MAC ID displayed on it. Use this MAC ID to map required number of licenses and download license file by clicking on “Register License Server” in the left side panel.

Thank you for your NVIDIA Enterprise software product purchase.
Chapter 2.
INSTALLING YOUR NVIDIA vGPU SOFTWARE LICENSE SERVER AND LICENSE FILES

The NVIDIA vGPU software License Server is used to serve a pool of floating licenses to NVIDIA vGPU software licensed products. The License Server is designed to be installed locally within a customer’s network, and be configured with licenses obtained from the NVIDIA Software Licensing Center.

These instructions cover only the installation and configuration of a single-instance license server. If you require high availability for the license server, refer to Virtual GPU License Server User Guide for instructions for how to configure a primary and secondary license server. If you do not register a secondary server when the primary server is registered, you cannot register the secondary server later.

2.1. Overview of NVIDIA vGPU software Licensing

NVIDIA vGPU software is a licensed product. Licensed vGPU functionalities are activated during guest OS boot by the acquisition of a software license served over the network from an NVIDIA vGPU software license server. The license is returned to the license server when the guest OS shuts down.
2.2. Platform Configuration Requirements

- The platform must have a fixed (unchanging) IP address. The IP address may be assigned dynamically by DHCP or statically configured, but must be constant.
- The platform must have at least one unchanging Ethernet MAC address, to be used as a unique identifier when registering the server and generating licenses in the NVIDIA Software Licensing Center.
- The platform's date and time must be set accurately. NTP is recommended.

2.3. Installing the Java Runtime Environment

If a suitable 32-bit Java version is not already installed on your system, download the current 32-bit Java runtime environment from the java.com: Java + You website and install it before running the NVIDIA license server installer.

Install the 32-bit Java runtime, regardless of whether your platform is 32-bit Windows or 64-bit Windows. If a 64-bit Java runtime is already installed, remove it before installing the 32-bit version to ensure that future updates to the Java software can be applied correctly.
2.4. Installing the License Server Software

1. Unzip the license server installer and run `setup.exe`.
2. Accept the EULA for the license server software and the Apache Tomcat software used to support the license server’s management interface.
3. Choose the destination folder where you want the license server software to be installed.
4. In the **Choose Firewall Options** dialog box, select the ports to be opened in the firewall.

To enable remote clients to access licenses from the server and prevent remote access to the management interface, use the default setting, which sets ports as follows:

- Port 7070 is open to enable remote clients to access licenses from the server.
- Port 8080 is closed to ensure that the management interface is available only through a web browser running locally on the license server host.
5. After installation has completed successfully, click **Done** to exit the installer.
2.5. Obtaining the License Server’s MAC Address

The license server’s Ethernet MAC address uniquely identifies your server to the NVIDIA Software Licensing Center. You will need this address to register your license server with the NVIDIA Software Licensing Center to generate license files.

1. Open a web browser on the license server host and connect to the URL http://localhost:8080/licserver.
2. In the license server management interface, select Configuration.
3. On the License Server Configuration page that opens, in the Server host ID drop-down list, select the platform’s ETHERNET address.
2.6. Registering Your License Server and Getting License Files

To be able to generate and download licenses from the NVIDIA Software Licensing Center, you must register your license server. Before downloading a license file, you must generate the file by mapping to it the add-ons that correspond to your licenses. The license file is empty by default and does not contain any licenses it until you map add-ons to it.

If you require high availability for the license server, you must register a secondary server when the primary server is registered. If you do not register a secondary server when the primary server is registered, you cannot register the secondary server later. For information about high availability for the license server, refer to Virtual GPU License Server User Guide.

1. If you are not already logged in, log in to the NVIDIA Enterprise Application Hub and click NVIDIA LICENSING PORTAL to go to the NVIDIA Software Licensing Center.

2. In the navigation pane of the NVIDIA Software Licensing Center page, under GRID Licensing, select Register License Server.

3. On the Register License Server page that opens, provide the details of your license server.
   a) In the MAC Address field, enter the MAC address of your license server.
      Enter only the numbers and letters in the address. Do not enter any spaces or punctuation.
   b) Leave the Backup License Server ID field unset.
   c) Optional: Provide an alias and site name for your license server.
If you do not provide an alias, it is set to the MAC address of your license server. You can edit the alias after your license server is registered.

If you do not provide a site name, your license server is registered without a site name. You cannot add a site name after your license server is registered.

d) Click **Create**.

