

**Instituto de Pesquisas Tecnológicas do Estado de São Paulo**

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**Analysis of Energy Consumption Reliability in  
IoT Network**

**São Paulo  
2021**

## APPENDIX A - SPECIFIC GRAPHS OF THE METRICS

Appendix A is composed of the graphics generated for each of the metrics used in the development of the dissertation. It has been separated into sections for better identification and organization.

### 1. Individual Standard Deviation Graphs

Each scenario was composed of four devices that generated the data for the voltage variation analyses. This section provides the individual graphs of the Standard Deviation metric for each of the sensors, in each of the experiments.

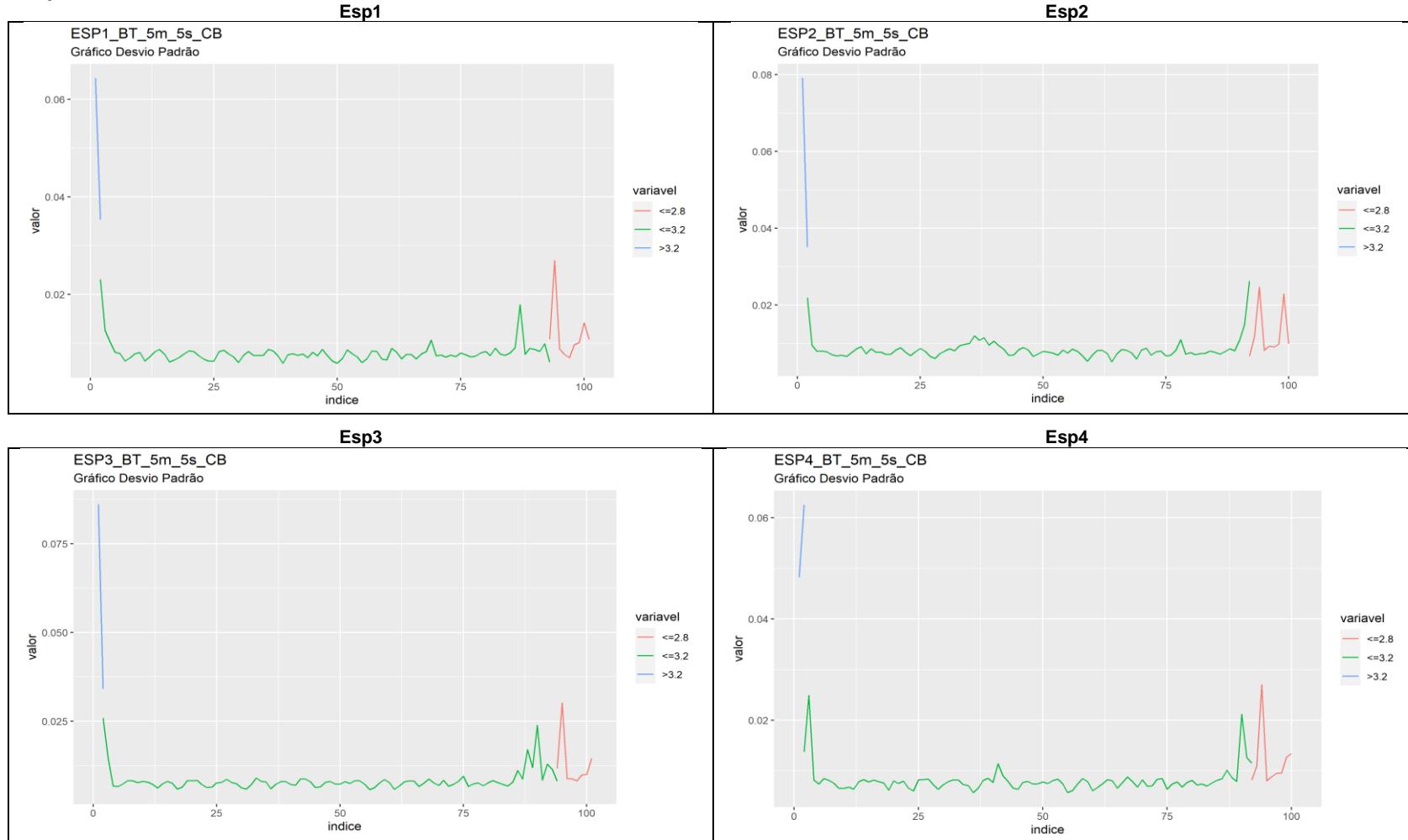
The scripts that generated the graphs are available in the repository:

[https://github.com/rogeriobcosta/Documents\\_Article.git](https://github.com/rogeriobcosta/Documents_Article.git)

Inside the Cenarios\_Bluetooth, Cenarios\_EspNow and Cenarios\_WiFi folders there are other folders with the names of the scenarios, in which are the projects in R that generated the graphics.

Graph 1 presents the result of the Standard Deviation in the BT 5m 5s CB Scenario for each of the sensors.

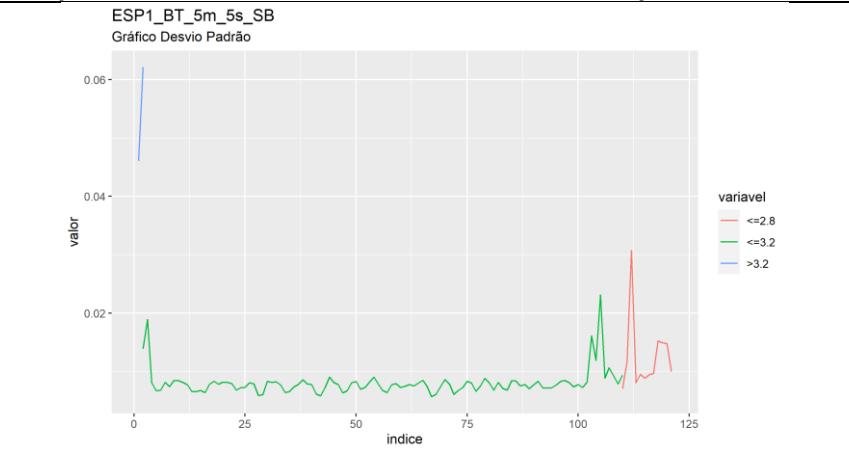
**Graph 1 - Standard Deviation Scenario BT 5m 5s CB**



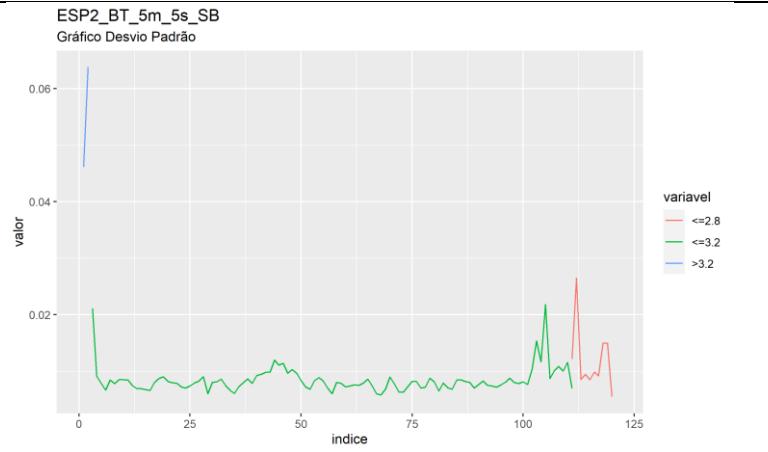
Source: Prepared by the author (2021)

Graph 2 presents the Standard Deviation result in the BT 5m 5s SB Scenario for each of the sensors.

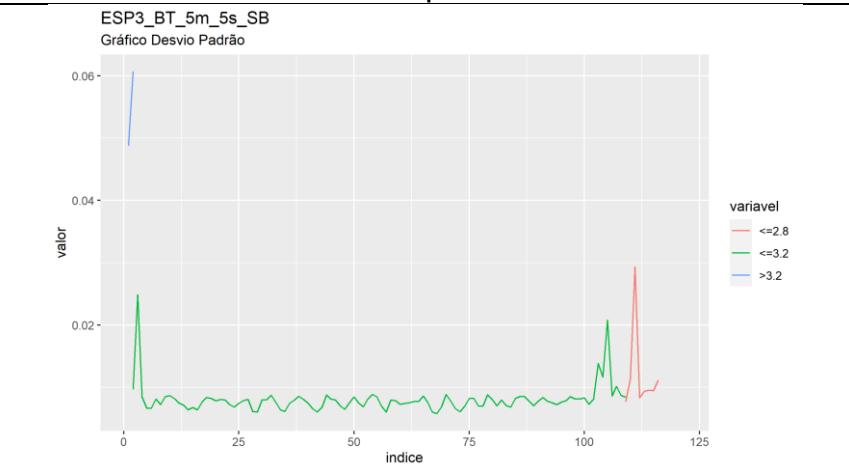
**Graph 2 - Standard Deviation Scenario BT 5m 5s Esp1**



