Monitoring the status of the garbage containers

Test

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Date: 14/12/2016

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2. Introduction

In following document, we will describe acceptance test for garbage bin collection system. Requirements to pass the tests can be found in the document ‘Requirement specification’.

3. Test specifications

In table 1 we list components being tested.

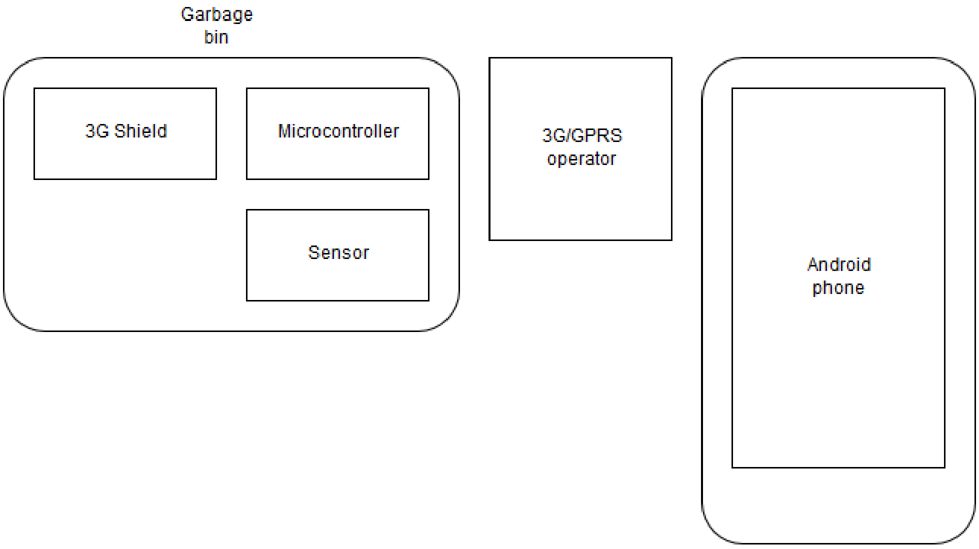
Device	**Environment**	**Notes**
Microcontroller	Arduino Mega2560	
Ultrasonic sensor	MB1202	
Smartphone	Android	API XX+
Communication module	SIM5218E	AT Commands

Table 1 List of devices

4. Test setup

Figure 1 shows testing setup for completed project. Some tests may be performed before final prototype is completed.

Figure 1 Test setup



From the figure 1 we can see that testing environment consists of two big section. For most use cases these sections can be tested separately. Full system also includes one external actor which is mobile operator.

5. Unit tests

5.1 Sensor

5.1.1 Description

This test is to see if sensor data can be read.

For this one we had to write the code to show the sensor's results first. Thus, unit test and implementation test were done simultaneously. After linking code, sensor and microcontroller, we confirmed that the sensor was receiving and delivering input & output. Then we did some basic range test on it, to confirm its adequacy; first putting obstacles in an open environment and then in an empty trash.

Putting obstacles on different distance, and comparing the real distance with what’s sonar sensor are sending to Arduino microcontroller, we can know how is the sonar accuracy. First, we tested with three different distances, just putting the sensor focus to ground.

And, we could compare the real distance with sonar response (display in the serial monitor). As you can see following we take different pictures while we was doing the test.

0,6 meter:

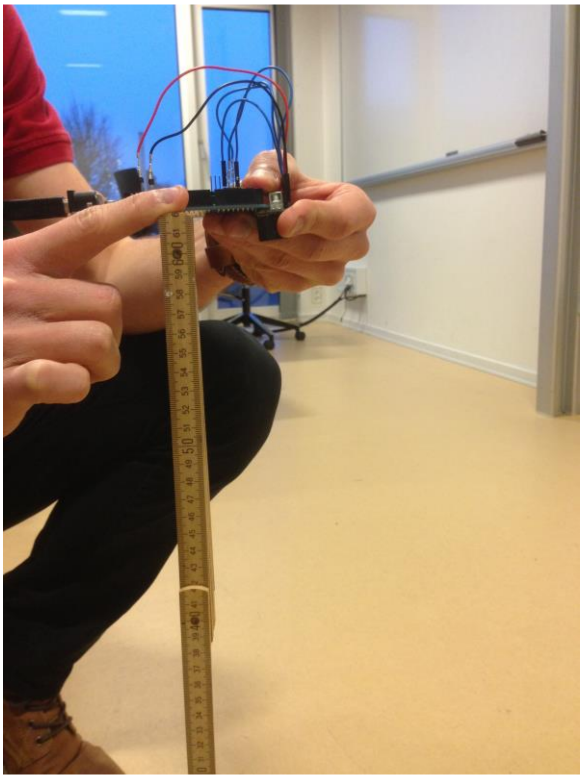
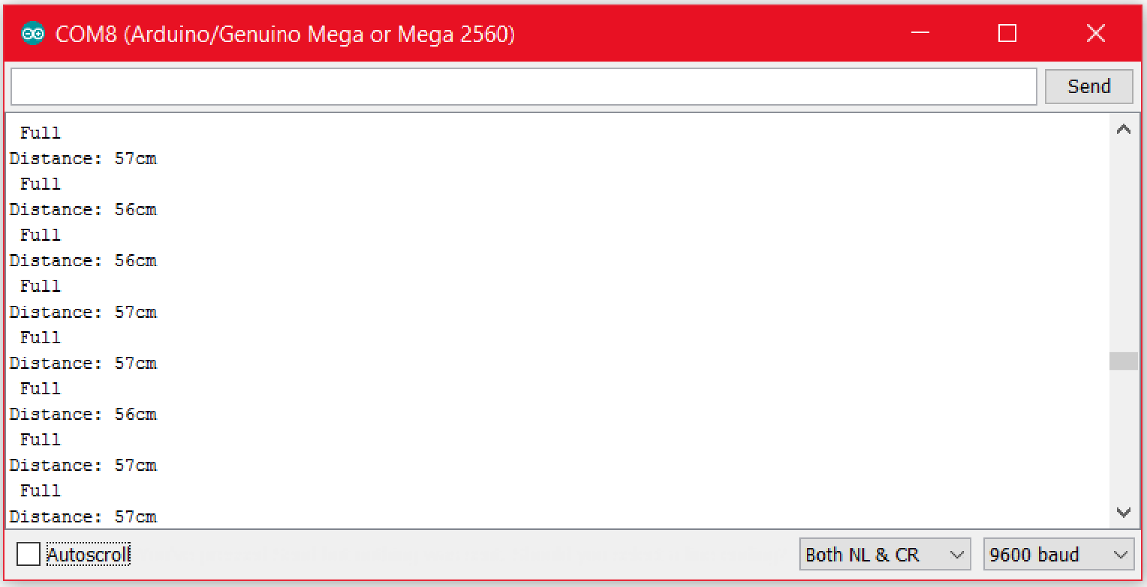


