Installation Tutorials

Reliability of IoT Network with Customer field Cellular

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1. Table of Contents

2. NS003 Cellular connectivity Requirements:

The NS003 LTE-M/2G (BG96) and 4G LTE/3G/2G (EG21-G) sensors should have following minimum connectivity to assure proper data upload.
The Below information can be provided by the NS003 net tester see section 4

2.1. 4G LTE/ LTE-M /NB-IoT

RSRP: **> -110 dBm**

RSRQ: **>-12 dBm**

Below an RSRP of -110 dBm and RSRQ of -12dBm, one might need a cellular signal booster that boosts the cellular network.

2.2. WCDMA/3G

RSCP: **> -95 dBm**

EC/IO: **>-11 dBm**

Below an RSCP of -95 dBm and EC/IO of -11dBm, one might need a cellular signal booster that boosts the cellular network.

2.3. GSM/2G

RSSI: **> -100 dBm**

If the RSSI of the 2G signal is below -100dbM, one might need a cellular signal booster that particularly is able to boost the 2G signal.

See chapter 6 for comprehensive study on NS003 vs smart phone

3. Cellular connectivity check for cellular signal strength using NS003 as a test sensor

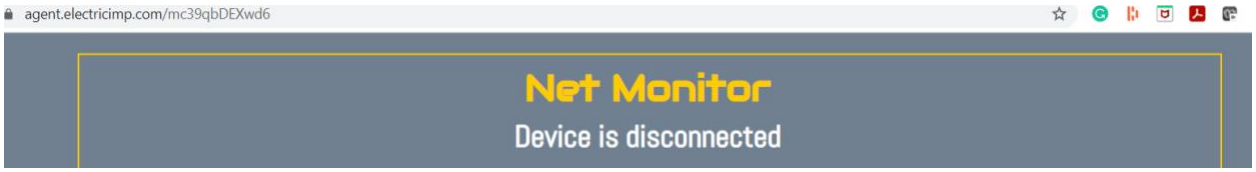
There are 2 versions of the NS003 sensors based on cellular connectivity, the LTE-M/2G (BG96) and 4G LTE/3G/2G (EG21-G) NS003 sensors. Both versions can be configured as a connectivity test sensor, by deploying a special firmware, which can continuously present the connection status on the sensor agent page. **Important**: **This firmware will deplete the battery within 102h** (since it uploads every 5 seconds) and therefore should never be deployed on a sensor that will be used in production. Ideally, a separate test sensor is used during installation only to perform the connectivity testing, or a new battery is installed after reverting to normal firmware.

3.1. Connectivity check procedure

Step 1: Provide the SensorTagId of the test sensor to NanoPrecise so the special firmware can be loaded and a link to the agent interface provided

Step 2: Go to the link that was provided for your test sensor, either on your mobile phone or on the laptop.

The status page will show as below:



Step 3: Please take the test sensor to every potential sensor location with sensor switched off. Ensure that sensor is not connected to any wifi network.

Switch on the sensor, for at max 60 sec at 1 single location depending upon cellular covrage

that time, the below status page will update to “Device is connected” and show following:

If the sensor is not able to connect to the internet, the “Device is Disconnected” will prompt.

While the device is connected, you will notice the RSSI [2G], RSRP, RSRQ[4G LTE/LTE-M], RSCP and EC/IO [WCDMA (3G)] and upload speed of the sensor is updated every 5 seconds.

See the video here for a demo on how NS003 can be used as a cellular connectivity test sensor, either LTE-M or 2G:

https://www.dropbox.com/s/g7v9321knz2c6fv/NS003_as_cellular_signal_Strength_analyzer.mp4?dl=0

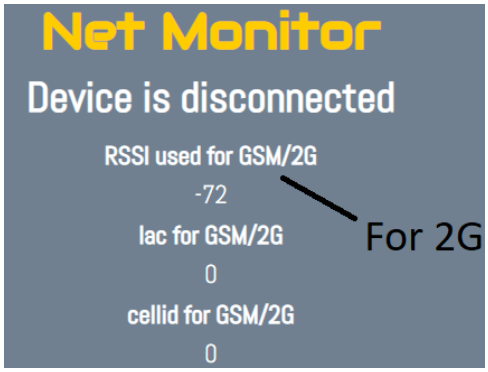
The below screen will show on your device.

Using the first 3 digits and last 3 digits in MCCMNC number you will be able to know which network the sensor is connected to using **mcc-mnc.com**.
For example in the above picture the code is 302720:
MCC is 302.
MNC is 720.
using the link above you can know the network the sensor is connected to:

