

# G-REX Firmware Manual

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This manual describes the standard firmware for the GeckoDrive G-REX series of step motor controller. The G-REX is field-programmable, meaning that its functionality can be changed and upgraded at any time, subject to limitations of the hardware. This manual pertains to the microcontroller firmware which is loaded on the RCM37xx core module as obtained from the factory.

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## **G-REX Firmware Overview**

The G-REX is a stand-alone 8-bit peripheral device. As normally obtained from the factory, the G-REX also has a microcontroller unit (MCU) installed. The role of the MCU is to perform communication with the host PC, and other higher level interface functions.

The standard MCU provided with the G-REX is a Rabbit Semiconductor RCM3720 core module. The pinout of this MCU is directly compatible with the MCU socket on the G-REX. It also includes a 10base-T Ethernet connector, which allows the G-REX to be attached to any compatible Ethernet segment, including most home and industrial Ethernet LANs which use UTP (Unshielded Twisted Pair) cable.

This manual describes the firmware which is loaded on to the MCU. The key features of this firmware are:

- Provides TCP/IP Ethernet connectivity
- Provides back-up USB connectivity
- Simple web browser based firmware and/or FPGA configuration updates. No special programming hardware required for routine maintenance.
- Divided into two main parts: the download manager (DLM) and the downloaded program (DLP firmware).
- Robust: the DLM is always "safe", and does not get touched in the upload process.
- Any DLP can be uploaded, however the factory-provided DLP provides high-level command-based access to the G-REX hardware facilities.

## **Hardware Setup**

There are two possible network connectivity options: Ethernet and USB. Either or both of these may be used to connect the host PC to the G-REX, however Ethernet is recommended because of its slightly better performance, plus it has a big advantage in terms of cable length (up to 100m), and it is electrically (transformer) isolated which is an important consideration in an industrial setting.

### **Ethernet Hardware Setup**

If your main PC is already connected to an Ethernet LAN, then simply plug the G-REX into a spare port on the LAN using a normal Ethernet patch cable. If your PC does not have an existing connection, then you will need to purchase and install a dedicated Ethernet adapter in the PC. In this case, either:

- connect the PC's adapter directly to the G-REX using an Ethernet crossover cable, or
- connect both the PC and the G-REX to an Ethernet switch (or hub) using standard patch cables.

When you power up the G-REX, you can verify that the Ethernet has physical connectivity by checking the "link light". On the RCM3720 core module, the link light is a small (surface mount) green LED near the Ethernet jack at the very corner of the circuit board. Normally, your Ethernet switch or hub (or the PC adapter, if using direct connection) will also have a link light. The link light at each end will be illuminated if it is receiving a valid signal from the other end, and the device is powered up. If not, you should check your cabling.

## USB Hardware Setup

USB setup is very easy: simply use a standard USB cable to connect the jack on the G-REX main board (not the core module!) to a USB hub or spare USB port on the PC.

## Networking Setup

IP (Internet Protocol) networking is very powerful and flexible, however the price to be paid is that the initial setup can sometimes try ones patience. This only has to be done once. After that, it works very well unless the network is subsequently misconfigured.

The G-REX makes use of IP for both the Ethernet and USB connection. Since IP is the protocol of choice for Ethernet, this is to be expected. For USB, it is slightly unconventional. Since the USB driver makes the G-REX look like a serial (TTY or COM port) device, you will need to configure your operating system to use IP over the USB serial connection, as if it was talking to an Internet Service Provider over a modem link. The advantage of using IP over both Ethernet and USB is that the host PC software does not need to be aware of the different hardware connections. Instead, it can always use a common interface (sockets). It also simplifies the process of allowing the G-REX to be accessed remotely i.e. not just from a directly connected host.

The following steps need to be taken to establish network connectivity to the G-REX:

- Determine the G-REX's network (IP) address.
  - a Windows utility is available to discover and/or assign the G-REX's IP address.
- Configure the host PC so that communication can be established.
- Use a web browser to access and configure the G-REX.