Figure 1: 0,6m measurement sensor unit test



```
 Full
Distance: 57cm
 Full
Distance: 56cm
 Full
Distance: 56cm
 Full
Distance: 57cm
 Full
Distance: 57cm
 Full
Distance: 56cm
 Full
Distance: 57cm
 Full
Distance: 57cm
```

Figure 2: sensor unit test getting data 0,6m

1 meter:

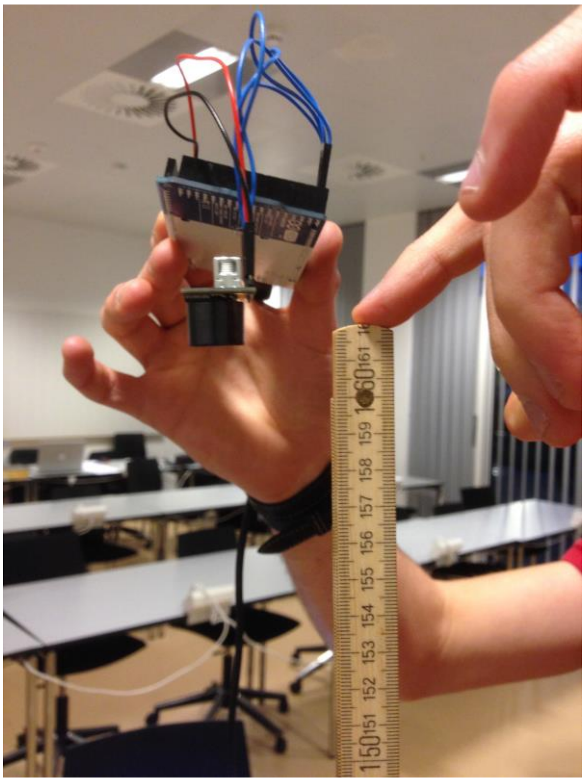
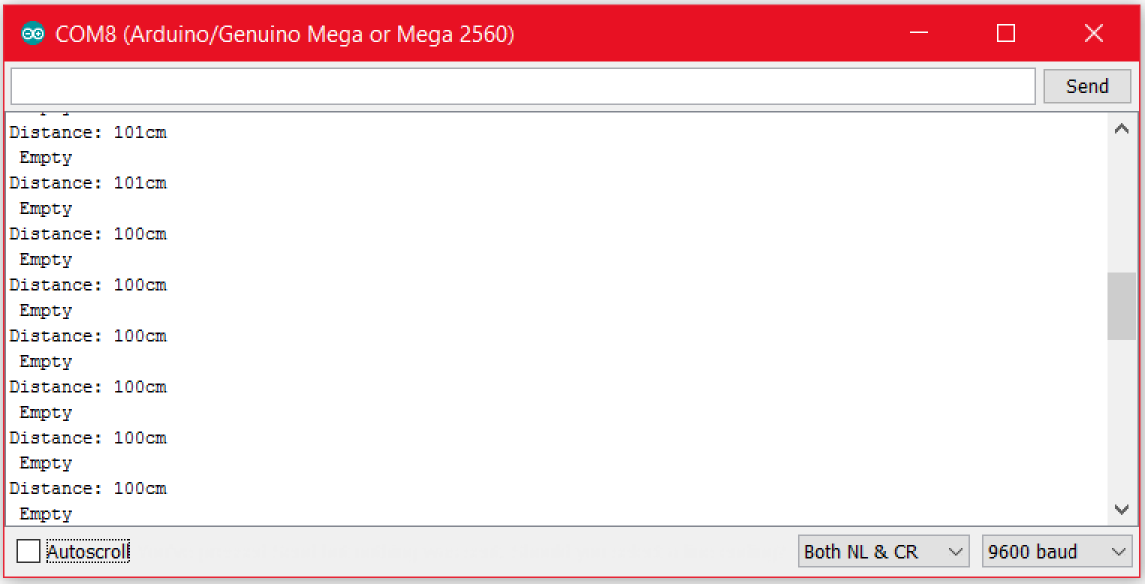


Figure 3: 1m measurement sensor unit test



```
Distance: 101cm
 Empty
Distance: 101cm
 Empty
Distance: 100cm
 Empty
Distance: 100cm
 Empty
Distance: 100cm
 Empty
Distance: 100cm
 Empty
Distance: 100cm
 Empty
Distance: 100cm
 Empty
```

Figure 4: sensor unit test getting data 1m

1,5 meter:

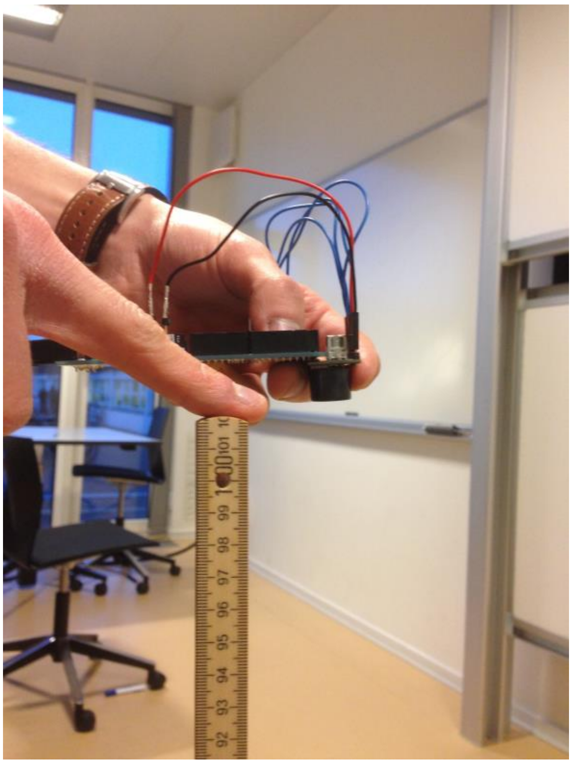
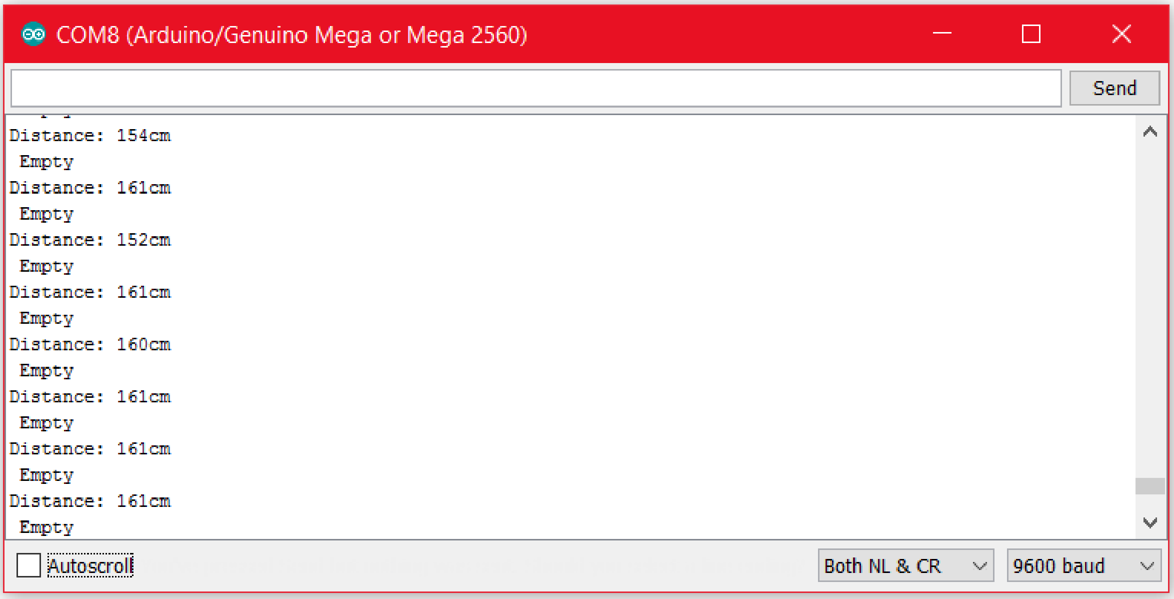