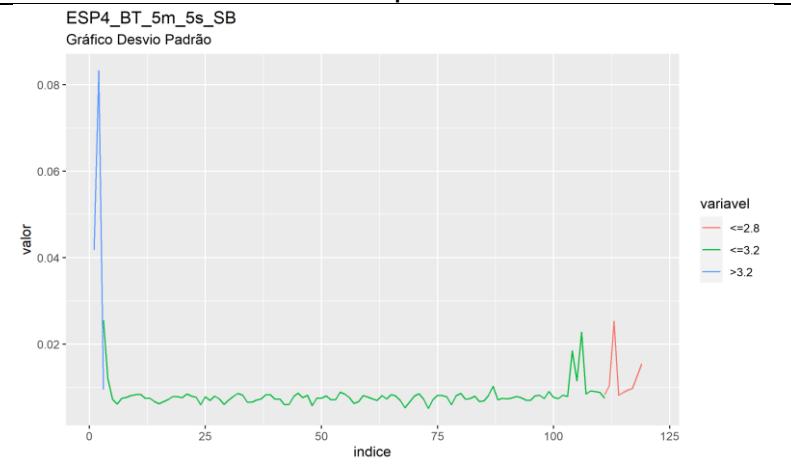
**Esp2**



**Esp3**



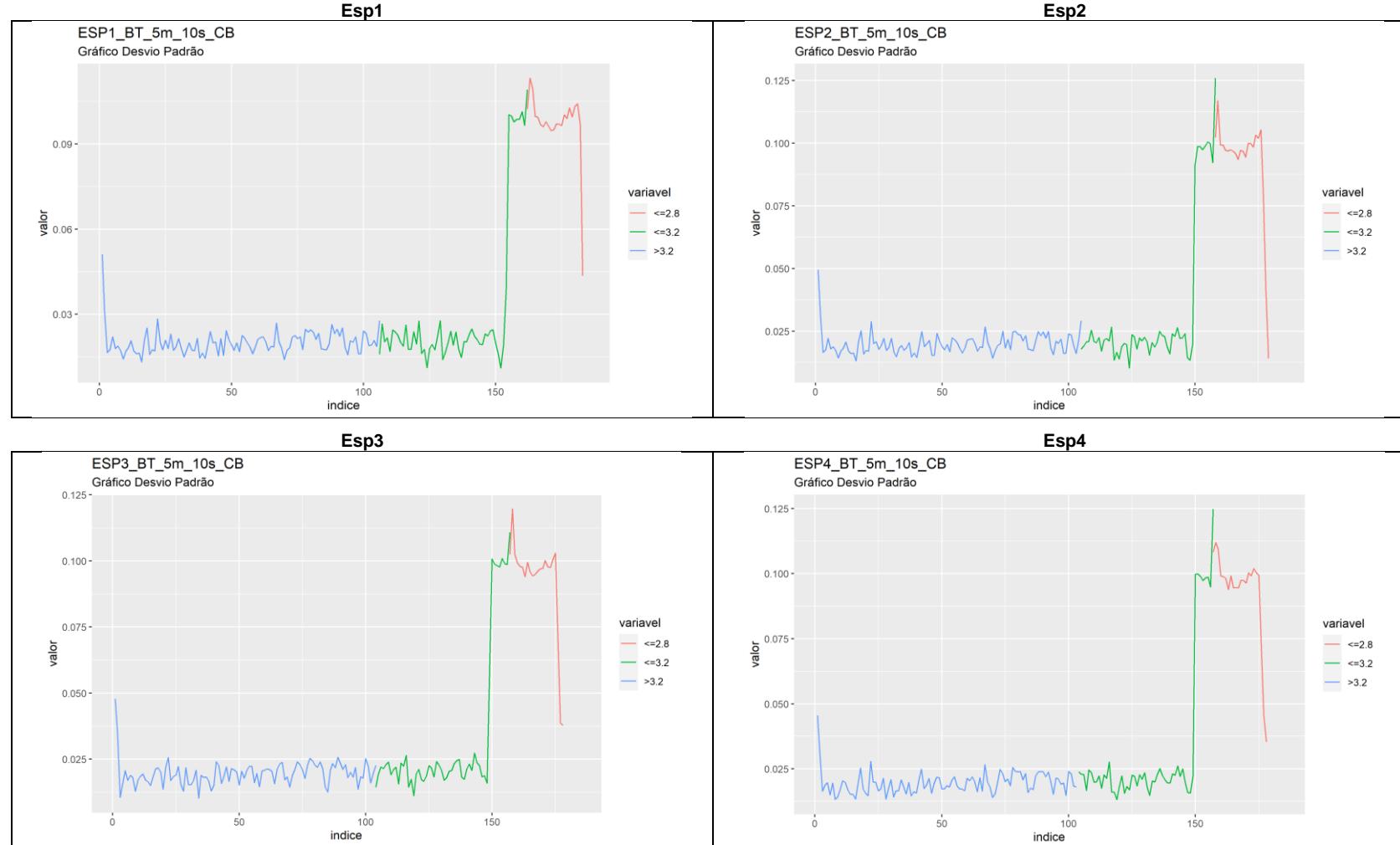
**Esp4**



Source: Prepared by the author (2021)

Graph 3 presents the Standard Deviation result in the BT 5m 10s CB Scenario for each of the sensors.

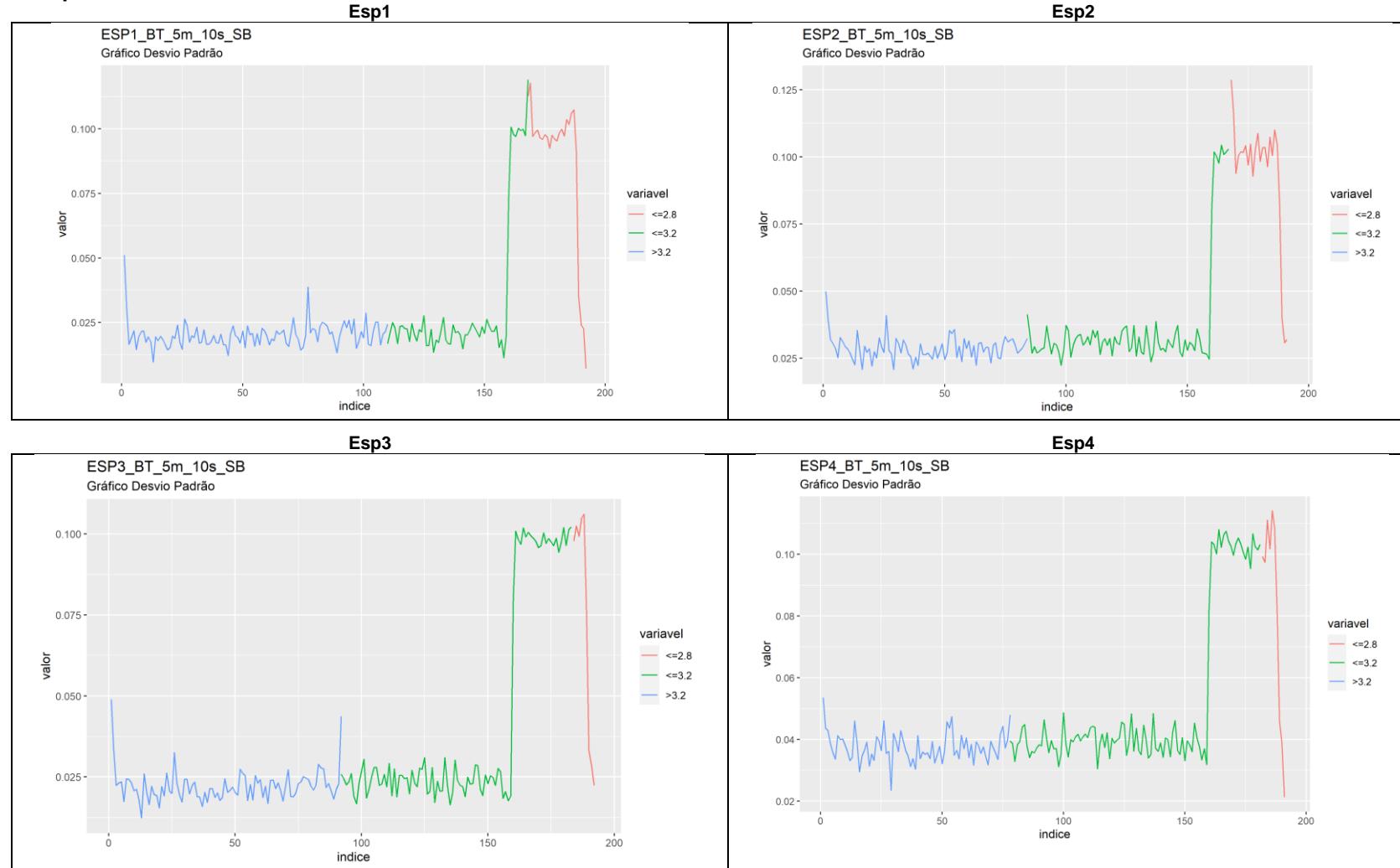
**Graph 3 - Standard Deviation Scenario BT 5m 10s CB**



Source: Prepared by the author (2021)

Graph 4 presents the result of the Standard Deviation in the BT Scenario 5m 10s SB for each of the sensors.

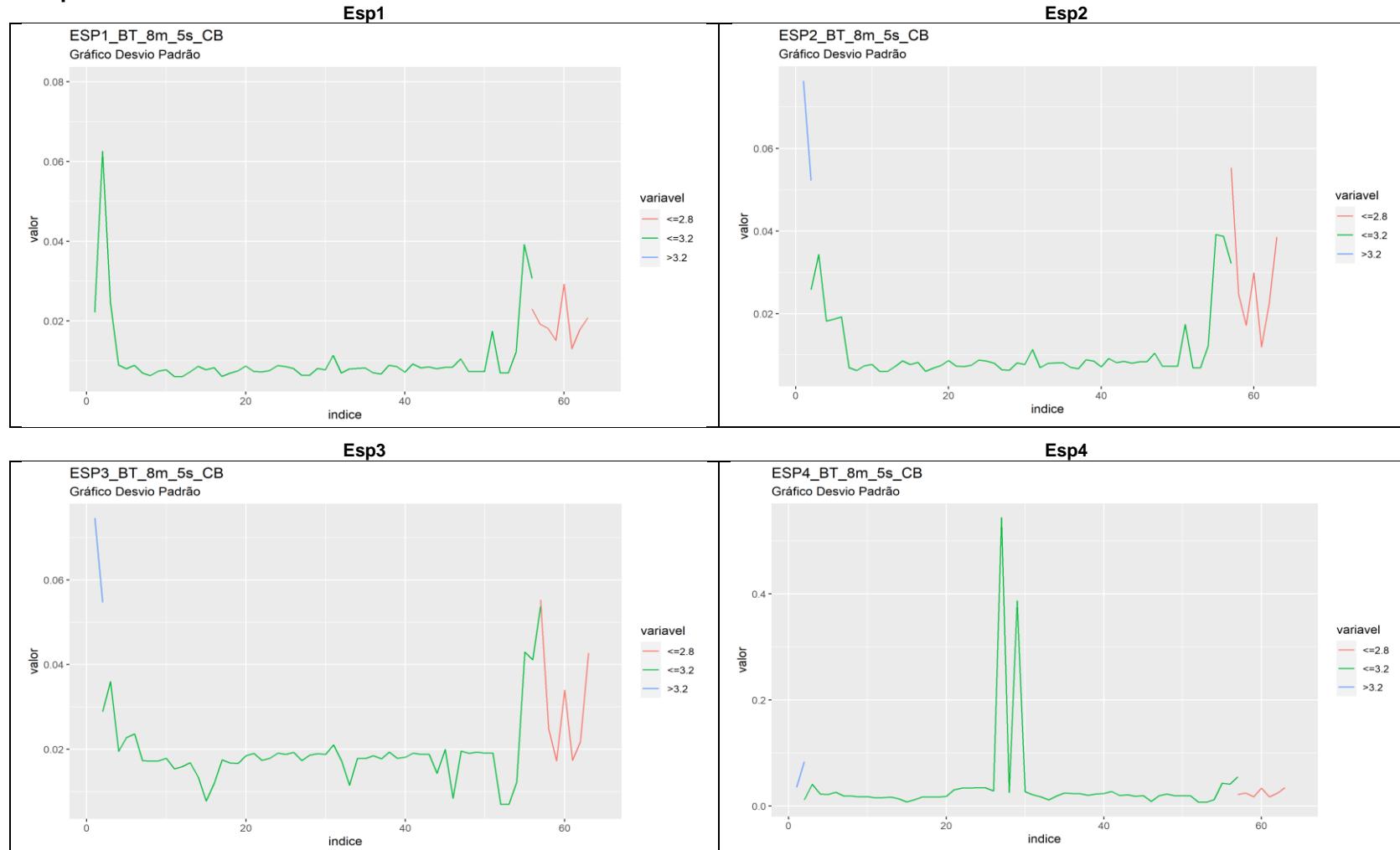
**Graph 4 - Standard Deviation Scenario BT 5m 10s SB.**



Source: Prepared by the author (2021)

Graph 5 presents the result of the Standard Deviation in the BT 8m 5s CB Scenario for each of the sensors.