## Ethernet IP Address

**Note:** the following may appear complicated, but it only has to be done once. It helps if you have some familiarity with IP (Internet Protocol) networking concepts. If not, then no matter since we will go through the steps in some detail.

When connecting using Ethernet, you need to know the IP (network) address of the G-REX. This address may be defined in several ways. By far the easiest way of accomplishing this, if you use Windows, is to use the Windows utility program called **GreX-loader.exe**. This program is self-explanatory when run. It automatically queries the network to find the address of the G-REX. If the address is not satisfactory for some reason, you can change it.

If you use GreX-loader.exe, then you can skip straight to "Opening a Web Browser Connection" on page 7 to complete the setup.

If you are running Linux, then the GreX-loader program is not (yet) available. In this case, follow the instructions below.

If your network has a DHCP (Dynamic Host Configuration Protocol) server, then the G-REX may be configured to use that service to obtain its own network address. This is quite convenient, however there still remains the problem of finding out the network address that was assigned by DHCP. This usually requires somebody to look through the DHCP server log.

Since the G-REX does not initially enable DHCP, and in any case most home networks do not have a DHCP server set up, the G-REX also comes configured with a default network address.

The factory default IP address is 169.254.X.Y where X and Y are derived from the last four digits of the Ethernet hardware address (MAC address) printed on the barcode label on the RCM3720 core module. IP addresses starting with 169.254 are reserved for temporary addresses for devices which are attached to a local network. These addresses are not accessible from the wider Internet, and indeed are not "routable" at all. You can easily change this address later, but when first connecting to a factory-fresh device, it is easiest if you just make sure that the PC and the G-REX are on the same Ethernet LAN. In other words, the only devices (if any) allowed between the PC and the G-REX are Ethernet switches or hubs; no routers or modems!

Unfortunately, IP addresses are expressed as dotted decimal, and MAC addresses are expressed in hexadecimal. You will need to manually translate. The following example shows how to do this:

Suppose the MAC address printed on the barcode is 'C790A1'. We want to translate this to 169.254.X.Y.

X is obtained from the 3rd and 4th digits from the right, '90' in this case. This is converted to decimal, giving  $9 \times 16 + 0 = 144$ .

Y is obtained from the 1st and 2nd digits from the right, 'A1'. Convert this to decimal, giving  $10 \times 16 + 1 = 161$ .

The IP address is thus 169.254.144.161. There is one further trick that is required with some MAC addresses. According to the standard, the 'X' part is not allowed to be 0 or 255, however it is possible for the MAC address to have 00 or FF in that position, for example C9007B or C6FF5E. In this case, you need to adjust the X part of the IP address as follows: if X would be 0, then change it to 1; if X would be 255, change it to 254.

There is a very slight possibility of the default address "colliding" with a device which is already using that address on the Ethernet segment. There is only a 1 in 65000 chance of this happening with any one device, and could only happen if the other device was also using "zero conf" or "Bonjour" networking and had not been configured with a permanent address. Such conflicts can cause major problems in the network, since each device *must* have a unique address. If you suspect this could be causing a problem, then either configure the other device to use a different address, or temporarily disconnect it until you have had a chance to assign a permanent address to the G-REX.

## USB IP Address

The USB connection is point-to-point. Unlike Ethernet, there is no possibility of an IP address conflict since there can only be two hosts on a point-to-point link. It is possible, however, that a given IP address may not be usable owing to conflicts with other, pre-existing, addresses that either end may already know about. For example, the G-REX could not use the same IP address that it is using for its Ethernet port, for the USB connection. Thus, there needs to be a mechanism for both ends to negotiate a mutually agreeable address.

The G-REX takes the approach of requesting an IP address of 192.168.0.2, plus it suggests the host PC uses 192.168.0.1 for its end. This will normally be satisfactory, since the 192.168 range of IP addresses is reserved for private networks. In some cases, this might conflict with the host PC's other network ports. In such cases, it is possible for the host PC to be configured to use other, non-conflicting, addresses on the USB port. The G-REX will always accept addresses specified by the host PC.