Figure 5: 1,6m measurement sensor unit test



```
Distance: 154cm
 Empty
Distance: 161cm
 Empty
Distance: 152cm
 Empty
Distance: 161cm
 Empty
Distance: 160cm
 Empty
Distance: 161cm
 Empty
Distance: 161cm
 Empty
Distance: 161cm
 Empty
```

Figure 6: sensor unit test getting data 1,6m

After that we proceeded to test in the real garbage bin. Then we take a random garbage bin and proceed to test it, first with an empty garbage bin and then we put an obstacle to simulated garbage content.

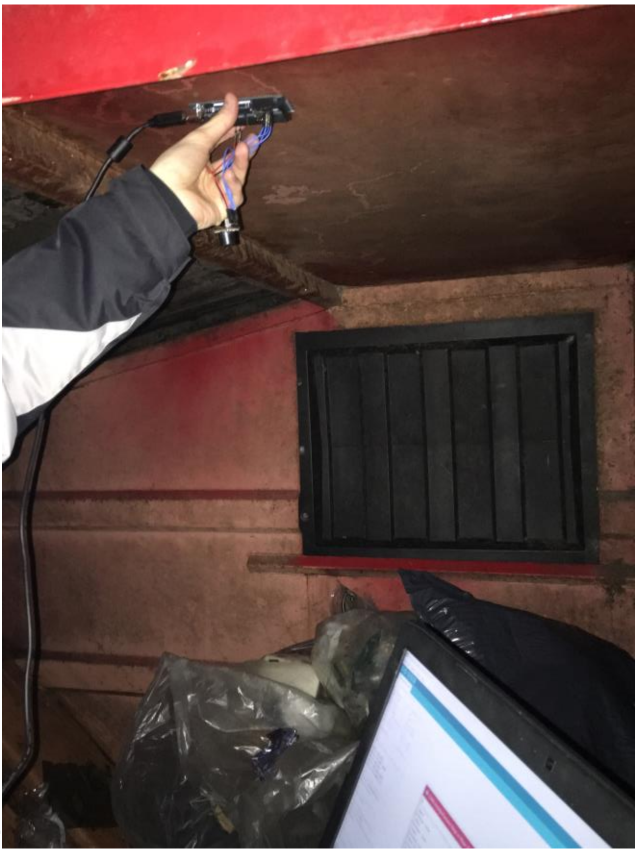
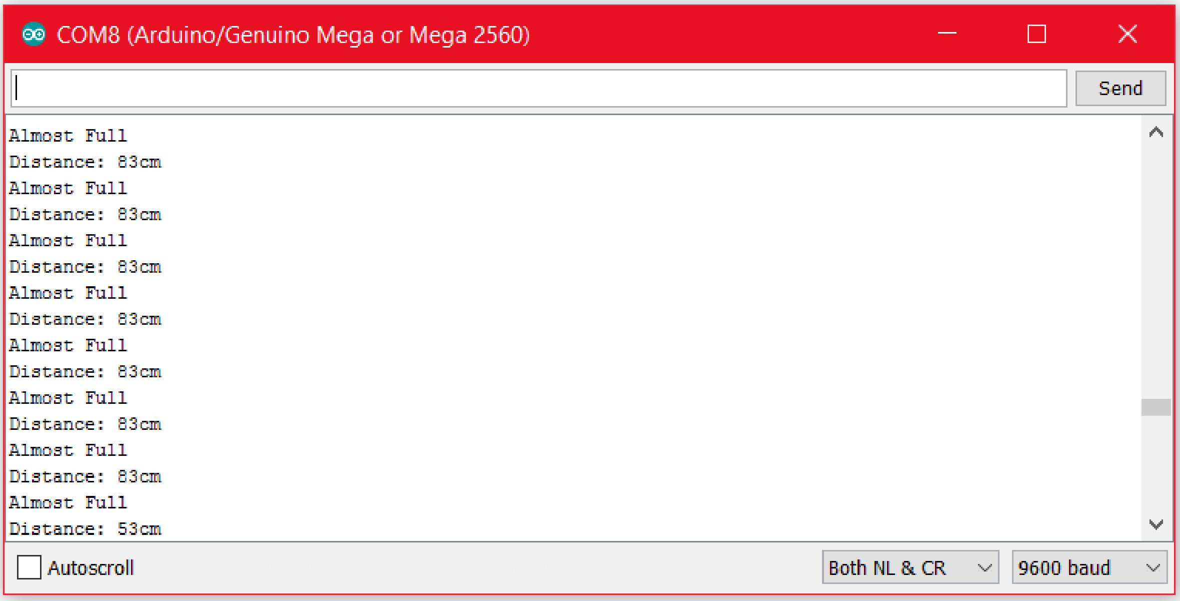


Figure 7: sensor unit test measurement in real garbage bin

We have measured the approximate distance and we could see that it was around 80cm. The sensor response it was like that:



```
Almost Full
Distance: 83cm
Almost Full
Distance: 83cm
Almost Full
Distance: 83cm
Almost Full
Distance: 83cm
Almost Full
Distance: 83cm
Almost Full
Distance: 83cm
Almost Full
Distance: 83cm
Almost Full
Distance: 53cm
```

Figure 8: sensor unit test getting data from real garbage bin

Now the garbage bin system without 3G shield it is completely working well.

