



# Open Source Rover: Software Instructions

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## 1 Flashing the Arduino Code

In this section we will be flashing the code that runs on the arduino to control the LED matrix in the head.

The following steps should be performed on your laptop or development machine (not the raspberry pi)

1. Install the Arduino IDE used for loading code onto the arduino:

<https://www.arduino.cc/en/Main/Software>

2. Clone the code repo:

- (a) `git clone https://github.com/nasa-jpl/osr-rover-code.git`
  - (b) `git checkout osr-ROS`
  - (c) `git pull`

3. Build our custom library:

- (a) Select the downloaded Arduino folder and create a .ZIP file from it
  - (b) Rename the Zip file to OsrScreen.zip

4. Load the sketch onto the Arduino

- (a) Unplug the Arduino shield JST cable so the Arduino isn't powered by the control board
  - (b) Connect the Arduino to your development machine with USB cable
  - (c) Open Arduino IDE
  - (d) Select Sketch - Include Library - Add .Zip Library
  - (e) Select the OsrScreen.zip folder created previously
  - (f) Click the Upload button in the Sketch Window

5. To load the example in the Arduino IDE:

- (a) File - Examples - OsrScreen - OsrScreen

## 2 Setting up the Raspberry Pi 3

In this section, we'll go over setting up the Raspberry Pi and setting up all the code that will run the rover.

Our rover uses ROS (Robotic Operating System), which will be installed on the Raspbian operating system; we will set up both of these below. We will also set up the bluetooth pairing from the android device.

## 2.1 Getting the Raspberry Pi running

The first step is to install Raspbian on your Raspberry Pi. To install Raspbian, we recommend following the "Getting started with Raspberry Pi" tutorial below. **\*\*NOTE: These instructions were tested and verified using Raspbian Stretch. Newer versions of Raspbian (such as Buster) may cause complications with these instructions. We therefore recommend installing Raspbian Stretch instead of the latest/default version of Raspbian, which the tutorial below will recommend.** Do not flash NOOBS onto your card; instead download the Raspbian Stretch image below and skip the NOOBS step in the tutorial. In addition, we have created a pre-built image with both Raspbian Stretch and ROS already installed. You can download this image as a last resort if you can't get Raspbian and ROS installed and working on your own, but please note that you will miss out on some the learning opportunities that come with debugging a software installation by doing so.

Tutorial for installing the latest version of Raspbian on a new Raspberry Pi:

<https://projects.raspberrypi.org/en/projects/raspberry-pi-getting-started>

Direct downloadable Raspbian Stretch image:

<https://downloads.raspberrypi.org/raspbian/images/raspbian-2019-04-09/2019-04-08-raspbian-stretch.zip>

Custom JPL image with both Raspbian Stretch and ROS pre-built:

<https://drive.google.com/drive/folders/1RbYWDRthpcktqkPEHb7qVqDiy27EiAc1>

**\*\*NOTE: If you install the Custom JPL image with Raspbian Stretch and ROS pre-built, skip to step 2.4.**

Once you finish the above tutorial and install Raspbian Stretch, you should be able to boot your Raspberry Pi and see a desktop!

## 2.2 Installing ROS

If you do not download the pre-built Raspbian Stretch / ROS image above, you will need to build ROS yourself:

First, make sure you update all the packages on your pi:

```
sudo apt-get update
```

```
sudo apt-get upgrade
```

(The above commands may take a few minutes to run.)

Next, we will install ROS (and specifically, the version called 'Kinetic').

**NOTE: Follow the ROS installation directions in the link below CAREFULLY! Do not ignore warnings, as they will lead to issues later in the installation. Some known "gotchas" to note before you get started are:**

- Make sure you install the Kinetic "desktop\_full" version of ROS, not the desktop ros-comm, or other versions.
- ROS changed their GPG keys as of June 7 2019. The ROS install instructions do not mention this as of July 2019 and will not work unless you update your GPG keys. See <https://discourse.ros.org/t/new-gpg-keys-deployed-for-packages-ros-org/9454> for instructions on how to update your GPG keys.
- Make sure you follow directions for KINETIC, not Indigo, Melodic, or any other ROS version.