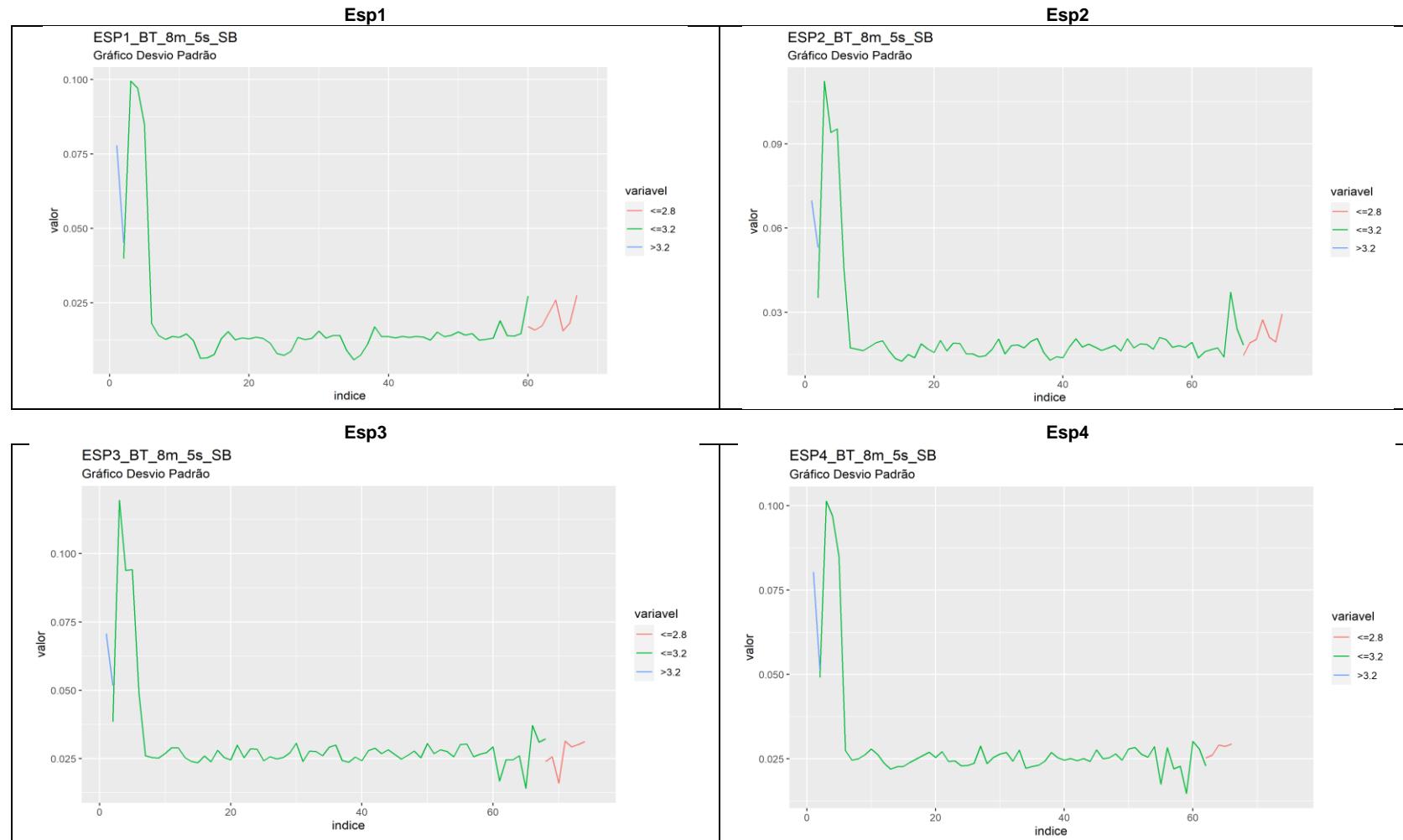
**Graph 5 - Standard Deviation Scenario BT 8m 5s CB**



Source: Prepared by the author (2021)

Graph 6 presents the Standard Deviation result in the BT 8m 5s SB Scenario for each of the sensors.

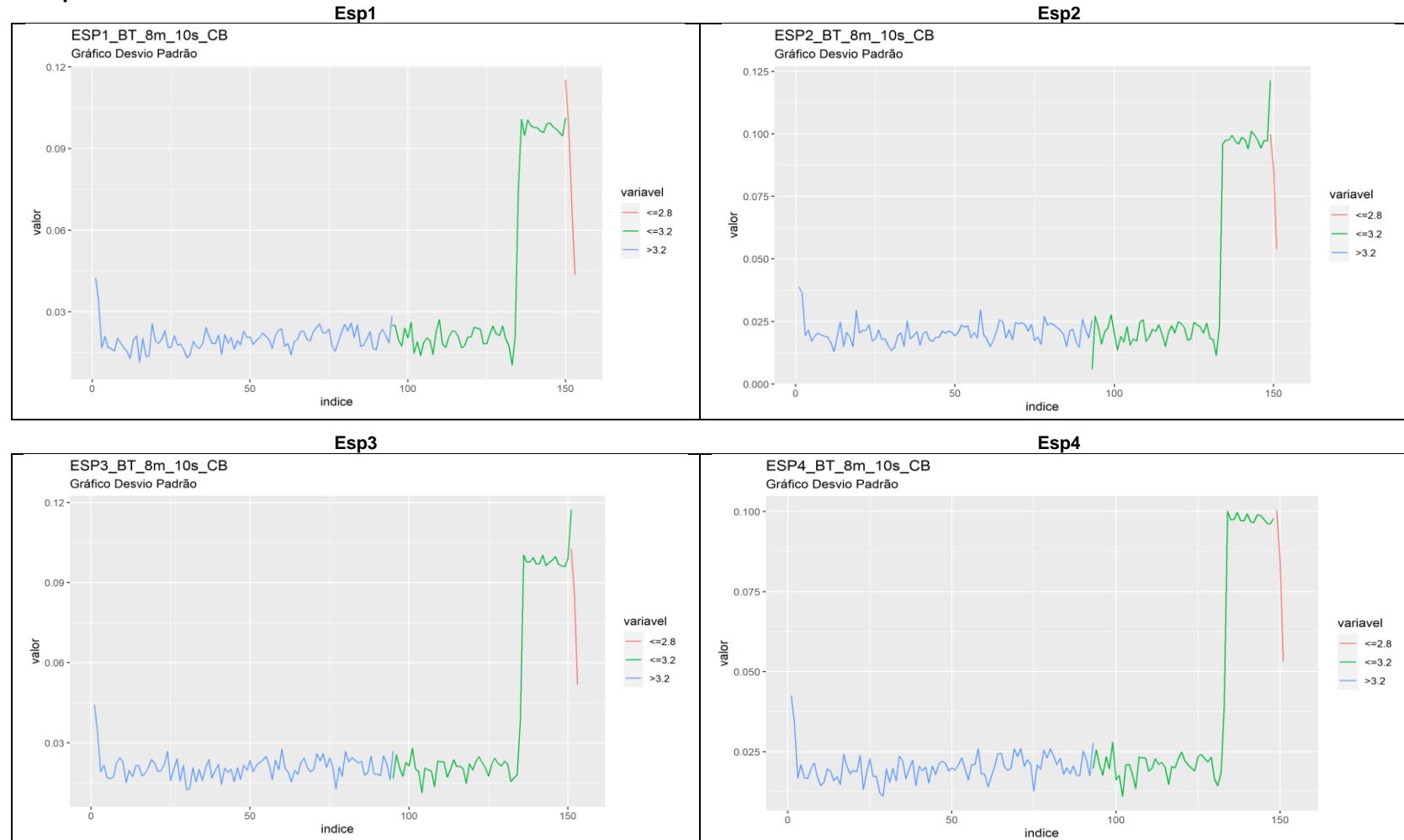
**Graph 6 - Standard Deviation Scenario BT 8m 5s SB**



Source: Prepared by the author (2021)

Graph 7 presents the Standard Deviation result in the BT 8m 10s CB Scenario for each of the sensors.

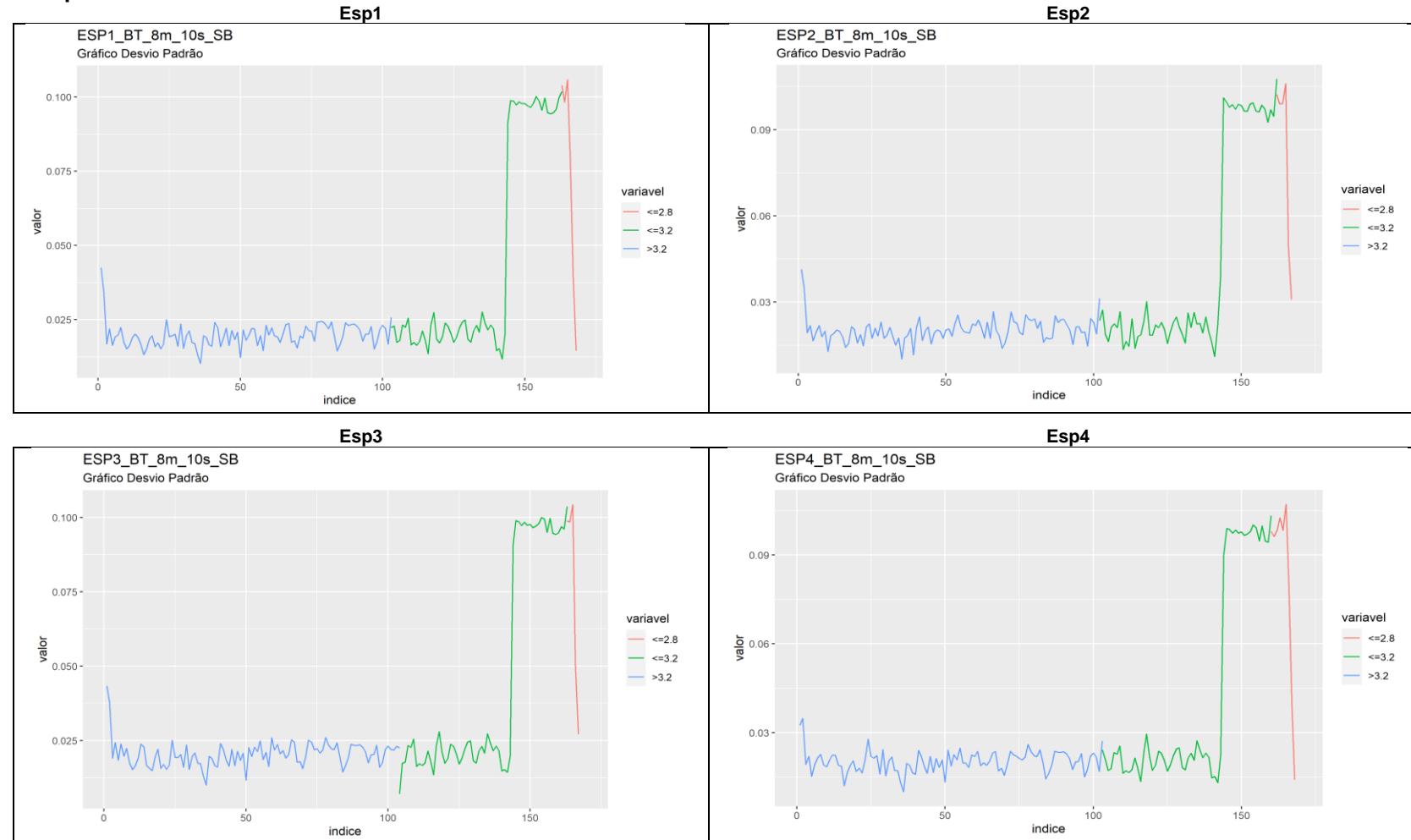
**Graph 7 - Standard Deviation Scenario BT 8m 10s CB**



Source: Prepared by the author (2021)

Graph 8 presents the Standard Deviation result in the BT 8m 10s SB Scenario for each of the sensors.