4. On the **View Server** page that opens, follow the **Map Add-Ons** link.

5. On the **Map Add-Ons** page that opens, in the **Qty to add** field, enter the number of licenses you want to add to your license file and click **Map Add-Ons**.
6. Back on the View Server page, follow the Download License File link and save the .bin license file to your license server for installation.

> The .bin license file is valid for 72 hours. If you do not install the file within 72 hours of downloading it, you must download it again.

### 2.7. Installing a License

NVIDIA vGPU software licenses are distributed as .bin files for download from the NVIDIA Software Licensing Center.

Before installing a license, ensure that you have downloaded the license file from the NVIDIA Software Licensing Center.

1. In the license server management interface, select License Management.
2. On the License Management page that opens, click Choose File.
3. In the file browser that opens, select the `.bin` file and click **Open**.
4. Back on the **License Management** page, click **Upload** to install the license file on the license server.
   The license server should confirm successful installation of the license file.
Before installing and configuring NVIDIA vGPU Manager and the Guest Driver, ensure that a VM running a supported Windows guest OS is configured in your chosen hypervisor.

The factory settings of some supported GPU boards are incompatible with NVIDIA vGPU software. Before configuring NVIDIA vGPU software on these GPU boards, you must configure the boards to change these settings.

### 3.1. Switching the Mode of a Tesla M60 or M6 GPU

Tesla M60 and M6 GPUs support compute mode and graphics mode. NVIDIA vGPU requires GPUs that support both modes to operate in graphics mode.

Only Tesla M60 and M6 GPUs require and support mode switching. Other GPUs that support NVIDIA vGPU do not require or support mode switching.

Recent Tesla M60 GPUs and M6 GPUs are supplied in graphics mode. However, your GPU might be in compute mode if it is an older Tesla M60 GPU or M6 GPU, or if its mode has previously been changed.

If your GPU supports both modes but is in compute mode, you must use the `gpumodeswitch` tool to change the mode of the GPU to graphics mode. If you are unsure which mode your GPU is in, use the `gpumodeswitch` tool to find out the mode.

For more information, see `gpumodeswitch User Guide`.

### 3.2. Installing the NVIDIA Virtual GPU Manager

Before guests enabled for NVIDIA vGPU can be configured, the NVIDIA Virtual GPU Manager must be installed in your chosen hypervisor. The process for installing the NVIDIA Virtual GPU Manager depends on the hypervisor that you are using.
If you need more detailed instructions, refer to the appropriate NVIDIA vGPU installation guide.

3.2.1. Installing the NVIDIA Virtual GPU Manager on VMware vSphere

The NVIDIA Virtual GPU Manager for VMware vSphere ESXi is distributed as a vSphere Installation Bundle (VIB) file.

1. Copy the NVIDIA Virtual GPU Manager VIB file to the ESXi host.
2. Put the ESXi host into maintenance mode.
   
   $ esxcli system maintenanceMode set --enable true

3. Run the `esxcli` command to install the NVIDIA Virtual GPU Manager from the VIB file.
   
   $ esxcli software vib install -v directory/NVIDIA**.vib

   `directory` is the path to the directory that contains the VIB file.

4. Exit maintenance mode.
   
   $ esxcli system maintenanceMode set --enable false

5. Reboot the ESXi host.
   
   $ reboot

6. Verify that the NVIDIA kernel driver can successfully communicate with the physical GPUs in your system by running the `nvidia-smi` command without any options.
   
   $ nvidia-smi

   If successful, the `nvidia-smi` command lists all the GPUs in your system.

3.2.2. Installing the NVIDIA Virtual GPU Manager on Citrix Hypervisor

The NVIDIA Virtual GPU Manager for Citrix Hypervisor is distributed as an RPM Package Manager (RPM) file. It runs in the Citrix Hypervisor Control Domain (dom0) shell.

1. Copy the NVIDIA Virtual GPU Manager RPM file to the Citrix Hypervisor dom0 shell.
2. Run the `rpm` command to install the package.
   
   [root@xenserver ~]# rpm -iv NVIDIA-**.rpm

3. Reboot the Citrix Hypervisor platform.
   
   [root@xenserver ~]# shutdown -r now
4. After the Citrix Hypervisor host has rebooted, verify the installation of the NVIDIA Virtual GPU Manager package for Citrix Hypervisor by checking for the NVIDIA kernel driver in the list of kernel-loaded modules.

```
[root@xenserver ~]# lsmod |grep nvidia
nvidia 8152994 0
i2c_core 20294 2 nvidia,i2c_
```

### 3.3. Disabling ECC Memory

Tesla M60, Tesla M6, and GPUs based on the Pascal GPU architecture, for example Tesla P100 or Tesla P4, support error correcting code (ECC) memory for improved data integrity. Tesla M60 and M6 GPUs in graphics mode are supplied with ECC memory disabled by default, but it may subsequently be enabled using `nvidia-smi`. GPUs based on the Pascal GPU architecture are supplied with ECC memory enabled.