There is no real acceptance test for the sensor, but some of the other acceptance tests are relying on the sensor to work.

5.1.2 Pre-requisites

- Sensor has been connected to Arduino
- Arduino has been programmed properly

5.1.3 Test procedure

STEP	PROCEDURE	EXPECTED RESULT	STATUS
1	Set up the sensor	Set up is done	OK
2	Get read from sensor	Data read successful	OK
3	Show sensor data	Sensor data is shown in serial console	OK

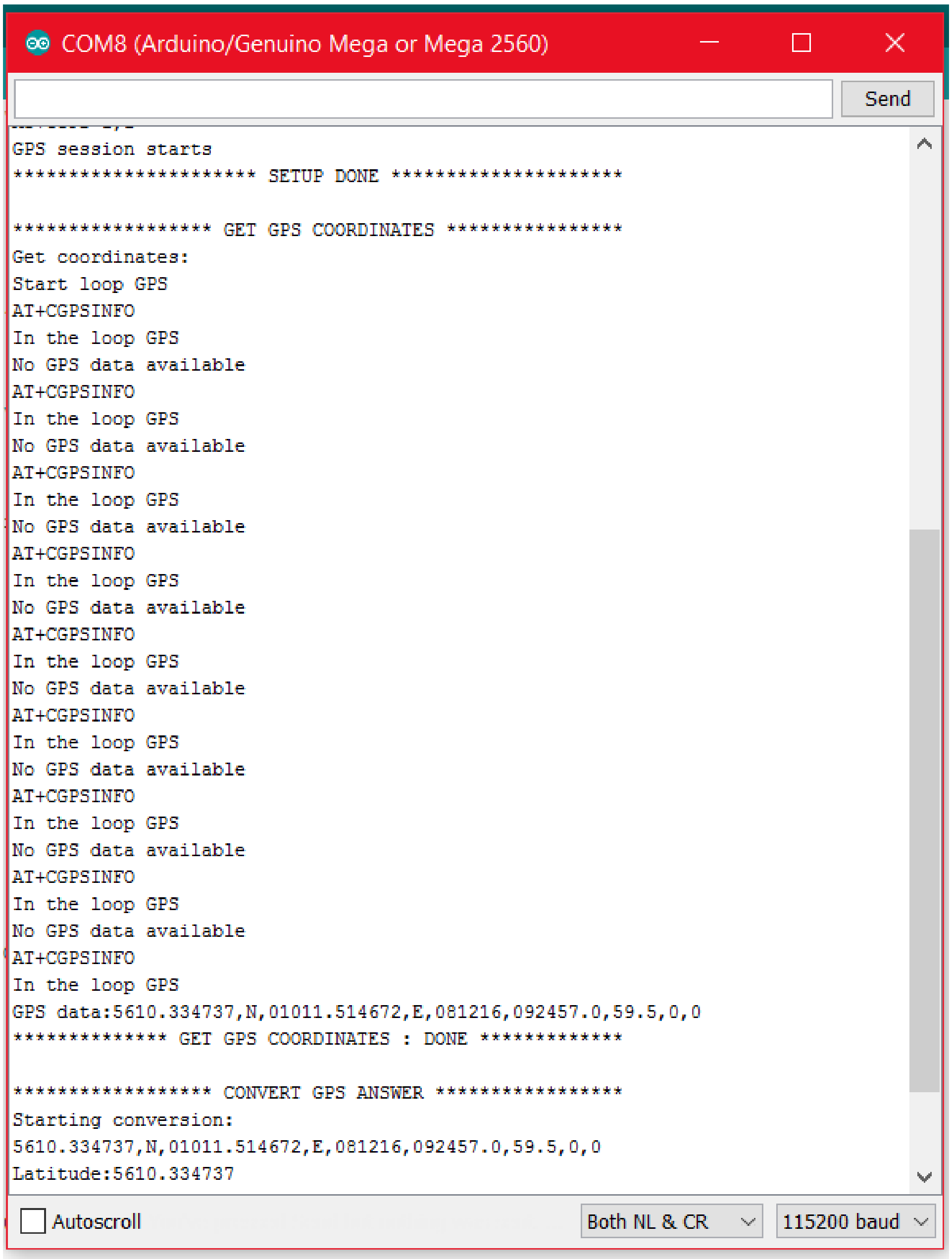
5.2 3G Shield

5.2.1 Description

This test is used to see if the 3G shield is functioning properly and can be used in our project. There are two different tests for the 3G shield, in one hand for get the location and in the other hand to send the data to the Xively personal.

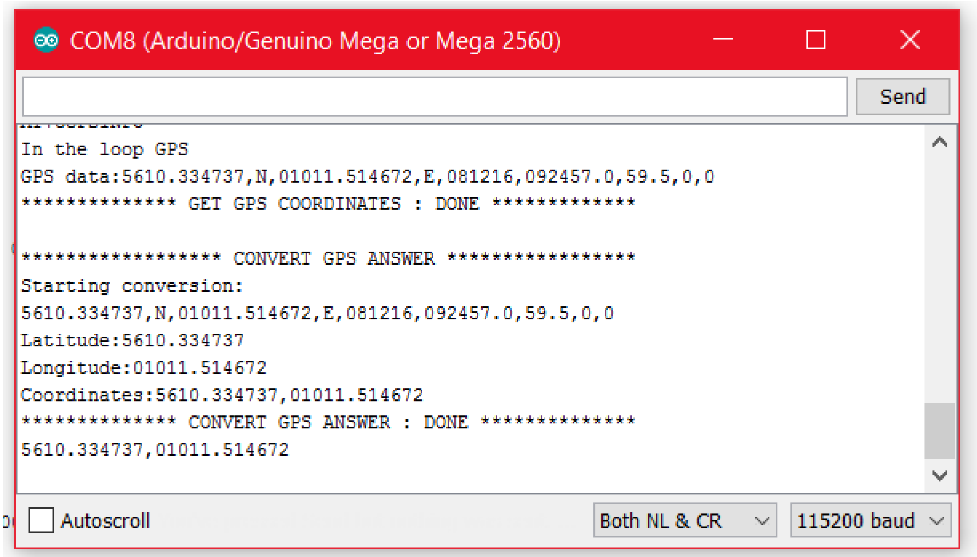
First we test the shield to get location of the supposed garbage bin. After gathering the location we have to transform the data in a more simple string because we don’t need date, altitude and time. After convert the data the Arduino microcontroller have the latitude and longitude to send it to the Xively personal cloud, but we will explain that after.