The IP address of the G-REX, using the USB interface, is thus 192.168.0.2, unless changed by the host PC configuration.

## Networking Setup - Windows

On Windows, you use the Control Panel to set up network connections. When you use the Windows Start button, click on "Control Panel", then click on "Network Connections" in the Control Panel. From this point, the actions differ between Ethernet and USB setup, as described in the following sections.

### Ethernet

If you have a working Ethernet connection, there will be a section in the Network Connections panel titled "LAN or High-Speed internet". If not, you will first need to install the Ethernet adapter card and drivers before proceeding.

Right click on the appropriate "local area connection", then click on "properties" from the pop-up menu. This will bring up the "Local Area Connection Properties" panel. Scroll down the list of items (if necessary) then click on "Internet Protocol (TCP/IP)" to highlight it. Now click the "Properties" button. This will bring up the "Internet Protocol (TCP/IP) Properties" panel.

We're not quite there yet. Click the "Advanced" button, to bring up the "Advanced TCP/IP Settings" panel. Make sure the "IP Settings" tab is selected on this panel. You will see a list of the IP addresses (or, usually, just one address) currently assigned to your PC's Ethernet port. If that list includes an address starting with "169.254" (with a corresponding netmask of "255.255.0.0") then you do not have to do anything else. Otherwise, click the "Add" button. In the panel which appears, enter "169.254.1.0" for the IP address, and "255.255.0.0" for the netmask. Click "Add" when done, then the "OK" button in each of the cascade of panels, then finally "Close" in the "Local Area Connections" panel.

### USB

Since the G-REX uses the FTDI FT245BM chip for the USB interface, you will need to install the latest drivers available from FTDI. The drivers are available from <http://www.ftdichip.com/FTDrivers.htm>.

When installing the USB driver from FTDI, make sure that you select the "Virtual COM Port" option (VCP).

After verifying that the installation was successful, power up the G-REX and connect it to the PC (or USB hub). Note down the name of the COM port which is created. This may be something like "COM3" or "COM5" depending on how many legacy serial ports are already in your machine. The COM port number also depends on whether you have any other USB/serial converters or adapters attached to the USB hub. In any case, if the G-REX was the most recent device added, then the COM port will probably be the highest numbered. Don't worry too much about this, since the available COM ports will be presented in a menu when you set up networking, as described below.

Start up the "Network Connections" panel (Start -> Control Panel -> Network Connections).

Double-click on "New Connection Wizard". Hit "Next" then select "Set up an advanced connection". Hit "Next" again, then select "Connect directly to another computer". Hit "Next", and select "guest". Hit "Next" and then enter the name that you wish to use to identify the connection. May as well make this "G-REX". Hit "Next". The next panel is where you specify the appropriate serial port connection. Of course, it's not really a serial port, but as far as networking support goes, it looks and acts like one. Select the appropriate COM port - it is probably not COM1, and it's definitely not a parallel printer cable. If you recently plugged the G-REX into the USB hub, then it is probably the highest numbered COM port.

Select this in the combo box. Click "Next" and then "Finish" to dismiss the wizard. The next panel to appear will be the "Connect" panel. You can ignore the userid and password fields, since the G-REX requires neither. But before you hit that "Connect" button, we are not quite ready for that, so hit the "Properties" button instead.

A panel will appear called "G-REX Properties" (or whatever name you selected for the connection). Click on the "Options" tab, and de-select the "prompt for name and password" checkbox, since that will save an unnecessary step when connecting. Click on the "Networking" tab. Make sure that the type of dial-up server is set to "PPP". In the "items" table, de-select everything that it lets you change, except "Internet Protocol (TCP/IP)". Then highlight "Internet Protocol (TCP/IP)" and click on the "Properties" button. In the panel that appears, check the "Use the following IP address" radio button, and enter "192.168.0.1" as the IP address. Also, click on the "Advanced" button. De-select both checkboxes ("use default gateway" and "use IP header compression"). Finally, click OK on all outstanding panels to save the settings.

If all goes well, you should now be able to connect to the G-REX over USB.