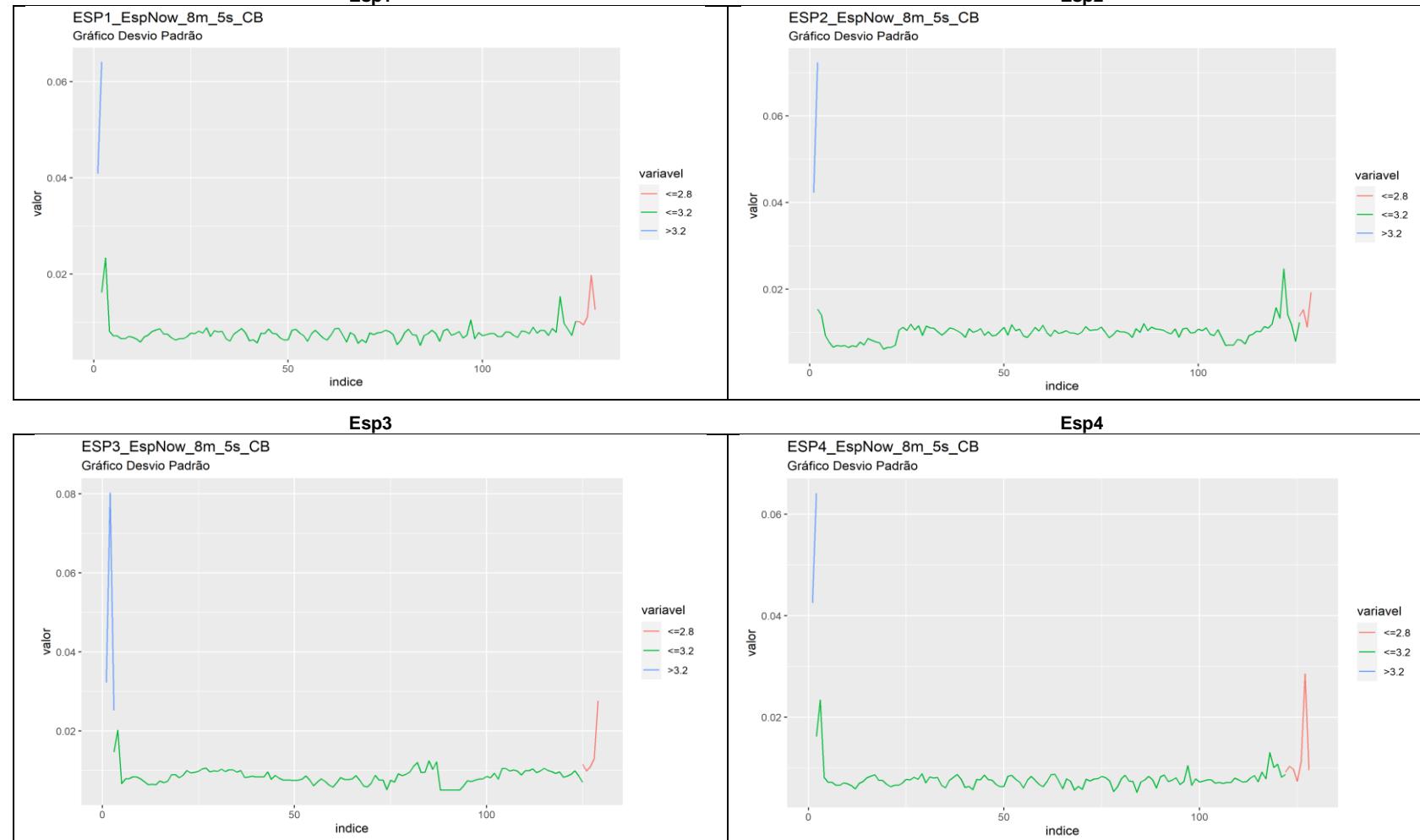
**Graph 8 - Standard Deviation Scenario BT 8m 10s SB**



Source: Prepared by the author (2021)

Graph 9 presents the Standard Deviation result in the EspNow 8m 5s CB Scenario for each of the sensors.

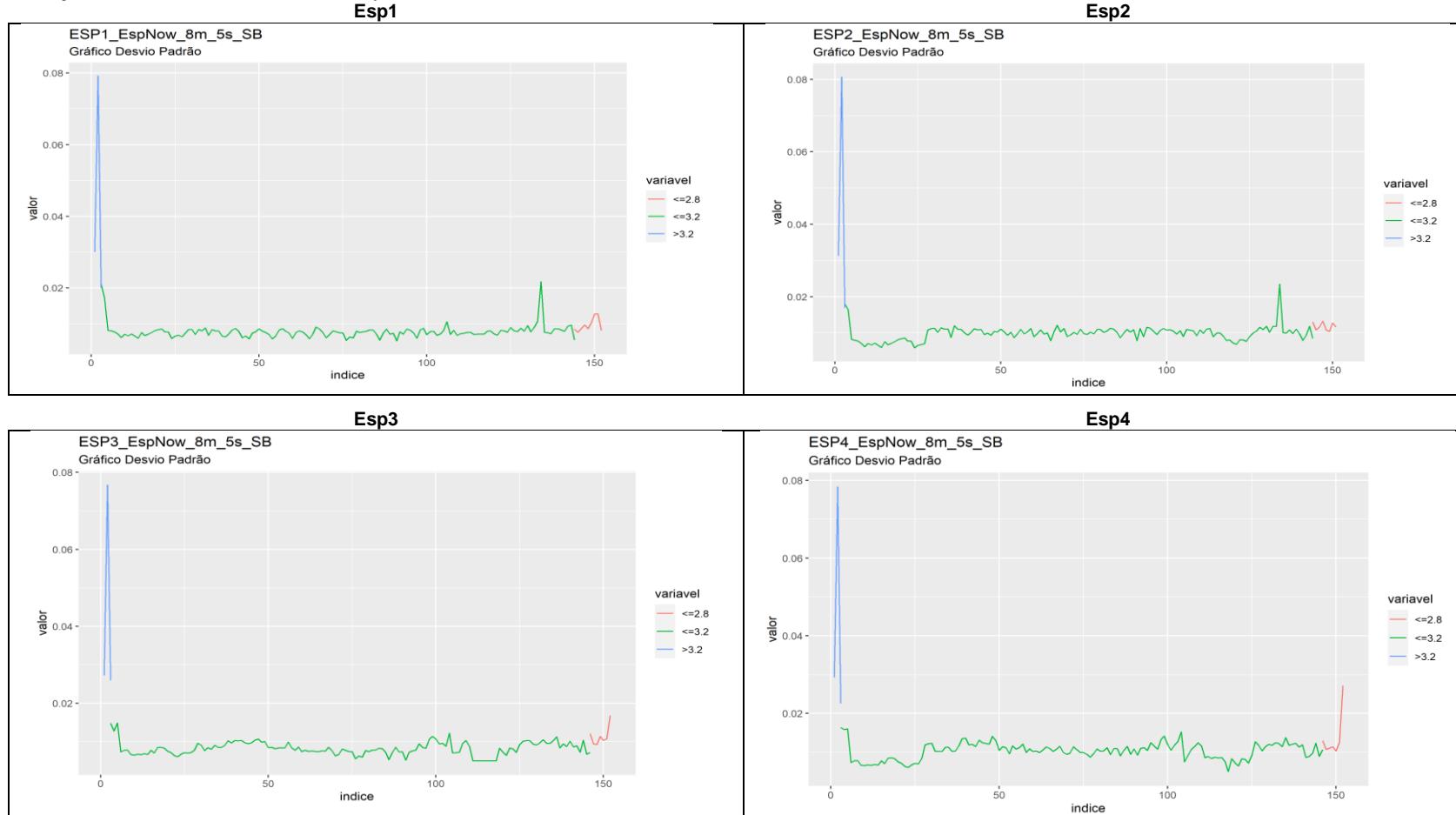
**Graph 9 - Standard Deviation EspNow Scenario 8m 5s CB**



Source: Prepared by the author (2021)

Graph 10 presents the result of the Standard Deviation in the EspNow Scenario 8m 5s SB for each of the sensors.

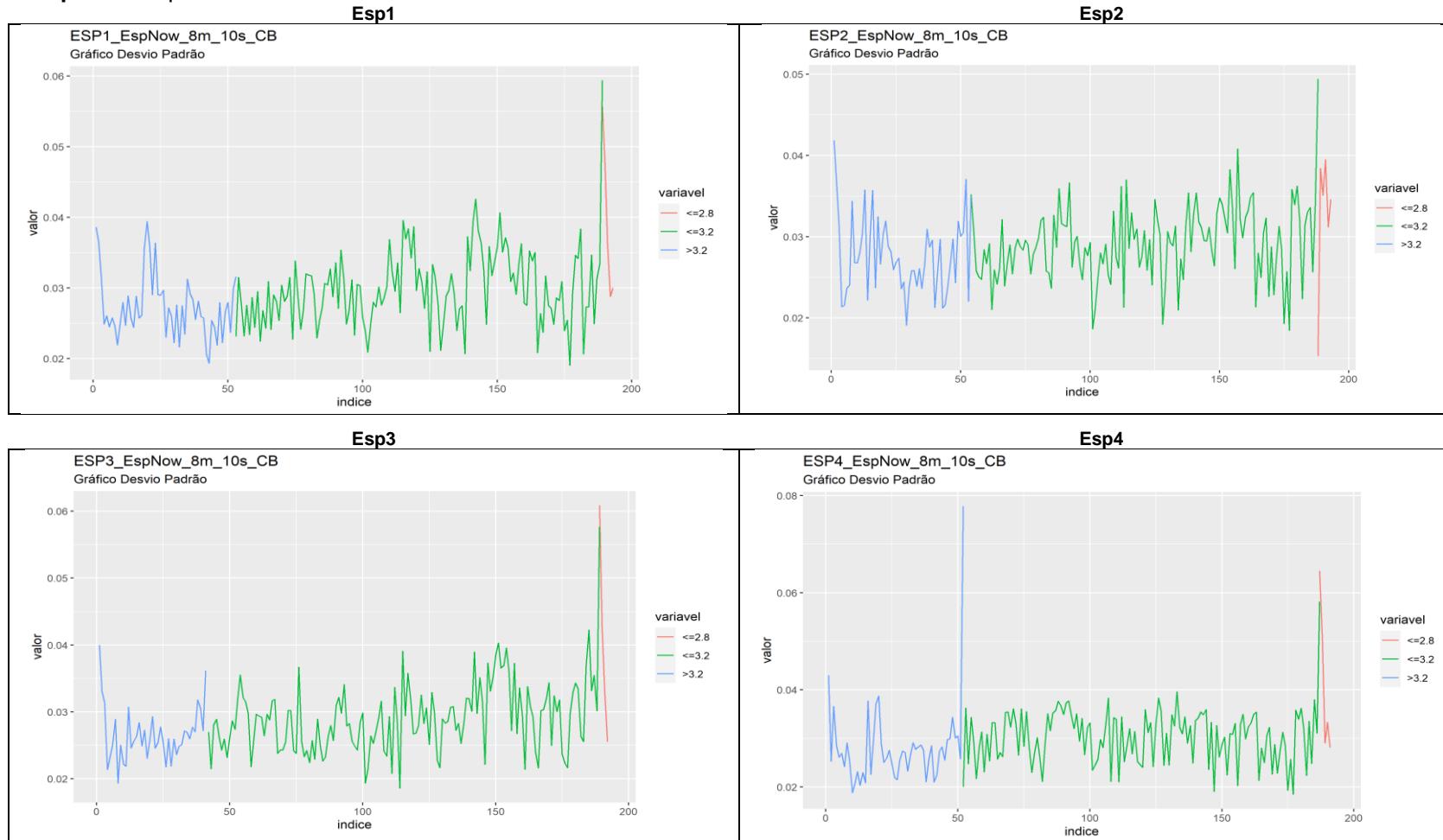
**Graph 10 - Standard Deviation EspNow Scenario 8m 5s SB1**



Source: Prepared by the author (2021)

Graph 11 presents the Standard Deviation result in the EspNow 8m 10s CB Scenario for each of the sensors.