However, NVIDIA vGPU does not support ECC memory. If ECC memory is enabled, NVIDIA vGPU fails to start. Therefore, you must ensure that ECC memory is disabled on all GPUs if you are using NVIDIA vGPU.

Before you begin, ensure that NVIDIA Virtual GPU Manager is installed on your hypervisor.

1. Use `nvidia-smi` to list the status of all GPUs, and check for ECC noted as enabled on GPUs.

```
# nvidia-smi -q
==============NVSMI LOG==============
Timestamp                           : Tue Dec 19 18:36:45 2017
Driver Version                      : 384.99
Attached GPUs                       : 1
GPU 0000:02:00.0
[...
    Ecc Mode
    Current                     : Enabled
    Pending                     : Enabled
[...]
```

2. Change the ECC status to off on each GPU for which ECC is enabled.

- If you want to change the ECC status to off for all GPUs on your host machine, run this command:

  ```
  # nvidia-smi -e 0
  ```

- If you want to change the ECC status to off for a specific GPU, run this command:

  ```
  # nvidia-smi -i id -e 0
  ```

  `id` is the index of the GPU as reported by `nvidia-smi`. 
This example disables ECC for the GPU with index 0000:02:00.0.

```
# nvidia-smi -i 0000:02:00.0 -e 0
```

3. Reboot the host.

4. Confirm that ECC is now disabled for the GPU.

```
# nvidia-smi -q
```

```
====== NVSMI LOG ======
Timestamp                           : Tue Dec 19 18:37:53 2017
Driver Version                      : 384.99
Attached GPUs                       : 1
GPU 0000:02:00.0
(...]

  Ecc Mode
  Current                     : Disabled
  Pending                     : Disabled

[...]
```

3.4. Attaching an NVIDIA vGPU Profile to a VM

To attach an NVIDIA vGPU profile to a virtual machine (VM), you must configure the VM hardware. The process for attaching an NVIDIA vGPU profile to a VM depends on the hypervisor that you are using.

3.4.1. Configuring a vSphere VM with NVIDIA vGPU

Caution Output from the VM console in the VMware vSphere Web Client is not available for VMs that are running vGPU. Make sure that you have installed an alternate means of accessing the VM (such as VMware Horizon or a VNC server) before you configure vGPU.

VM console in vSphere Web Client will become active again once the vGPU parameters are removed from the VM's configuration.

1. Open the vCenter Web UI.
2. In the vCenter Web UI, right-click the VM and choose Edit Settings.
3. Click the Virtual Hardware tab.
4. In the New device list, select Shared PCI Device and click Add.
   The PCI device field should be auto-populated with NVIDIA GRID vGPU.
5. From the **GPU Profile** drop-down menu, choose the type of vGPU you want to configure and click **OK**.

6. Ensure that VMs running vGPU have all their memory reserved:
   a) Select **Edit virtual machine settings** from the vCenter Web UI.
   b) Expand the **Memory** section and click **Reserve all guest memory (All locked)**.

After you have configured a vSphere VM with a vGPU, start the VM. VM console in vSphere Web Client is not supported in this vGPU release. Therefore, use VMware Horizon or VNC to access the VM's desktop.
3.4.2. Configuring a Citrix Hypervisor VM with Virtual GPU

1. Ensure the VM is powered off.
2. Right-click the VM in XenCenter, select Properties to open the VM’s properties, and select the GPU property.
   The available GPU types are listed in the GPU type drop-down list:

![Image of GPU properties in XenCenter]

After you have configured a Citrix Hypervisor VM with a vGPU, start the VM, either from XenCenter or by using `xe vm-start` in a dom0 shell. You can view the VM’s console in XenCenter.

3.5. Installing the NVIDIA vGPU Software Graphics Driver

After you create a Windows VM on the hypervisor and boot the VM, the VM should boot to a standard Windows desktop in VGA mode at 800×600 resolution. You can use the Windows screen resolution control panel to increase the resolution to other standard resolutions, but to fully enable GPU operation, the NVIDIA vGPU software graphics driver must be installed.

1. Copy the NVIDIA Windows driver package to the guest VM where you are installing the driver.
2. Execute the package to unpack and run the driver installer.
3. Click through the license agreement.

4. Select **Express Installation** and click **NEXT**.
   After the driver installation is complete, the installer may prompt you to restart the platform.