The Arduino steps while it get the location and convert the data:



```
GPS session starts
********************** SETUP DONE *********************

****************** GET GPS COORDINATES ****************
Get coordinates:
Start loop GPS
AT+CGPSINFO
In the loop GPS
No GPS data available
AT+CGPSINFO
In the loop GPS
No GPS data available
AT+CGPSINFO
In the loop GPS
No GPS data available
AT+CGPSINFO
In the loop GPS
No GPS data available
AT+CGPSINFO
In the loop GPS
No GPS data available
AT+CGPSINFO
In the loop GPS
No GPS data available
AT+CGPSINFO
In the loop GPS
No GPS data available
AT+CGPSINFO
In the loop GPS
No GPS data available
AT+CGPSINFO
In the loop GPS
GPS data:5610.334737,N,01011.514672,E,081216,092457.0,59.5,0,0
************** GET GPS COORDINATES : DONE *************

****************** CONVERT GPS ANSWER *****************
Starting conversion:
5610.334737,N,01011.514672,E,081216,092457.0,59.5,0,0
Latitude:5610.334737
```

Figure 9: 3G shield unit test getting location



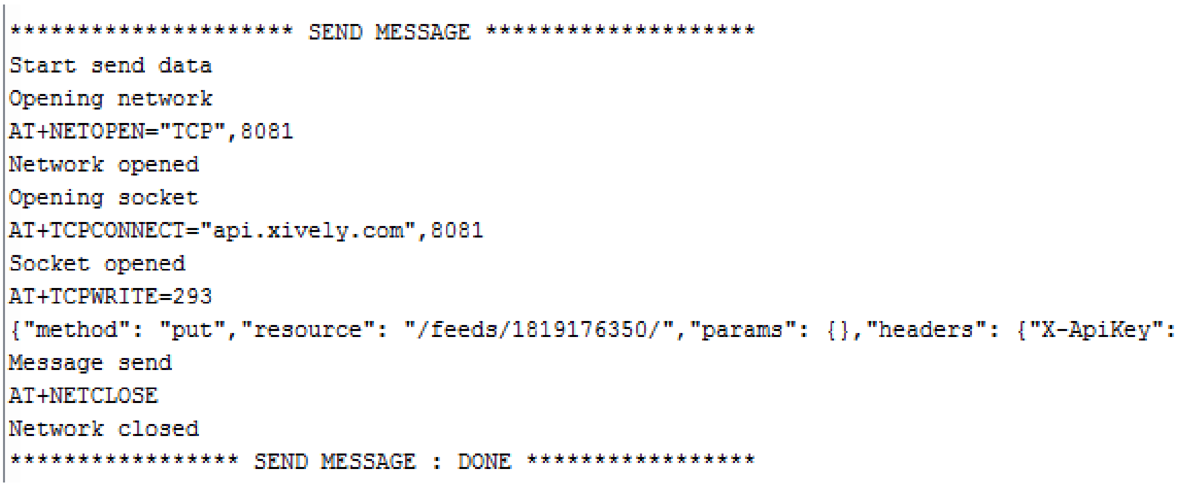
```
In the loop GPS
GPS data:5610.334737,N,01011.514672,E,081216,092457.0,59.5,0,0
************** GET GPS COORDINATES : DONE *************

***************** CONVERT GPS ANSWER *****************
Starting conversion:
5610.334737,N,01011.514672,E,081216,092457.0,59.5,0,0
Latitude:5610.334737
Longitude:01011.514672
Coordinates:5610.334737,01011.514672
************* CONVERT GPS ANSWER : DONE **************
5610.334737,01011.514672
```

Figure 10: 3G shield unit test convert data

In the second step is test the connection between Arduino board (with the 3G shield) to Xively personal.

We fake two strings just for testing the connection, one for the distance and other one for the location. Distance fake is 45cm and the longitude and latitude are 5610.322888 for latitude and 01011.539104 for longitude.

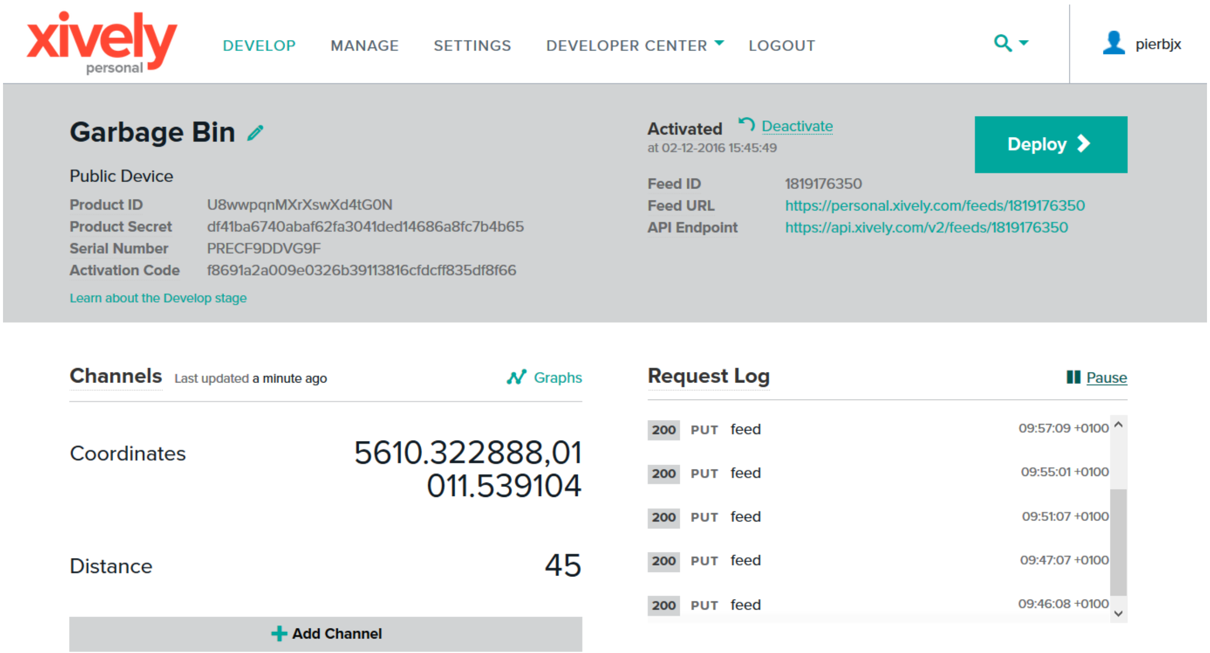
First the Arduino board do the set up of the ports, after that it tries to send the two fake data to the Xively.



```
********************* SEND MESSAGE *******************
Start send data
Opening network
AT+NETOPEN="TCP",8081
Network opened
Opening socket
AT+TCPCONNECT="api.xively.com",8081
Socket opened
AT+TCPWRITE=293
{"method": "put","resource": "/feeds/1819176350/","params": {},"headers": {"X-ApiKey":
Message send
AT+NETCLOSE
Network closed
***************** SEND MESSAGE : DONE *****************
```

Figure 11: 3G shield unit test getting data

As we can see the data we faked it is the same than is stored in Xively personal database, so the connection between Arduino board and Xively personal cloud is working correctly.