302	652	ca	Canada	1	BC Tel Mobility
302	630	ca	Canada	1	Bell Aliant
302	610	ca	Canada	1	Bell Mobility
302	651	ca	Canada	1	Bell Mobility
302	670	ca	Canada	1	CityWest Mobility
302	361	ca	Canada	1	Clearnet
302	360	ca	Canada	1	Clearnet
302	380	ca	Canada	1	DMTS Mobility
302	710	ca	Canada	1	Globalstar Canada
302	640	ca	Canada	1	Latitude Wireless
302	370	ca	Canada	1	FIDO (Rogers AT&T/ Microcell)
302	320	ca	Canada	1	mobilicity
302	702	ca	Canada	1	MT&T Mobility
302	655	ca	Canada	1	MTS Mobility
302	660	ca	Canada	1	MTS Mobility
302	701	ca	Canada	1	NB Tel Mobility
302	703	ca	Canada	1	New Tel Mobility
302	760	ca	Canada	1	Public Mobile
302	657	ca	Canada	1	Quebectel Mobility
302	720	ca	Canada	1	Rogers AT&T Wireless
302	654	ca	Canada	1	Sask Tel Mobility
302	680	ca	Canada	1	Sask Tel Mobility
302	780	ca	Canada	1	Sask Tel Mobility
302	656	ca	Canada	1	Tbay Mobility
302	653	ca	Canada	1	Telus Mobility
302	220	ca	Canada	1	Telus Mobility
302	500	ca	Canada	1	Videotron
302	490	ca	Canada	1	WIND

3.2. 2G Connectivity

Repeat the test for each location you want to install a sensor and if you are in a country or area where there is no LTE-M network, you have to focus on the RSSI [2G] tab, which looks like below:



If the RSSI of 2G network is an avergage of -100 or above, that means the 2G network is good enough for continuous connection atleast most of the times, unless the cellular tower itself is completely closed or some other disturbance or obstruction comes in between in the future.

If the RSSI of 2G network is below -100, a 2G cell signal booster might be required.

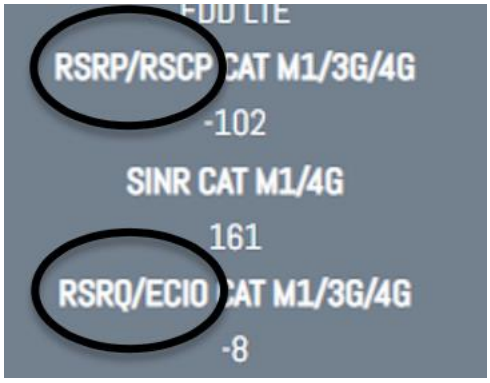
3.3. WCDMA(3G) Connectivity

For 3G Networks, the Received Signal Code Power (RSCP) and Energy to Interference Ratio (EC/IO) are used to determine the signal strength and quality. RSCP values > -95 dbM and EC/IO > -11 dbM are required to have reliable data communications.

3.4. LTE(4G) Connectivity

For 4G LTE Networks, the Reference Signal Received Power (RSRP) and Reference Signal Received Quality (RSRQ) are used to determine the signal strength and quality. When these values are both above recommended levels, there is efficient cellular connectivity.

If you are in a country, where LTE-M is widespread or using the 4G LTE/3G/2G NS003 Sensor, RSRP and RSRQ for the LTE technologies and RSCP and EC/IO for 3G are the appropriate metrics , not RSSI as shown below in the app:



If the RSRP and RSRQ of the 4G LTE or LTE-M network is above an avergage of -110dbM and -12 dbM respectively, the NS003 sensor will connect regularly in the future provided the current arrangement of line of sight is intact.

3.5. RSRP and RSRQ coorelation

From the data, it is clear that RSRP and RSRQ are approx. 90% correlated. Thus, having either good RSRP above -110dbM and RSRP above -12dbM should be sufficient, but there can be edge cases that can give some surprises. Thus, it is important to have both RSRP and RSRQ be above the threshold values mentioned here.

RSRP	RSRQ
-100	-14
-105	-17
-105	-17
-94	-12
-122	-18
-122	-18
-122	-18
-122	-18
-123	-17
-123	-17
-118	-17
-118	-17
-113	-12
-89	-8
-116	-14
-105	-13

RSRP	RSRQ
-105	-13
-110	-15
-96	-7
-102	-10
-102	-10
-88	-7
-90	-9
-117	-17
-119	-17
-116	-17
-116	-17
-116	-17
-118	-18
-124	-18
-90	-8
-98	-8

In case, the RSRP and RSRQ are below -110dbM and -12dbM respectively, a cellular signal booster, that is capable of boosting LTE is required.

3.6. Cellular booster options

Below are some good LTE-M boosters available in the market (please exercise caution while buying LTE-M cell signal booster as it can be different for different regions or countries):

1. Cel-Fi GO X from Nextivity
2. Wilson Pro IoT 5-Band Direct Connect Booster | 460119 460219 461119
3. Pro Signal 4G IoT / M2M Hardwire Cell Booster Wilson 460219/ 470219

Here are some good 3G/4G cell signal boosters available in the market on 13 Aug 2021:

1. Amazboost Cell Phone Signal Booster for Home Office - Full Band Cell Phone Booster
2. Lintratek Cell Phone Booster, 3G 4G Dual Band Band 2 Band 5 65dB Cell Phone Signal Booster for Telus Bell Rogers and Fido HD Voice & Data with Oudoor and Indoor Antennas
3. 900Mhz 3G/4G Signal Booster Repeater Amplifier Antenna for Cell Phone Signal Receiver