Once you familiarize yourself with the above issues, go ahead and complete your ROS installation by following the instructions at:

<http://wiki.ros.org/ROSberryPi/Installing%20ROS%20Kinetic%20on%20the%20Raspberry%20Pi>

### 2.3 Setting up serial communication

In this project we will be using serial communication to talk to the motor controllers. Serial communication is a communication protocol that describes how bits of information are transferred between one device and another. You can find more information on serial communication at:

- <https://learn.sparkfun.com/tutorials/serial-communication>

Run the following commands on the Pi to setup/enable the serial communication for the RoboClaws:

```
sudo raspi-config
```

In the raspi-config menu, set the following options:

- Interface Options – > Serial
- Would you like a login shell to be accessible over serial? – > No
- Would you like the serial port hardware to be enabled? – > Yes
- Would you like to reboot now? – > Yes

Once the Pi reboots, open up a terminal again and look at the serial devices:

```
ls -l /dev/serial*
```

Make sure that this shows serial0 -> ttyS0 . If it does not, ensure that you have followed every step in this tutorial in order. Next, edit the /boot/cmdline.txt file:

```
sudo nano /boot/cmdline.txt
```

Change **ONLY** the part with "console = ...." to read "console=tty1" and remove any other instance where it references console. The first bit of that line should look similar to the Figure 1: <sup>1</sup>

```
dwc_otg.lpm_enable=0 console=tty1 root=/dev/mmcblk0p7
```

Figure 1: boot/cmdline.txt File

Below is a link to help with the above steps if you need additional help:

- <https://spellfoundry.com/2016/05/29/configuring-gpio-serial-port-raspbian-jessie-including-pi-3/>.

Once you've completed the above steps, reboot the Pi.

```
sudo reboot
```

## 2.4 Downloading the Rover Code

On the Raspberry Pi, open up a terminal (**ctl + alt + t**) and then type the following commands<sup>2</sup>:

Move to your home directory: `cd /home/pi`

Clone the rover code repository: `git clone https://github.com/nasa-jpl/osr-rover-code osr`

Move into the directory you just cloned: `cd osr`

Pull to make sure you have the latest code: `git pull`

## 2.5 Building the Rover Code to work with your ROS installation

Now, you must build the rover code packages so that ROS can run them on your Raspberry Pi. To do this, run the following commands in a terminal:

Create a catkin workspace directory and move into it:

---

<sup>1</sup>It is okay if it does not exactly match what we show here; the important part is that the "console=tty1" flag matches.

<sup>2</sup>In this document, terminal commands will be highlighted.

## **2 SETTING UP THE RASPBERRYPI** Set Rover Code to work with your ROS installation

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```
mkdir -p /home/pi/osr_ws/src && cd /home/pi/osr_ws
```

Build a basic, empty catkin project: `catkin_make`

Move to the directory containing the main OSR logic: `cd /home/pi/osr/ROS`

Copy the OSR source files to the catkin workspace:

```
mv led_screen/ osr/ osr_bringup/ osr_msgs/ /home/pi/osr_ws/src
```

Make all of the source files executable: `cd /home/pi/osr_ws/src/osr/scripts && chmod +x *.py`

Move back to your catkin workspace: `cd /home/pi/osr_ws`

Build the sensor\_msgs ROS package:

```
rosinstall_generator sensor_msgs --rosdistro kinetic --deps --wet-only --tar >kinetic-sensor_msgs-wet.rosinstall
```

```
wstool init src kinetic-sensor_msgs-wet.rosinstall
```

Run a "catkin make" of the OSR workspace (this will take some time): `catkin_make`

If your catkin make command succeeded, you should now see new build/ and devel/ directories in /home-/pi/osr\_ws.

Source your newly created ROS environment:

```
source /opt/ros/kinetic/setup.bash
```

```
source /home/pi/osr_ws/devel/setup.bash
```

```
source /home/pi/osr_ws/devel/setup.sh
```

Use nano (or your editor of choice) to add the above three 'source' commands to the end of your `~/.bashrc` file, each on its own line. This will allow you to re-launch the OSR code without needing to source the OSR ROS environment each time:

```
sudo nano ~/.bashrc
```

## 2.6 Running the Rover Code Manually

At this point, all the code should be ready to run on your rover! You can start the rover code by running the following command in a terminal:

Run the rosrun command (read more about rosrun at <http://wiki.ros.org/rosrun>):