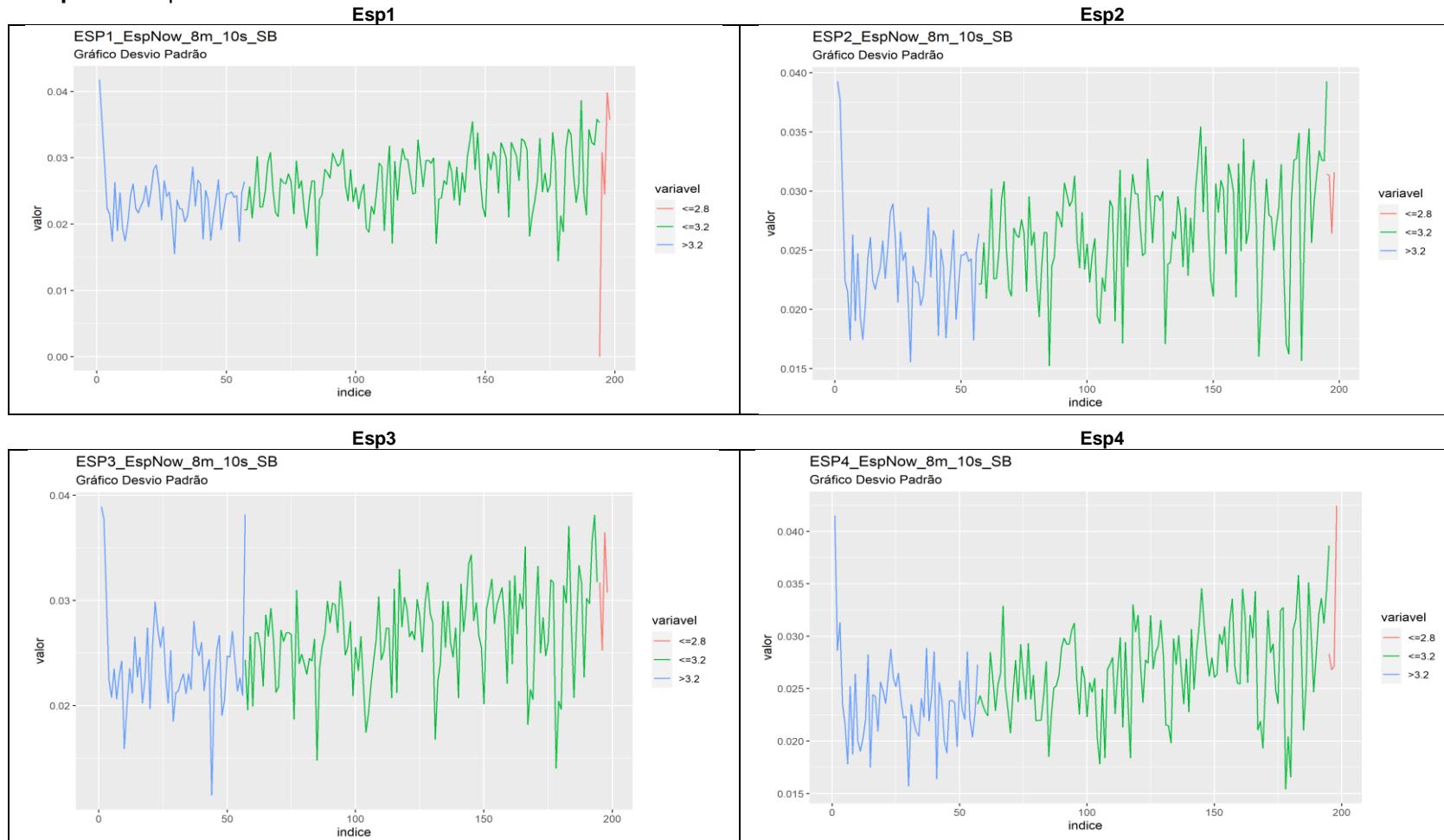
**Graph 11 - EspNow Scenario Standard Deviation 8m 10s CB**



Source: Prepared by the author (2021)

Graph 12 presents the result of the Standard Deviation in the EspNow Scenario 8m 10s SB for each of the sensors.

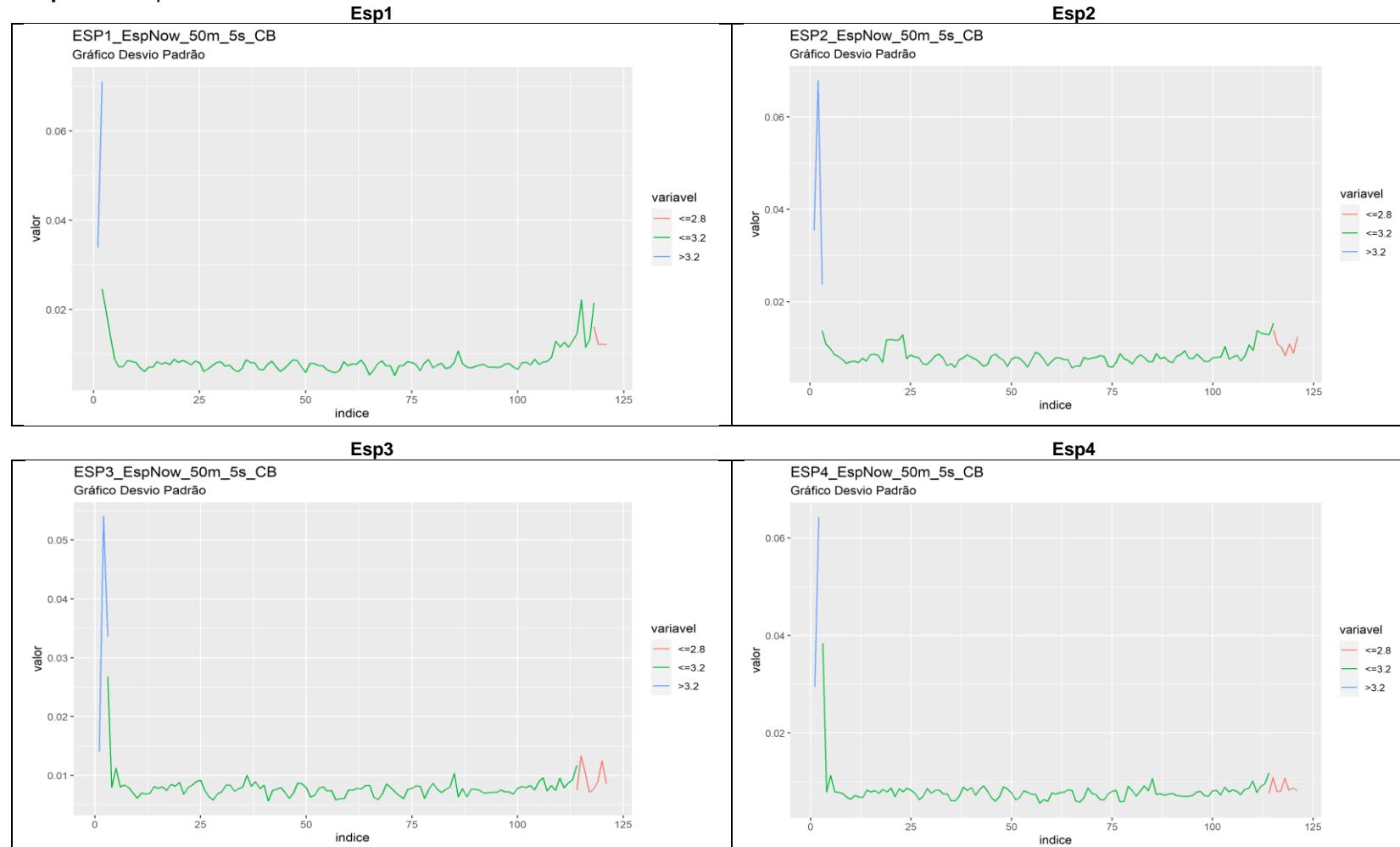
**Graph 12 - EspNow Scenario Standard Deviation 8m 10s SB**



Source: Prepared by the author (2021)

Graph 13 presents the Standard Deviation result in the EspNow 50m 5s CB Scenario for each of the sensors.

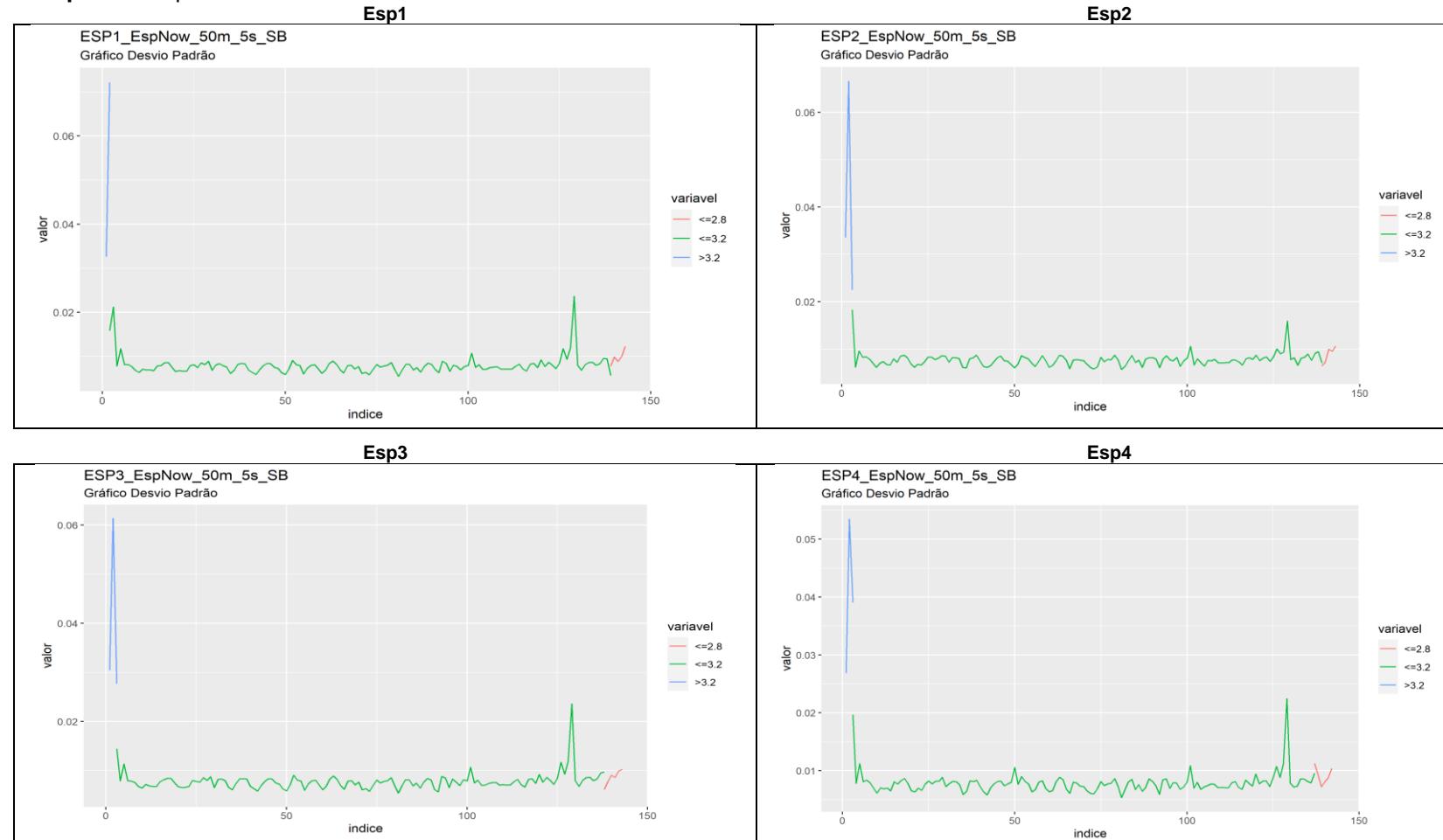
**Graph 13 - EspNow Scenario Standard Deviation 50m 5s CB**



Source: Prepared by the author (2021)

Graph 14 presents the result of the Standard Deviation in the EspNow Scenario 50m 5s SB for each of the sensors.