**Note:** there is a problem with Windows and/or the FTDI drivers: if the G-REX is powered off, or the USB cable disconnected, while a network connection is established (over USB) then you might not be able to reconnect later. An indication that this has happened is if the correct COM port refuses to show up in the G-REX Properties panel. The only known work-around is to reboot Windows. You can avoid this problem by making sure that you tell Windows to disconnect before powering off or unplugging the G-REX.

Having configured networking, it is easy to start and stop the connection. From the Windows "start" menu, you can select "Connect To -> G-REX". You can also quickly edit the connection properties if, instead of (left) clicking on the G-REX menu item, you right click on it and select "properties".

## Networking Setup - Linux

### Ethernet

The factory default IP address (169.254.X.Y) is probably not accessible unless you add an explicit route table entry for it.

The Unix/Linux command to manipulate the routing table is called "route" or "/sbin/route". Become root user, then issue

```
# /sbin/route -n
```

Which will list the existing router table entries e.g. you might get something like

```
Kernel IP routing table
Destination Gateway      Genmask           Iface
10.0.0.0     *                255.255.255.0     eth0
0.0.0.0      10.0.0.2         0.0.0.0           eth0
```

If there is no route to 169.254.0.0, then you will need to add one. The following command shows how.

```
# /sbin/route add -net 169.254.0.0 netmask 255.255.0.0 dev eth0
```

As a check, you can try pinging the G-REX (no need to be root for this):

```
$ ping 169.254.144.154
```

(naturally, substitute the correct IP address in here). If you see ping responses printed, then press CTRL-C to quit ping, then start up a browser and try to connect.

## USB

According to the FTDI web site, the appropriate VCP driver for Linux is available pre-installed starting with kernel version 2.4.20. In general, robust Linux support for USB has been lacking until at least kernel version 2.4.18. It is recommended that you upgrade your kernel to at least 2.4.20 before attempting to use USB.

When you use the FTDI drivers, you will end up with a device node in `/dev` called something like `/dev/ttyUSB0` or `/dev/usb/tty0`. The aim is to set up a PPP connection which uses this device as a "serial port".

The G-REX does not initially speak PPP. For compatibility with Windows, it first requires a few ascii messages to pass back and forth. Initially, when Windows opens the connection, it sends the string "CLIENT". It then expects the peer to respond with "CLIENTSERVER" (i.e. echo the "CLIENT" message then send "SERVER"). Don't ask me why, it's just the way Microsoft decided to do it. After this trivial exchange, normal PPP starts up.

On Linux, you will need to emulate this initial exchange by using a simple chat script (which can be included in the appropriate PPP options file). Here is an example of a suitable PPP options file (in `/etc/ppp/options.ttyUSB0`).

[FIXME]

## Opening a Web Browser Connection

The next step after setting up the hardware and software network configuration is to establish a web browser connection to the G-REX. Any browser may be used, including Firefox, Mozilla, Opera, Internet Explorer etc., provided that the browser supports HTTP uploads. This means that the browser version must not be incredibly ancient.

You have already determined the IP address of the G-REX, following the previous steps. For ease of explanation, we assume this address is 169.254.144.154. Obviously, substitute the actual IP address that you determined.

Now, start up the web browser, and enter the following URL:

`http://169.254.144.154`

This is a normal URL, except that we use a numeric address rather than typing in a domain name like "www.foobar.com".

If all goes well, you will see the G-REX's home page, and you can skip to the next sections.

Otherwise, you need to perform some troubleshooting.

## Troubleshooting: Ethernet

Here are the most common causes of inability to establish a browser connection over Ethernet:

### The G-REX IP address is not what you expect

Since the G-REX will make use of DHCP if it is available (but only if you explicitly told it to), then it may not be using the factory default (169.254.X.Y) address, or an address that you previously configured via the web interface. Note that some DSL "modems" and firewalls include a DHCP server. In this case, you need to check the server's log to find out which address was assigned to the G-REX.