```
rosrun osr Bringup osr.launch
```

You should now see the rover trying to launch all its ROS "nodes", which are the various parts of the robot that all communicate to each other. Figure 2 shows more information about the ROS ecosystem on this rover:

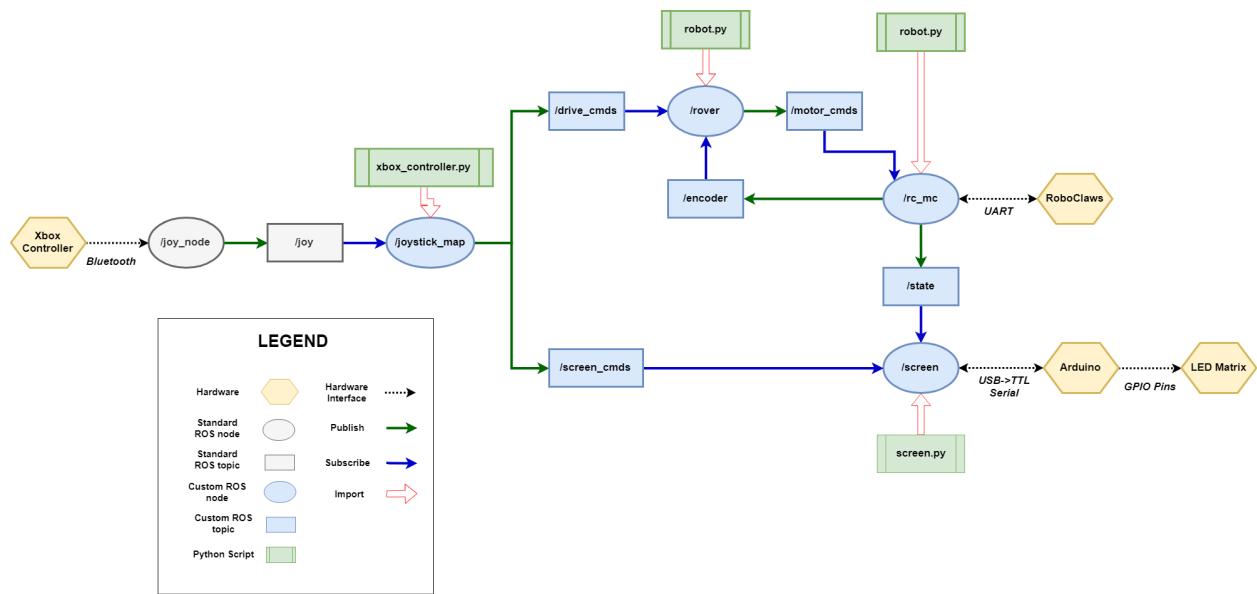


Figure 2: OSR ROS Architecture

You can find more details about the software / ROS architecture in the README document in the osr-rover-code repository at <https://github.com/nasa-jpl/osr-rover-code/tree/osr-ROS>.

If you wish to control the rover in any manner other than with an Xbox controller, you can do so by publishing commands onto the "/joystick" topic using the Joystick message type from osr\_msgs. To do this, you would simply write a ROS node to read in whatever control method you wish and output a corresponding Joystick message. The rover's ROS ecosystem will see these Joystick messages and drive the rover based on your commands!

## 2.7 Init Script

Starting scripts on boot using ROS can be a little more difficult than starting scripts on boot normally from the Raspberry Pi because of the default permission settings on the RPi and the fact that that ROS cannot be ran as the root user. The way that we will start our rover code automatically on boot is to create a service that starts our roslaunch script, and then automatically run that service on boot of the robot. Further information on system service scripts running at boot can be found at:

- <https://www.linode.com/docs/quick-answers/linux/start-service-at-boot/>.

There are two scripts in the "Software/Init Scripts" folder. The first is the bash file that runs the roslaunch file, and the other creates a system service to start that bash script. Open up a terminal on the raspberry Pi and execute the following commands.

```
cd /home/pi/osr/Init\ Scripts
```

```
sudo cp LaunchOSR.sh /usr/bin/LaunchOSR.sh
```

```
sudo chmod +x /usr/bin/LaunchOSR.sh
```

```
sudo cp osr_startup.service /etc/systemd/system/osr_startup.service
```

```
sudo chmod 644 /etc/systemd/system/osr_startup.service
```

Your osr\_startup service is now installed on the Pi and ready to be used. The following are some commands related to managing this service which you might find useful:

Description	Command
Start service	sudo systemctl start osr_startup.service
Stop service	sudo systemctl stop osr_startup.service
Enable service (runs on boot of RPi)	sudo systemctl enable osr_startup.service
Disable service (doesn't run on boot of RPi)	sudo systemctl disable osr_startup.service
Check status of service	sudo systemctl status osr_startup.service
View live service list	sudo journalctl -f

**Note: We do not recommend enabling the service until you have verified that everything on your robot runs successfully manually. Once you enable the service, as soon as you power on the RPi it will try and run everything. This could cause issues if everything has not yet been fully tested and verified. Additionally, if you are doing development of your own software**

for the robot we suggest disabling the service and doing manual launch of the scripts during testing phases. This will help you more easily debug any issues with your code. Once you have fully tested the robot and made sure that everything is running correctly by starting the rover code manually via `roslaunch osr_bringup osr.launch`, enable the startup service on the robot with the command below:

```
sudo systemctl enable osr_startup.service
```

At this point, your rover should be fully functional and automatically run whenever you boot it up! Congratulations and happy roving!!