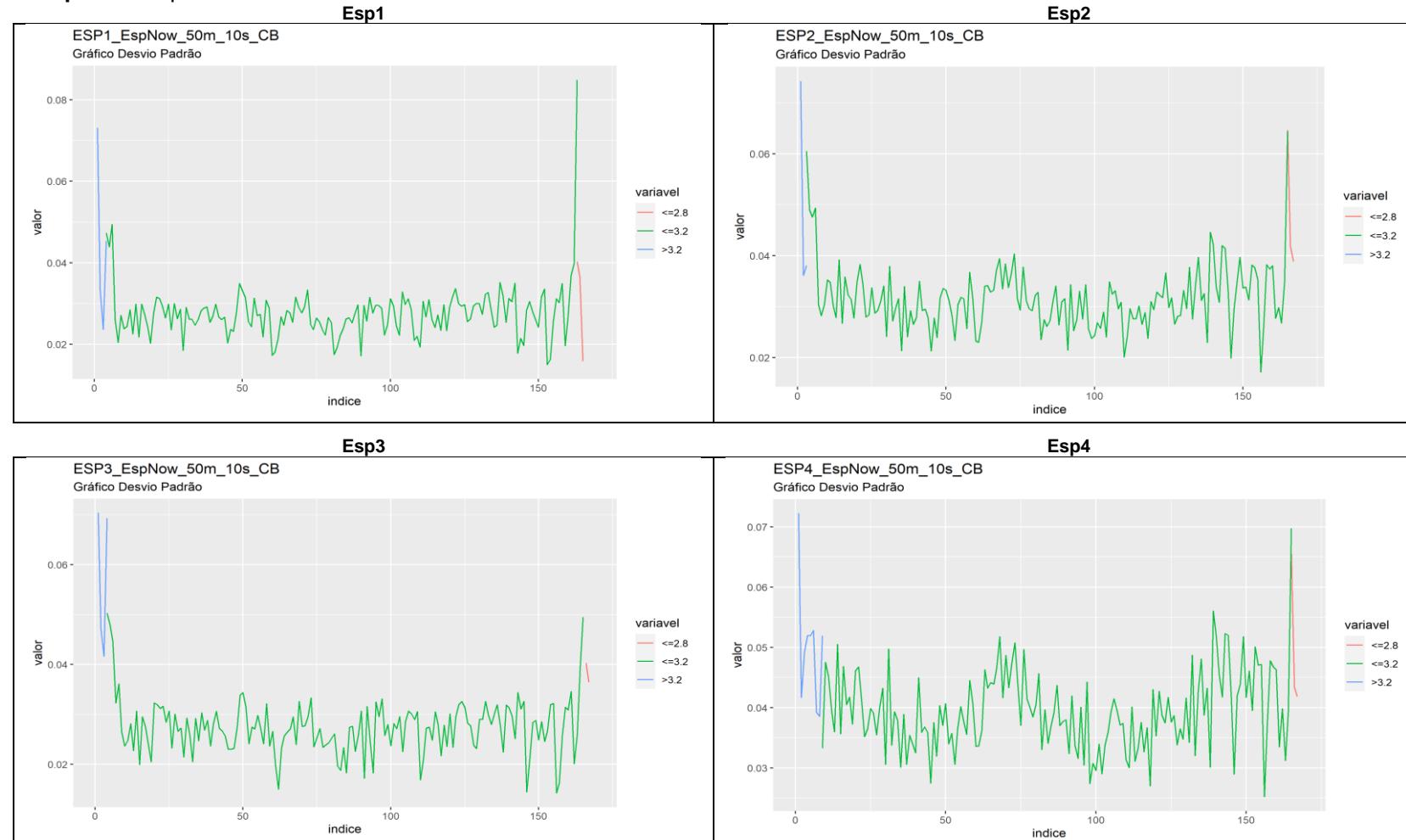
**Graph 14 - EspNow Scenario Standard Deviation 50m 5s SB**



Source: Prepared by the author (2021)

Graph 15 presents the Standard Deviation result in the EspNow 50m 10s CB Scenario for each of the sensors.

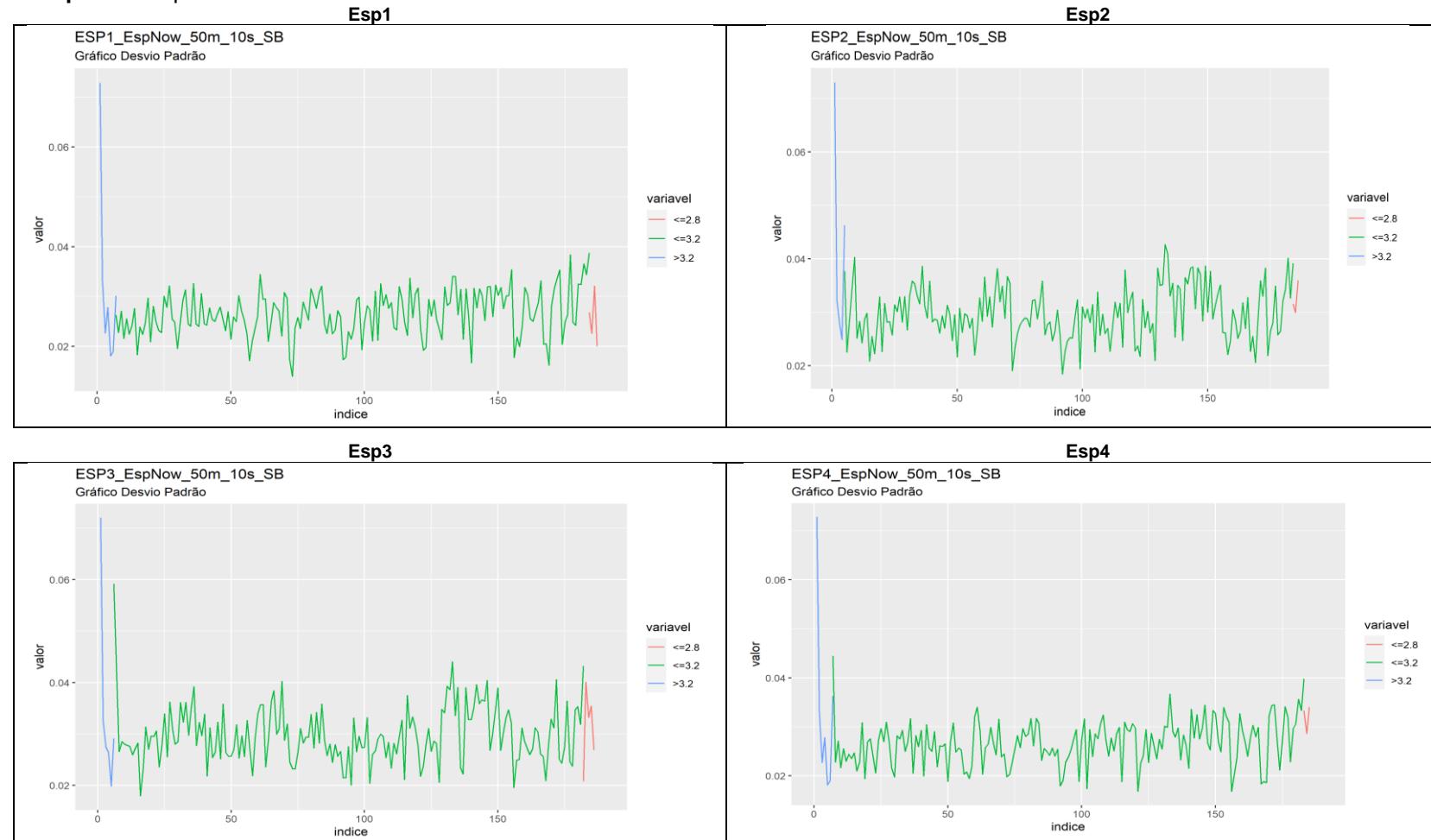
**Graph 15 - EspNow Scenario Standard Deviation 50m 10s CB**



Source: Prepared by the author (2021)

Graph 16 presents the result of the Standard Deviation in the EspNow Scenario 50m 10s SB for each of the sensors.

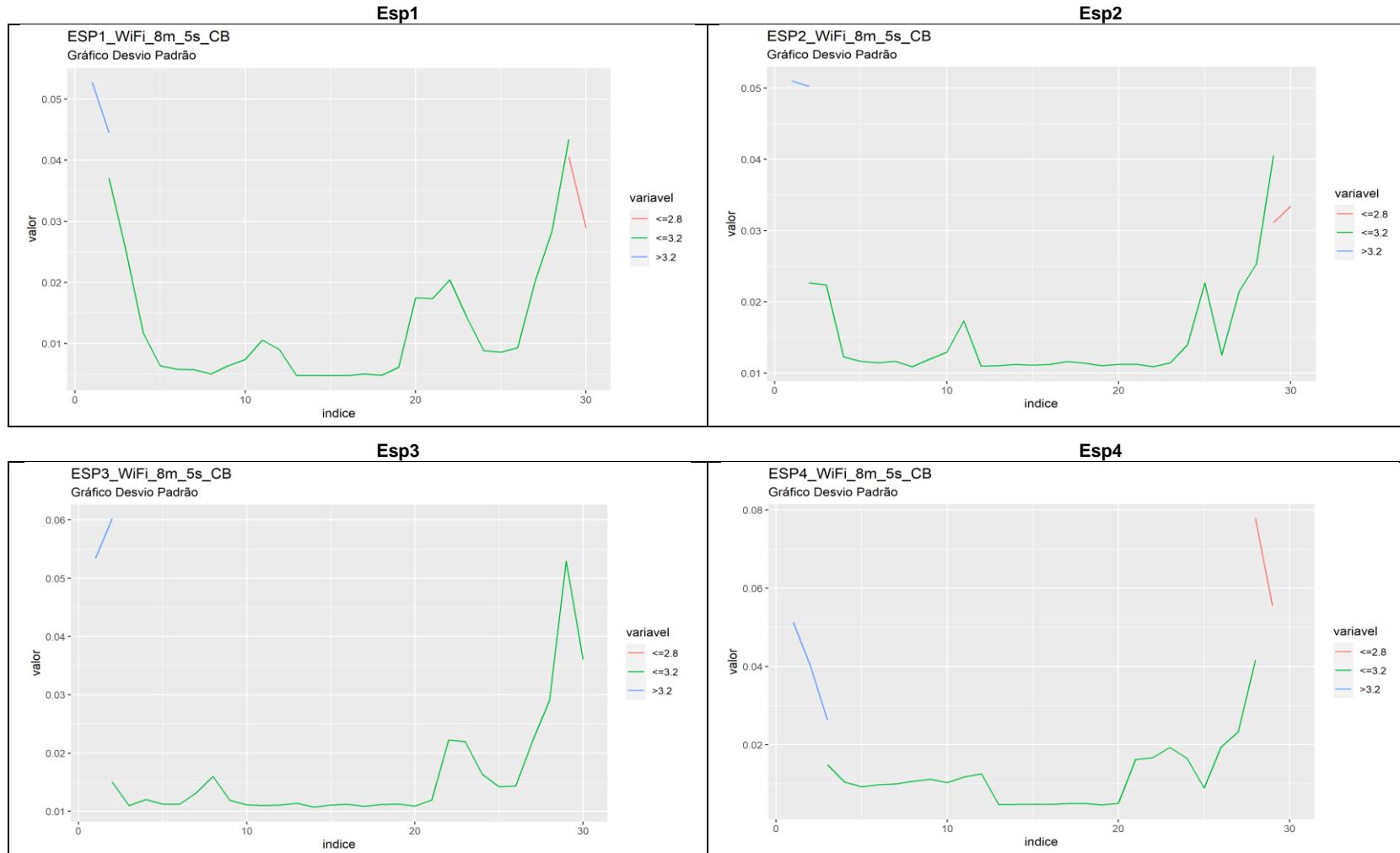
**Graph 16 - EspNow Scenario Standard Deviation 50m 10s SB**



Source: Prepared by the author (2021)

Graph 17 presents the Standard Deviation result in the WiFi 8m 5s CB Scenario for each of the sensors.