### **The host PC does not know how to connect to the given address**

This is caused by an incorrect or missing routing table entry. On Windows, you can open up a command (DOS) prompt window and enter the command `route print`. On Linux, you enter `/sbin/route -n`. Examine the output to confirm that the target IP address lies within the appropriate range of available addresses. If not, add a suitable route.

## ***Configuring the Download Manager***

The G-REX main page is divided into sections. The first section is titled "Current Download Manager Settings". In this section you can fill in and submit a form which allows several things to be configured:

### **Default FPGA Config**

You can upload up to 6 FPGA configuration files, numbered 1-6. This field indicates the default config to load when starting the DLP firmware. If left at zero, the lowest numbered config is used.

### **Auto Boot Time**

If you enter a value above 3 (seconds) in this field, then the G-REX will automatically start the DLP firmware after this amount of time, after it is powered up. Before this time limit expires, if you connect to the G-REX with a web browser then the timeout will be cancelled. A minimum timeout is required to give you time to connect in case something goes wrong with the DLP firmware.

If you enter a value of 0 for the timeout, then the G-REX will wait indefinitely in the download manager. In this case, you will need to start a web browser session to the G-REX, then press the "Run Firmware" button in order to start the DLP firmware.

It is recommended that you set this to 0 when trying out new firmware. When happy with it, set the value to 3 or more so that the new firmware starts automatically.

### **New Ethernet IP Address and Netmask**

This field allows you to change the current IP address to something more convenient or workable on your network.

**Important:** when you change these network parameters, make sure you write them down! If you forget what you entered, it may be very difficult to find out what they were. It is recommended to write the address on a plastic tag and affix it to the G-REX. If you forget the Ethernet address, then your only recourse may be to connect via USB.

You must be careful to assign an IP address which is not already in use, and is compatible with your network configuration. This is a job for your network administrator. If you are the administrator, then you might like to brush up on your admin skills by consulting one of the many good books on this subject, or searching the Internet for tips on setting up home or small office networks.

If in doubt, do not change these settings.



## DHCP Timeout

If set non-zero, this specifies an allowable timeout (in seconds) for the G-REX to search for a DHCP server when it is booted. If zero, then the G-REX does not attempt to use DHCP. If you set this non-zero, but there is no DHCP server on the network, then no harm is done except that it extends the bootup time by the number of seconds specified. You will not be able to connect until that timeout has expired.

If you have no DHCP server, or you don't know (or want to know) what DHCP is, then leave this field zero.

## Viewing the DLM Log

A link is provided at the bottom of the Download Manager Settings section. Clicking on this link will take you to the DLM's log. In this log, any error messages are highlighted in red, and warnings in blue.

At the end of the log listing, there are two links one of which retains the current log and the other which clears it. You will be returned to the G-REX home page.

Here is a typical log listing, showing both network interfaces starting (Ethernet and USB), as well as the results of pressing the "test" button for an FPGA configuration:

```
<6>Jan 19 21:37:28 [1]: Download manager started
<6>Jan 19 21:37:35 [2]: Ethernet interface is up at 169.254.144.154
<6>Jan 19 21:37:37 [3]: CRC OK -- yes
<6>Jan 19 21:37:40 [4]: PPP/USB interface is up at 192.168.0.2
<6>Jan 19 21:39:17 [5]: Loading FPGA config 1...
<6>Jan 19 21:39:18 [6]: XSVF loader completed
<6>Jan 19 21:39:18 [7]: Programming time = 914ms
<6>Jan 19 21:39:18 [8]: Config completed
<6>Jan 19 21:39:18 [9]: FPGA version register (addr 0x01) reads 0x03
<6>Jan 19 21:39:18 [10]: FPGA vers.release = 0.3
<6>Jan 19 21:39:18 [11]: FPGA status register (addr 0x00) reads 0x86
```

Note that the absolute value of the date (e.g. Jan 19) and time should be ignored, since there is no way provided to set the RCM3720's real-time clock. The date/time actually reflects the elapsed time since the RCM3720 was first plugged into a battery-backed power source (With Jan 1 00:00:00 representing the starting time).

The first number on each line (inside angle brackets) represents the message priority, with lower numbers representing higher priority. This corresponds to standard Unix-style syslog priority numbering.