Garbage Bin

Public Device

Product ID U8wwpqnMXrXswXd4tG0N
Product Secret df41ba6740abaf62fa3041ded14686a8fc7b4b65
Serial Number PRECF9DDVG9F
Activation Code f8691a2a009e0326b39113816cfdcff835df8f66

Activated
at 02-12-2016 15:45:49

Feed ID 1819176350
Feed URL https://personal.xively.com/feeds/1819176350
API Endpoint https://api.xively.com/v2/feeds/1819176350

Channels Last updated a minute ago

Coordinates 5610.322888,01 011.539104

Distance 45

Request Log

```
200 PUT feed    09:57:09 +0100
200 PUT feed    09:55:01 +0100
200 PUT feed    09:51:07 +0100
200 PUT feed    09:47:07 +0100
200 PUT feed    09:46:08 +0100
```

Figure 12: 3G shield unit test Xively personal database

Now we have all the results to pass to next step that it is to do the integration test.

5.2.2 Pre-requisites

- The 3G shield has been connected to Arduino
- Arduino has been programmed to properly

5.2.3 Test procedure

STEP	PROCEDURE	EXPECTED RESULT	STATUS
1	Set up the 3G shield	Set up is done	OK
2	3G gets the location	Location is got	OK
3	Convert the data	Data is converted	OK
4	Send the data to the Xively cloud	Data is sent	OK

6. Integration tests

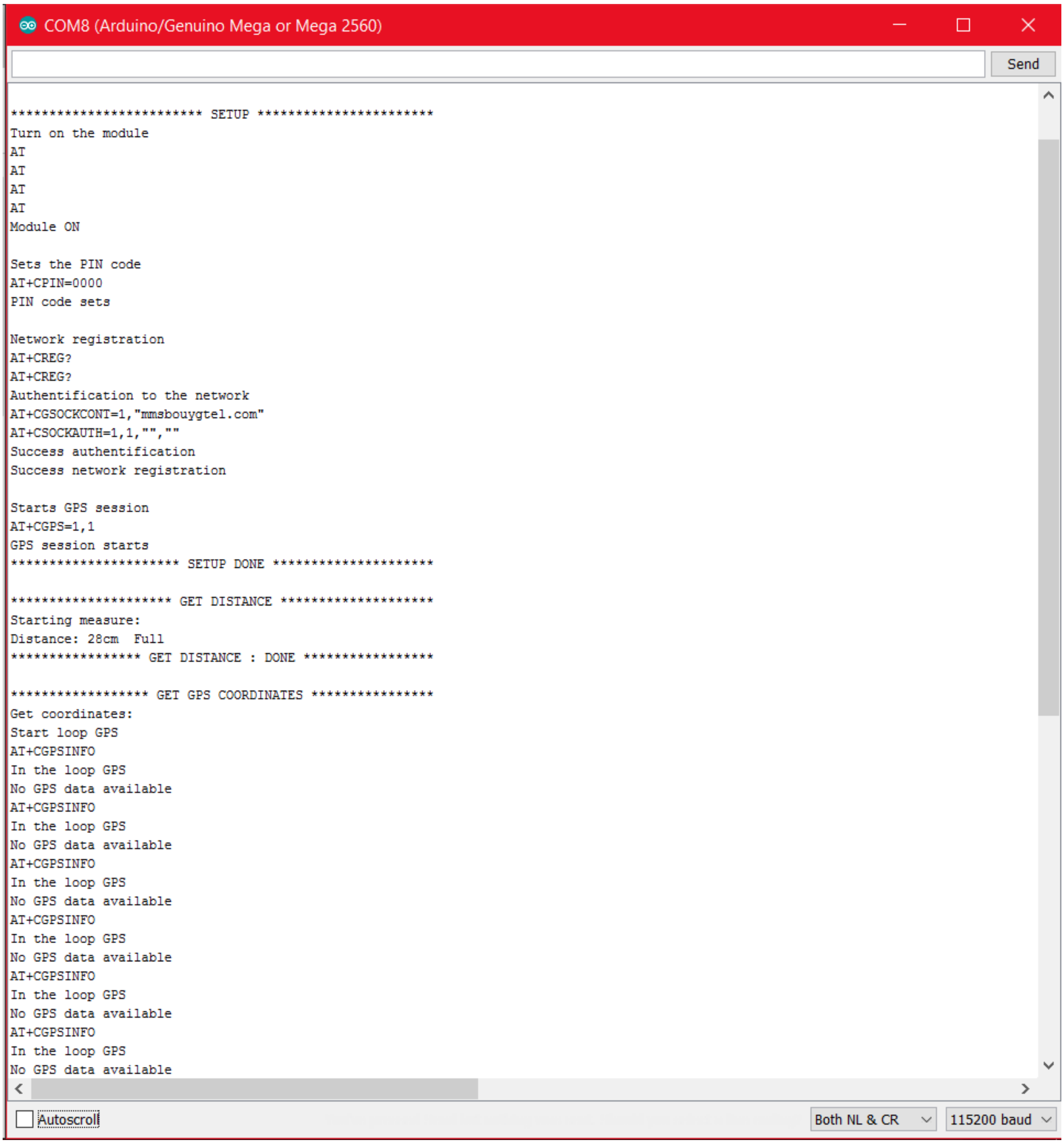
6.1 Definition

Integration testing is where each individual software modules is combined and tested as a group, it occurs after unit testing and before validation testing.

6.2 Description

This test is done to see if the real data from the ultrasonic sensor can be sent from the Arduino to the Xively personal cloud.

We wrote code to implement the final connection between entire system. So now the first step is turn on the entire system and set up all pins. After that the ultrasonic sensor is going to get the distance and the microcontroller stores it. Besides system is waiting for GPS answer but sometimes it can be long because of the weather or place we are. In the next picture, we can see all this process.