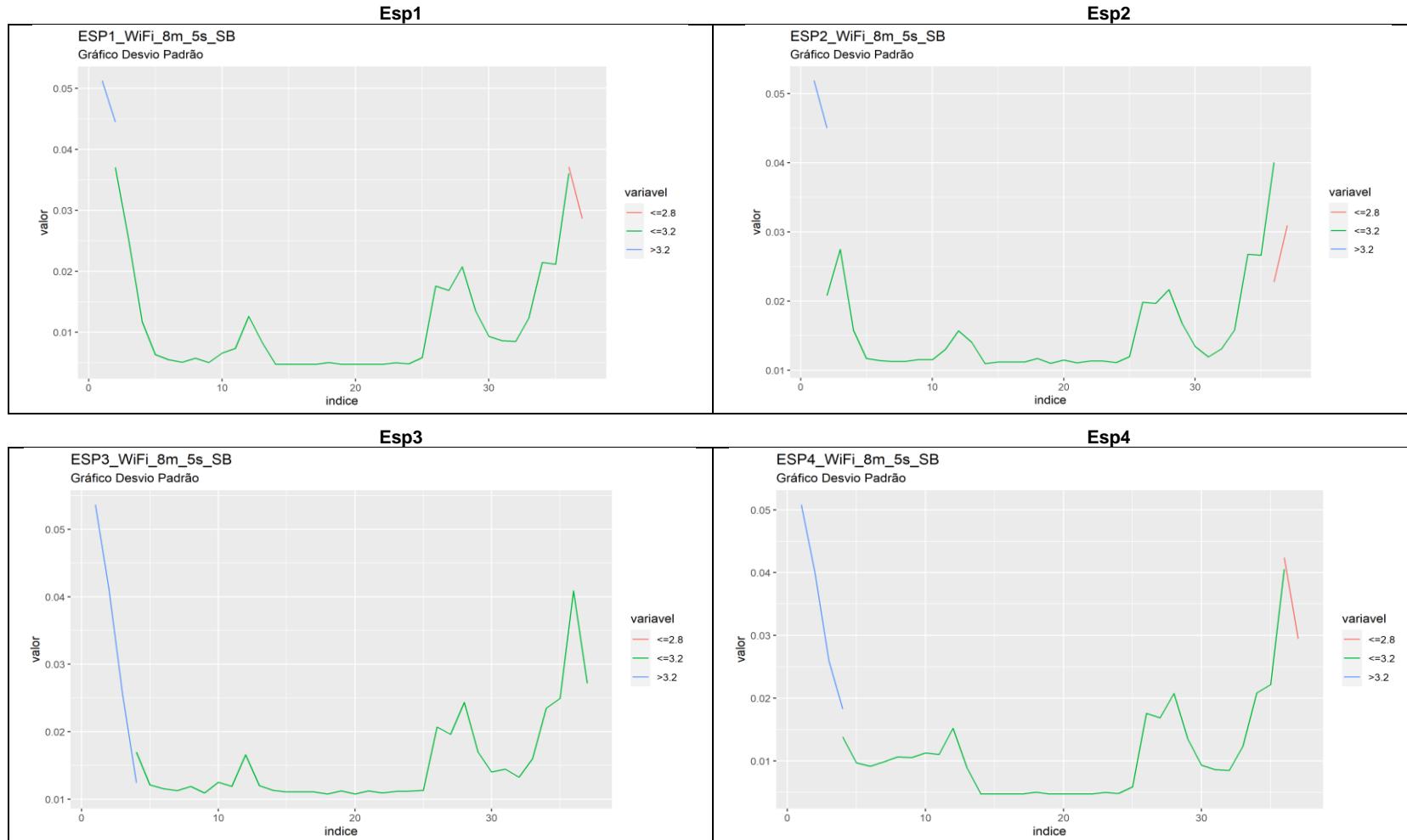
**Graph 17 - WiFi Scenario Standard Deviation 8m 5s CB**



Source: Prepared by the author (2021)

Graph 18 presents the Standard Deviation result in the WiFi 8m 5s SB Scenario for each of the sensors.

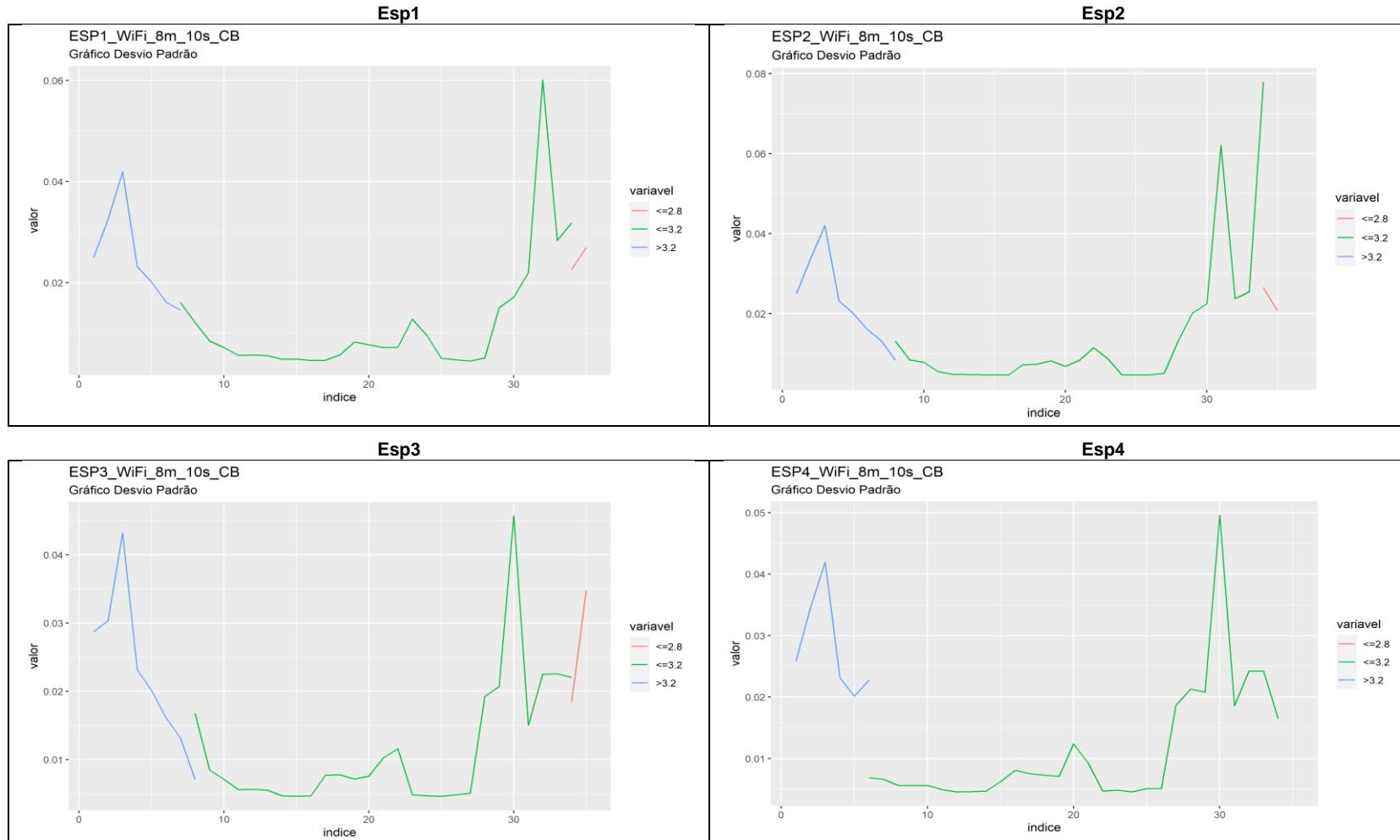
**Graph 18 - Standard Deviation Scenario WiFi 8m 5s SB**



Source: Prepared by the author (2021)

Graph 19 presents the Standard Deviation result in the WiFi 8m 10s CB Scenario for each of the sensors.

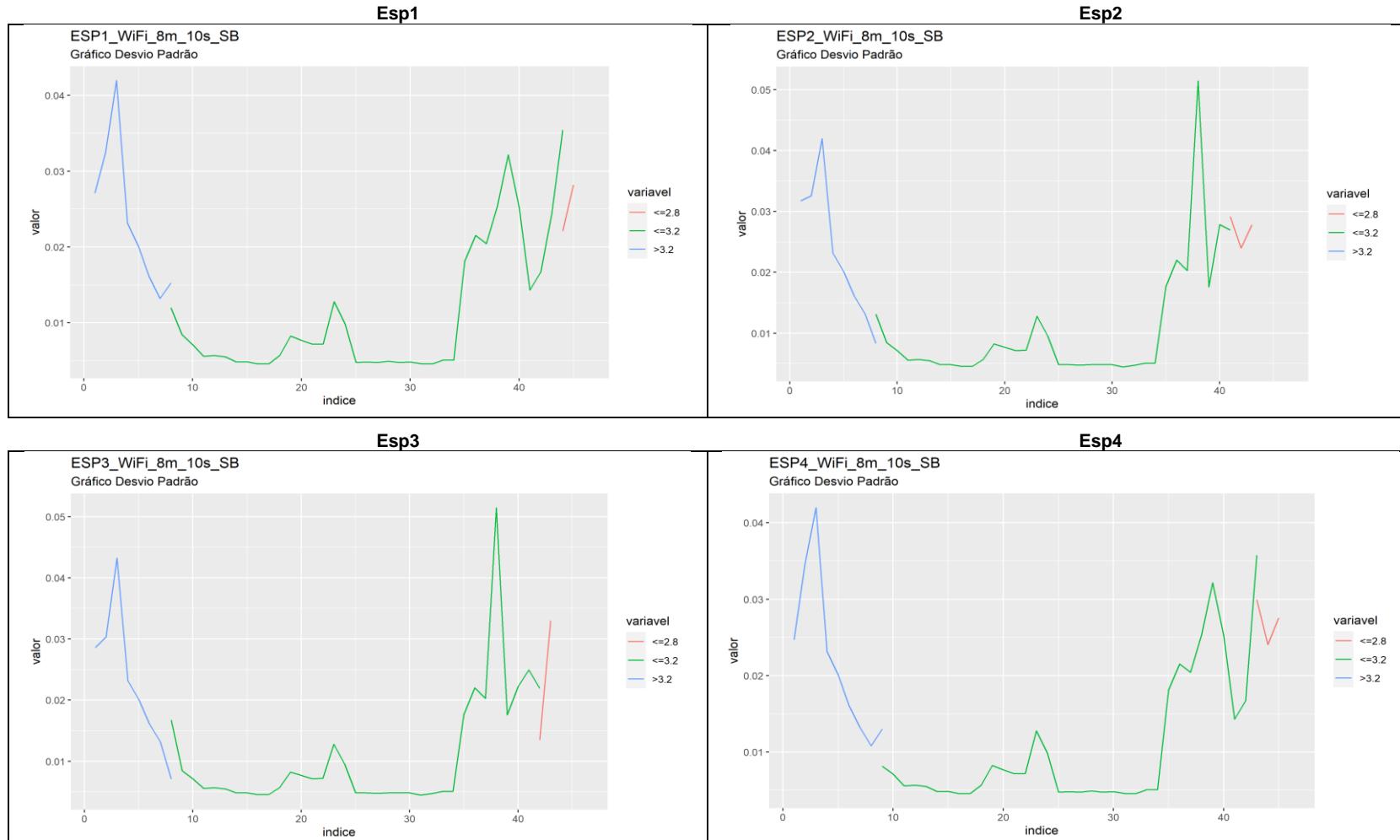
**Graph 19 - Standard Deviation Scenario WiFi 8m 10s CB**



Source: Prepared by the author (2021)

Graph 20 presents the result of the Standard Deviation in the WiFi Scenario 8m 10s SB for each of the sensors.