5. If prompted to restart the platform, do one of the following:
   - Select **Restart Now** to reboot the VM.
   - Exit the installer and reboot the VM when you are ready.

   After the VM restarts, it boots to a Windows desktop.

6. Verify that the NVIDIA driver is running.
   a) Right-click on the desktop.
   b) From the menu that opens, choose **NVIDIA Control Panel**.
   c) In the **NVIDIA Control Panel**, from the **Help** menu, choose **System Information**.

   **NVIDIA Control Panel** reports the vGPU that is being used, its capabilities, and the NVIDIA driver version that is loaded.
3.6. Licensing an NVIDIA vGPU

Perform this task from the guest VM to which the vGPU is assigned.

The NVIDIA Control Panel tool that you use to perform this task detects that a vGPU is assigned to the VM and, therefore, provides no options for selecting the license type. After you license the vGPU, NVIDIA vGPU software automatically selects the correct type of license based on the vGPU type.

These instructions cover only licensing for a single-instance license server. If you configured a primary and secondary license server, refer to Virtual GPU Client Licensing User Guide for instructions for how to specify the address and port number of the primary and secondary license servers.

1. Open NVIDIA Control Panel:
   - Right-click on the Windows desktop and select NVIDIA Control Panel from the menu.
   - Open Windows Control Panel and double-click the NVIDIA Control Panel icon.
2. In NVIDIA Control Panel, select the Manage License task in the Licensing section of the navigation pane.

   If the Licensing section and Manage License task are not displayed in NVIDIA Control Panel, the system has been configured to hide licensing controls in NVIDIA Control Panel. For information about registry settings, see Virtual GPU Client Licensing User Guide.

The Manage License task pane shows that NVIDIA vGPU is currently unlicensed.
3. In the **Primary License Server** field, enter the address of your NVIDIA vGPU software License Server.
   
   The address can be a fully-qualified domain name such as `gridlicense1.example.com`, or an IP address such as `10.31.20.45`.

4. Leave the **Port Number** field under the **Primary License Server** field unset.
   
   The port defaults to `7070`, which is the default port number used by NVIDIA vGPU software License Server.

5. Leave the **Secondary License Server** field and the **Port Number** field under it unset.

6. Click **Apply** to assign the settings.
   
   The system requests the appropriate license for the current vGPU from the configured license server.

The vGPU within the VM should now exhibit full frame rate, resolution, and display output capabilities. The VM is now capable of running the full range of DirectX and OpenGL graphics applications.

You have now completed the process of installing NVIDIA vGPU software and setting up a single VM to use NVIDIA vGPU.

If the system fails to obtain a license, see *Virtual GPU Client Licensing User Guide* for guidance on troubleshooting.
Notice

ALL NVIDIA DESIGN SPECIFICATIONS, REFERENCE BOARDS, FILES, DRAWINGS, DIAGNOSTICS, LISTS, AND OTHER DOCUMENTS (TOGETHER AND SEPARATELY, "MATERIALS") ARE BEING PROVIDED "AS IS." NVIDIA MAKES NO WARRANTIES, EXPRESSED, IMPLIED, STATUTORY, OR OTHERWISE WITH RESPECT TO THE MATERIALS, AND EXPRESSLY DISCLAIMS ALL IMPLIED WARRANTIES OF NONINFRINGEMENT, MERCHANTABILITY, AND FITNESS FOR A PARTICULAR PURPOSE.

Information furnished is believed to be accurate and reliable. However, NVIDIA Corporation assumes no responsibility for the consequences of use of such information or for any infringement of patents or other rights of third parties that may result from its use. No license is granted by implication of otherwise under any patent rights of NVIDIA Corporation. Specifications mentioned in this publication are subject to change without notice. This publication supersedes and replaces all other information previously supplied. NVIDIA Corporation products are not authorized as critical components in life support devices or systems without express written approval of NVIDIA Corporation.

HDMI

HDMI, the HDMI logo, and High-Definition Multimedia Interface are trademarks or registered trademarks of HDMI Licensing LLC.

OpenCL

OpenCL is a trademark of Apple Inc. used under license to the Khronos Group Inc.

Trademarks

NVIDIA, the NVIDIA logo, NVIDIA GRID, vGPU, Pascal, Quadro, and Tesla are trademarks or registered trademarks of NVIDIA Corporation in the U.S. and other countries. Other company and product names may be trademarks of the respective companies with which they are associated.

Copyright

© 2013-2019 NVIDIA Corporation. All rights reserved.

www.nvidia.com