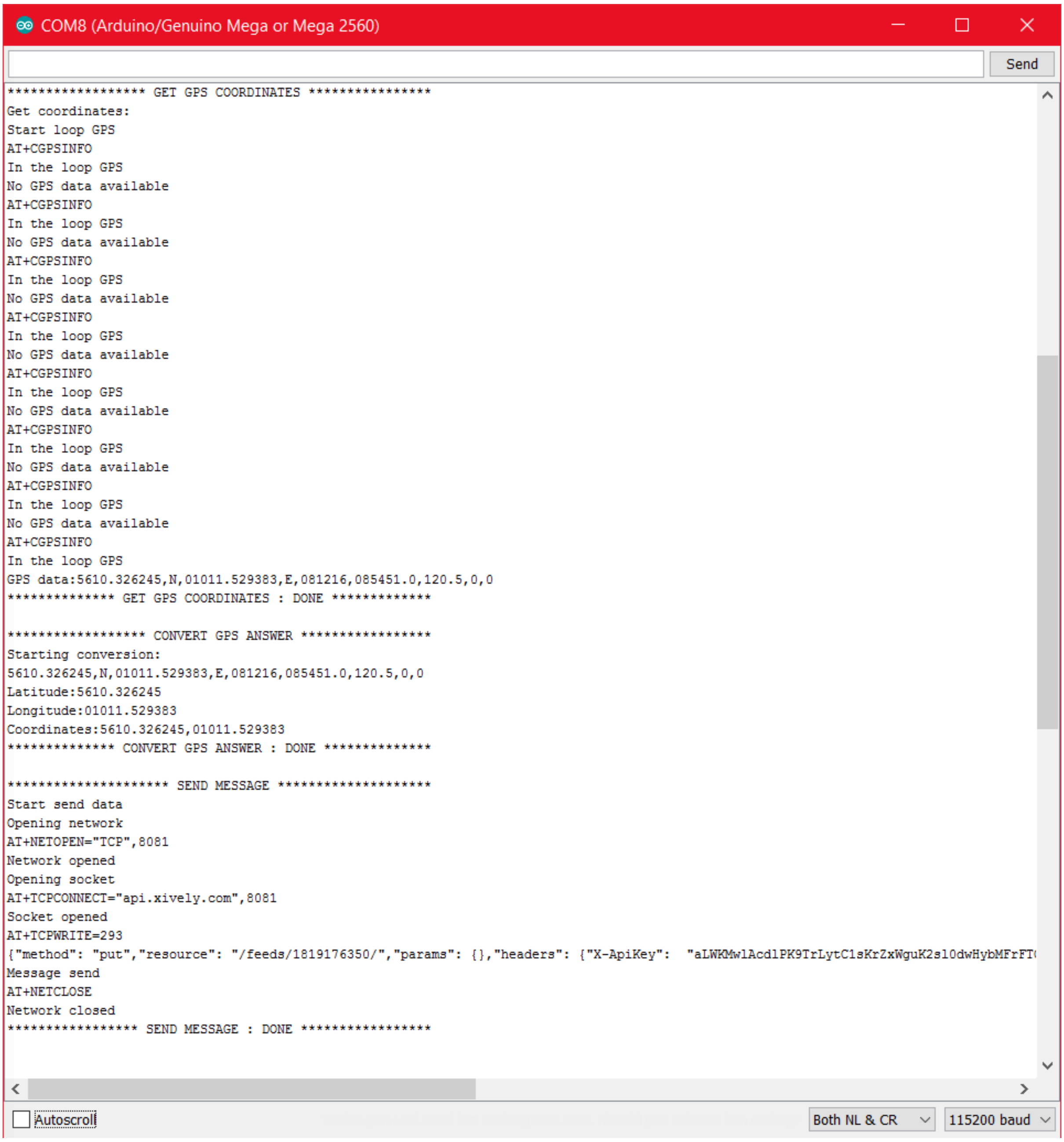


```
************************* SETUP ***********************
Turn on the module
AT
AT
AT
AT
Module ON

Sets the PIN code
AT+CPIN=0000
PIN code sets

Network registration
AT+CREG?
AT+CREG?
Authentification to the network
AT+CGSOCKCONT=1,"mmsbouygtel.com"
AT+CSOCKAUTH=1,1,"",""
Success authentification
Success network registration

Starts GPS session
AT+CGPS=1,1
GPS session starts
********************** SETUP DONE *********************

********************* GET DISTANCE ********************
Starting measure:
Distance: 28cm  Full
***************** GET DISTANCE : DONE *****************

****************** GET GPS COORDINATES ****************
Get coordinates:
Start loop GPS
AT+CGPSINFO
In the loop GPS
No GPS data available
AT+CGPSINFO
In the loop GPS
No GPS data available
AT+CGPSINFO
In the loop GPS
No GPS data available
AT+CGPSINFO
In the loop GPS
No GPS data available
AT+CGPSINFO
In the loop GPS
No GPS data available
AT+CGPSINFO
In the loop GPS
No GPS data available
```

Figure 13: First step of integration test

After waiting enough finally the microcontroller get the coordinate location and precede it to convert ass we already see it in the unit test part.

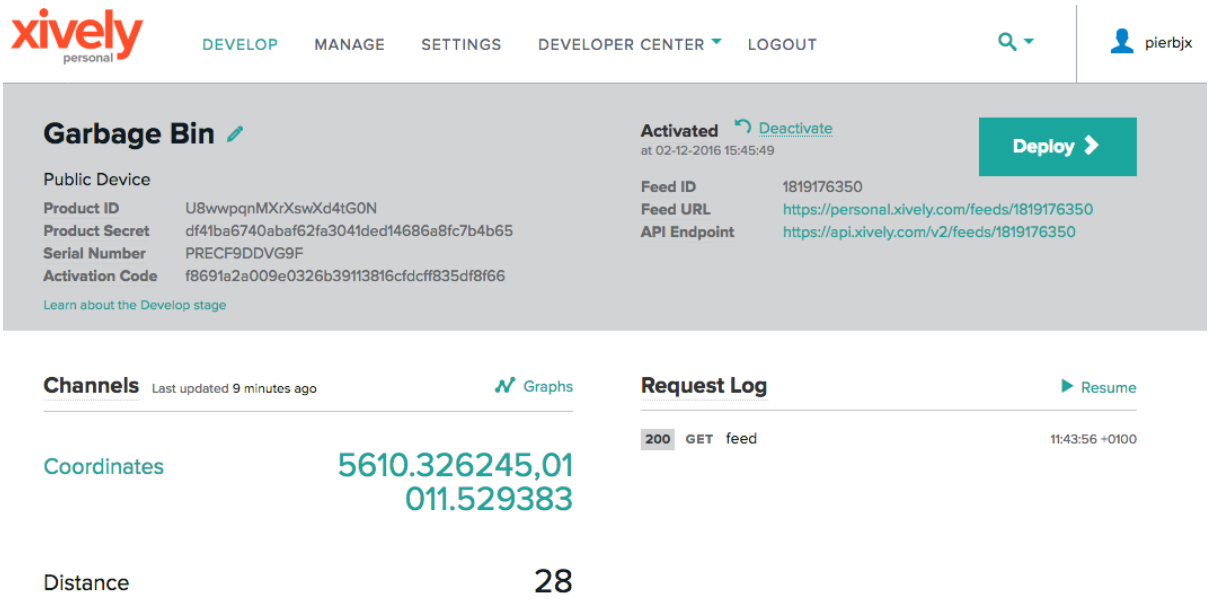
Once microcontroller has all the data it proceed to send it to the Xively cloud. Thenceforth the code has a delay of 10 minutes before it starts the loop again.



```
****************** GET GPS COORDINATES ****************
Get coordinates:
Start loop GPS
AT+CGPSINFO
In the loop GPS
No GPS data available
AT+CGPSINFO
In the loop GPS
No GPS data available
AT+CGPSINFO
In the loop GPS
No GPS data available
AT+CGPSINFO
In the loop GPS
No GPS data available
AT+CGPSINFO
In the loop GPS
No GPS data available
AT+CGPSINFO
In the loop GPS
No GPS data available
AT+CGPSINFO
In the loop GPS
No GPS data available
AT+CGPSINFO
In the loop GPS
GPS data:5610.326245,N,01011.529383,E,081216,085451.0,120.5,0,0
************** GET GPS COORDINATES : DONE **************

****************** CONVERT GPS ANSWER *****************
Starting conversion:
5610.326245,N,01011.529383,E,081216,085451.0,120.5,0,0
Latitude:5610.326245
Longitude:01011.529383
Coordinates:5610.326245,01011.529383
************** CONVERT GPS ANSWER : DONE **************

********************** SEND MESSAGE *******************
Start send data
Opening network
AT+NETOPEN="TCP",8081
Network opened
Opening socket
AT+TCPCONNECT="api.xively.com",8081
Socket opened
AT+TCPWRITE=293
{"method": "put","resource": "/feeds/1819176350/","params": {},"headers": {"X-ApiKey":  "aLWKMwlAcdlPK9TrLytClsKrZxWguK2sl0dwHybMFrFT
Message send
AT+NETCLOSE
Network closed
***************** SEND MESSAGE : DONE *****************
```