3.7. Industry standards for connectivity

Below are some general industry accepted signal strength and quality levels for cellular connectivity:

4G LTE/LTE-M

RSRP

RSRP	Signal strength	Description
>= -80 dBm	Excellent	Strong signal with maximum data speeds
-80 dBm to -90 dBm	Good	Strong signal with good data speeds
-90 dBm to -100 dBm	Fair to poor	Reliable data speeds may be attained, but marginal data with drop-outs is possible. When this value gets close to -100, performance will drop drastically
<= -100 dBm	No signal	Disnonnection

RSRQ

RSRQ	Signal quality	Description
>= -10 dB	Excellent	Strong signal with maximum data speeds
-10 dB to -15 dB	Good	Strong signal with good data speeds
-15 dB to -20 dB	Fair to poor	Reliable data speeds may be attained, but marginal data with drop-outs is possible. When this value gets close to -20, performance will drop drastically
<= -20 dB	No signal	Disconnection

Source: https://wiki.teltonika-networks.com/view/Mobile_Signal_Strength_Recommendations

WCDMA-3G

RSCP

RSCP	Signal strength	Description
-60 to 0	Excellent	Strong signal with maximum data speeds
-75 to -60	Good	Strong signal with good data speeds
-85 to -75	Fair	Fair but useful, fast and reliable data speeds may be attained
-95 to -85	Poor	Marginal data with drop-outs is possible
-124 to -95	Very poor	Performance will drop drastically, closer to -124 disconnects are likely

EC/IO

EC/IO	Signal quality	Description
0 to -6	Excellent	Strong signal with maximum data speeds
-7 to -10	Good	Strong signal with good data speeds
-11 to -20	Fair to poor	Reliable data speeds may be attained, but marginal data with drop-outs is possible. When this value gets close to -20, performance will drop drastically

Source: https://wiki.teltonika-networks.com/view/Mobile_Signal_Strength_Recommendations

GSM/EDGE-2G

2G and 3G signal levels

RSSI	Signal strength	Description
>= -70 dBm	Excellent	Strong signal with maximum data speeds
-70 dBm to -85 dBm	Good	Strong signal with good data speeds
-86 dBm to -100 dBm	Fair	Fair but useful, fast and reliable data speeds may be attained, but marginal data with drop-outs is possible
< -100 dBm	Poor	Performance will drop drastically
-110 dBm	No signal	Disconnection

Source: https://wiki.teltonika-networks.com/view/Mobile_Signal_Strength_Recommendations

4. Cellular connectivity status check for NS003 after the sensors are installed

A startup sequence is implemented in our standard sensor firmware which will prompt the sensor to upload additional data during the first connection time after turned on for the first time.

This will allow to verify in the dashboard the sensor connectivity statistics (RSSI/RSRQ/RSRP etc.), Connection Type (4G LTE, LTE-M, 2G etc.) and upload speed to assure a proper and stable connection is available during commissioning.

If sensor is turned off and on again this sequence will repeat.

Sensor startup sequence:

1. Switch on the sensor and within 1 to 2 mins the sensor will establish a connection to the cloud, status LED will be blinking a combination of red and Amber. And a blue LED on the top board will be Blinking during the first time connection. If the sensor finds the network and is connected to the internet the LED on the main board will blink green at least 2 times.

   Unsuccessful connection: The sensor will only show Red or Amber for approximately 1 to 2 mins and then time out. This means the sensor is not able to connect to the internet.

   Blue LED sequence: Sending data

   Short on, long off: Searching for network.

   Long on, short off: Found a network.

   Blinking fast short on and short off: Transmiting data with the network.

   The sensor will then show a green light on the main board.

   If a green light is not present. Please refer to the below table for trouble shooting

2. The sensor will send a small set of data and a dark green light will be on during the first upload.

3. If the sensor is connected and the connection is good. The sensor will start uploading 1 set every 30 mins a total of 4 times. This data will be available on the dashboard as it gets received by the cloud.

At the end of the first hour sensor will upload a small set again with statistical information on connectivity which can be viewed in loggly in case there was any data loss.

Note: the total number of sets in the first 2 hours is 5 sets [1 small set and 4 full sets]

4. After sending the above data the sensor will shift back to its normal measurement sequence and time.

5. The uploads for all the sensors can be analyzed during commissioning and after 2 hr of first turning the sensor on.

   If the upload rate (No. of samples supposed to be received/No. of samples received)> 80%, it is considered to be satisfactory connection and will provide consistent reliability unless the cell tower itself goes down or some thing really blocks the line of sight.

5. Conclusion

To have the best sensor performance all the below 3 things have to be ensured:

1- For 4G LTE and LTE-M connections, good RSRP above -110 dBm and RSRQ above -12dbM, and for 2G RSSI above -105 on the NS003 signal tester app or the API. For WCDMA (3G) connections, RSCP values > -95 dbM and EC/IO > -11 dbM are required.

4- Make sure sensor is quite in an open area and not in a enclosed chamber with metal walls all around.

5- If the signal strength and quality thresholds are not met, appropriate signal boosters are to be used that can cover appropriate area so that all the sensors that are having low connectivity issue in a specific area can be easily connected.