The log has a limited capacity. When full, it deletes the oldest messages and wraps around.

## Running the DLP Firmware

The second section of the G-REX home page is titled "Actions". In this section, you can start the current DLP firmware, and upload new FPGA configurations and firmware.

In the "Run Firmware" sub-heading, there is a single button which, when pressed, immediately starts the current DLP firmware. Optionally, you can fill in a parameter field to pass commands to the firmware. Normally, you don't need to put anything in the parameter field unless the instructions which (hopefully) came with the DLP firmware indicate that you should do so. The factory default firmware does not use any of these parameters. They are provided mainly for 3rd party firmware suppliers.

If there is no firmware loaded (maybe because a previous upload attempt was interrupted) then pressing the "Run" button will have no effect other than show an error message in the log.

## ***Installing Firmware and FPGA Upgrades***

The G-REX's flexibility mainly comes about because of its ability to change both software (DLP firmware) and hardware logic (FPGA configurations).

As it comes from the factory, it is already loaded with useful firmware and a suitable configuration. From time to time, updates to these may become available from the Geckodrive website, as well as third-party suppliers, including open source development efforts. When such updates become available, you can use the download manager to install the new files in the G-REX.

Only one firmware program may be loaded at any time, however you can store up to 6 FPGA configurations, and an additional 6 general data files.

## **Uploading FPGA Configurations**

All uploads work in basically the same way. First, you click the "upload" link in the table entry corresponding to the configuration number you wish to use. Normally, you would pick an unused entry (size set to 0) rather than overwriting an existing entry. It is useful to keep the previous version around just in case you need to go back to it. The only reason for overwriting an old entry is if you are running out of storage space, or if there are no free entries.

When you click the upload link, a new page appears in which you can specify the file to upload, plus you can give an identifying name to the file.

The identifier is purely for your benefit, and may be anything (or nothing), but it is recommended that you include at least a datecode or version identifier.

An FPGA configuration must be a valid .xsvf file. This is the only format that is usable by the G-REX. If the wrong file type is uploaded, then the FPGA will probably fail to load. You will see a message in the log in this case. It is recommended that you perform a dry-run of the FPGA configuration by using the "test" button in the main page. When pressed, this button will take you to the log page. If there are any error messages added, they will be shown in red. If all appears to be OK, then the contents of the FPGA version and status registers will be logged. This is not a 100% guarantee that the FPGA configuration will actually work, but at least it verifies that the file format is correct and the MCU-FPGA interface is functional.

**Note:** if you use one of the "test" buttons, then that FPGA configuration will be used when you start the firmware using the "run" button. If you don't want this, then press "test" on the desired configuration before starting the firmware.

## **Uploading Other Data**

The G-REX home page lists these files as "White Heat Programs", however any file data may be stored in these slots (numbered 16-21). You should only upload files which are required by the firmware, and you should consult the firmware manual to find out which files are required. The factory default firmware does not make use of any of these files.

## Uploading Firmware

As stated above, only one firmware can be installed at any point in time. This is because the firmware needs to be stored in the RCM3720 core module's program flash (256k byte capacity), rather than in the larger serial flash (1M byte). In addition, the core module has no operating system as such, thus it is not possible to dynamically load different firmware programs.

The last link on the G-REX home page is "Upload New Firmware". Clicking here will take you to an upload page where you can enter the name of the file to upload, which must be a valid binary file (.bin). Depending on the size of the firmware .bin file, it will take about 10-30 seconds for the file to upload.

**Note:** do not confuse DLM (Download Manager) binary files with DLP (Download Program) files. Some firmware distributions may contain both types. You should only load **DLP binary files**. Do not attempt to load DLM files, since this will only work if you have special hardware.

The current naming convention for files relevant to the G-REX project is:

- G101\_DLM\_*datecode*.BIN - Download manager (do not load using web browser!)
- G101\_DLP\_*datecode*.BIN - Download program
- TOP\_S50\_*datecode*.XSVF - Standard FPGA configurations.