Figure 14: Second step of integration test

So, microcontroller got a distance of 28 centimetres, latitude of 5610.326245 and longitude of 01011.529383. We check on the Xively and we can see that is the data of it is stored there, so the system works perfectly.



Garbage Bin

Activated at 02-12-2016 15:45:49

Public Device

Product ID	U8wwpqnMXrXswXd4tG0N
Product Secret	df41ba6740abaf62fa3041ded14686a8fc7b4b65
Serial Number	PRECF9DDVG9F
Activation Code	f8691a2a009e0326b39113816cfdcff835df8f66

Feed ID	1819176350
Feed URL	https://personal.xively.com/feeds/1819176350
API Endpoint	https://api.xively.com/v2/feeds/1819176350

Channels Last updated 9 minutes ago

Coordinates	5610.326245,01 011.529383
Distance	28

Request Log

```
200 GET feed                                   11:43:56 +0100
```

Figure 15: Xively after the integration test

6.2 Pre-requisites

- 3G shield has been connected
- Arduino has been programmed properly.

6.3 Test procedure

STEP	PROCEDURE	EXPECTED RESULT	STATUS
1	Set up of the entire system	Set up is done	OK
2	Sensor gets de distance	Data is got	OK
3	3G shield gets the location	Location is got	OK
4	Convert the data	Data is converted	OK
5	Send data to Xively cloud	Data is received in Xively cloud	OK

7. Acceptance tests

In this part, all the acceptance tests are done through checking the status of our miscellaneous use cases tests described previously. Theses use case test consists mainly of using the application and its interface.

7.1 Use case 1: authentication test

7.1.1 Description

This test is used to see that authentication works and is secure. It is done through verifying if our authentication system is working properly, i.e. if login works as intended and if there are no escape mechanism in the login part that could be used to modify our database through the login system.

7.1.2 Pre-requisites

- Smartphone application is installed
- Database with credentials has been created

7.1.3 Test procedure

STEP	PROCEDURE	EXPECTED RESULT	STATUS
1	Insert wrong credentials (username: horse, password: race)	Failure to authenticate	OK
2	Insert special characters (!?,;)	Failure to authenticate	OK
3	Insert correct credentials (admin, 1234)	Successful authentication	OK

7.2 Use case 2: check status of garbage bins

7.2.1 Description

Test is to see connection between android phone and system.

7.2.2 Pre-requisites

- System inside garbage bin is online
- Sensor is reading data
- Data can be sent to android smartphone
- Smartphone application is installed

7.2.3 Test procedure

STEP	PROCEDURE	EXPECTED RESULT	STATUS
1	Establish communication link	Data can be sent and received between interfaces	OK
2	Store data	Data is stored in Xively	OK
3	Fetch data	Data from Xively is fetched and parsed in Android	OK
4	Display status	Object is displayed in Android	OK

7.3 Use case 3: check position of garbage bins

7.3.1 Description

Test is to see if garbage bins are shown correctly on a map inside smartphone application.

7.3.2 Pre-requisites

- Garbage bin objects are stored in android
- Application is installed
- Google maps API is working

7.3.3 Test procedure

STEP	PROCEDURE	EXPECTED RESULT	STATUS
1	Open MapsActivity	Map loads	OK
2	Get GPS position from objects	LatLng object is created	OK
3	Put markers on the map	Markers are placed in garbage bin locations	OK
4	Show location of bins on the map	Garbage bins are shown on the map correctly	OK

7.4 Use case 4: See details of garbage bin

7.4.1 Description

Find more information about selected garbage bin.

7.4.2 Pre-requisites

- Use case 3 must be working
- Smartphone application must be installed

7.4.3 Test procedure

STEP	PROCEDURE	EXPECTED RESULT	STATUS
1	Select desired garbage bin from the map	Show detailed view of selected bin	OK
2	Select desired garbage bin from the list	Show detailed view of selected bin	OK

7.5 Use case 5: Find the best garbage collection route

7.5.1 Description

Navigate from current position to desired garbage bin

7.5.2 Pre-requisites

- Smartphone application must be installed
- Google maps must be working
- You must have network connection on smartphone
- Current location must be determinable

7.5.3 Test procedure

STEP	PROCEDURE	EXPECTED RESULT	STATUS
1	Select desired garbage bin from the map	Show detailed view of selected bin	OK
2	Choose to navigate to garbage bin	Route to garbage bin is shown	OK

7.6 Use case 6: Change status of garbage bin

7.6.1 Description

Modify data inside smartphone to match status of garbage bin.

7.6.2 Pre-requisites

- Data about garbage bins must be stored inside smartphone
- Smartphone application must be installed

- Use case 4 must be working

7.6.3 Test procedure

STEP	PROCEDURE	EXPECTED RESULT	STATUS
1	Select desired garbage bin	Show detailed view of selected bin	OK
2	Choose operation to perform on garbage bin object	Data is modified correctly	OK