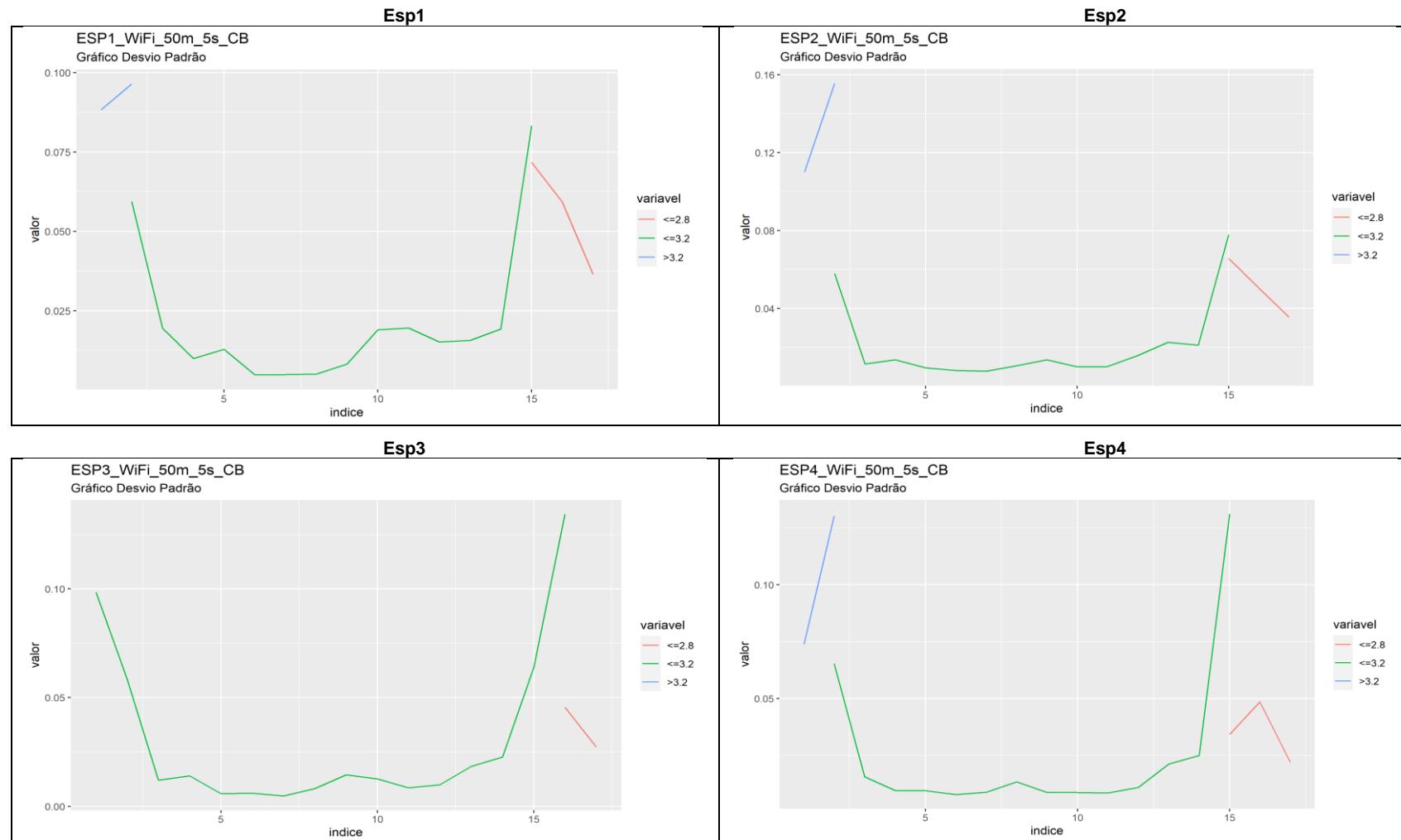
**Graph 20 - Standard Deviation Scenario WiFi 8m 10s SB**



Source: Prepared by the author (2021)

Graph 21 presents the Standard Deviation result in the WiFi 50m 5s CB Scenario for each of the sensors.

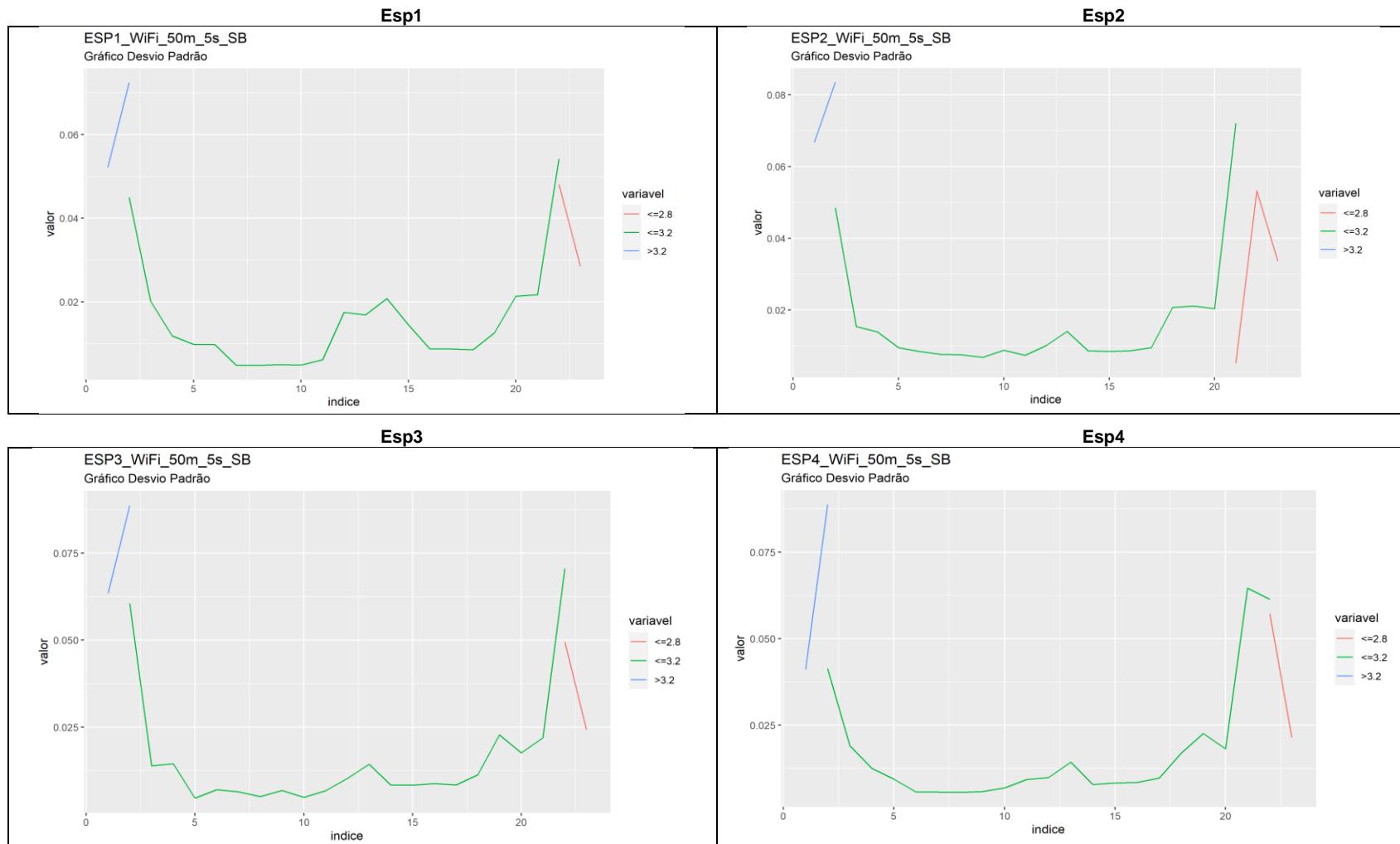
**Graph 21 - Standard Deviation Scenario WiFi 50m 5s CB**



Source: Prepared by the author (2021)

Graph 22 presents the Standard Deviation result in the WiFi 50m 5s SB Scenario for each of the sensors.

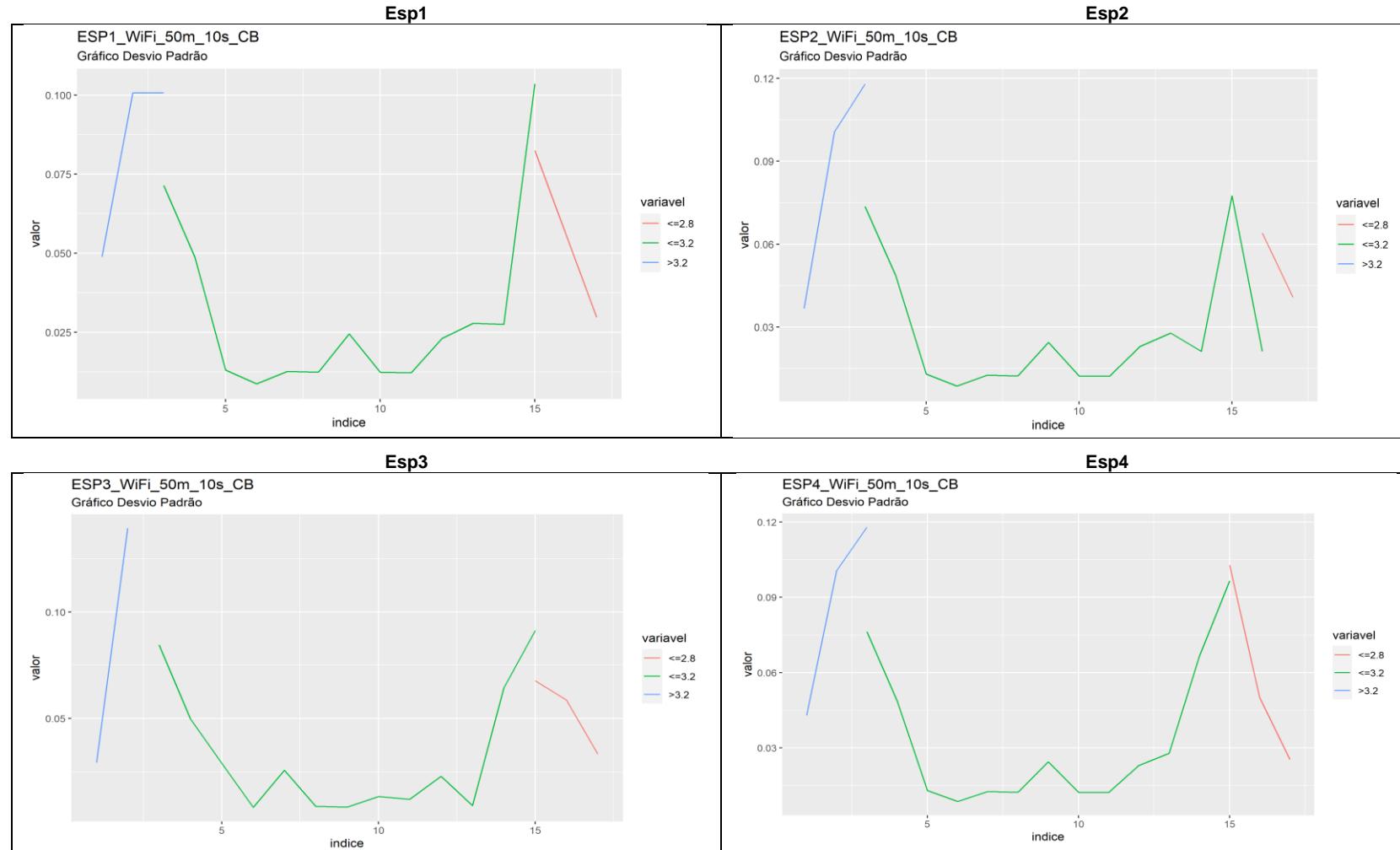
**Graph 22 - Standard Deviation Scenario WiFi 50m 5s SB**



Source: Prepared by the author (2021)

Graph 23 presents the result of the Standard Deviation in the WiFi 50m 10s CB Scenario for each of the sensors.

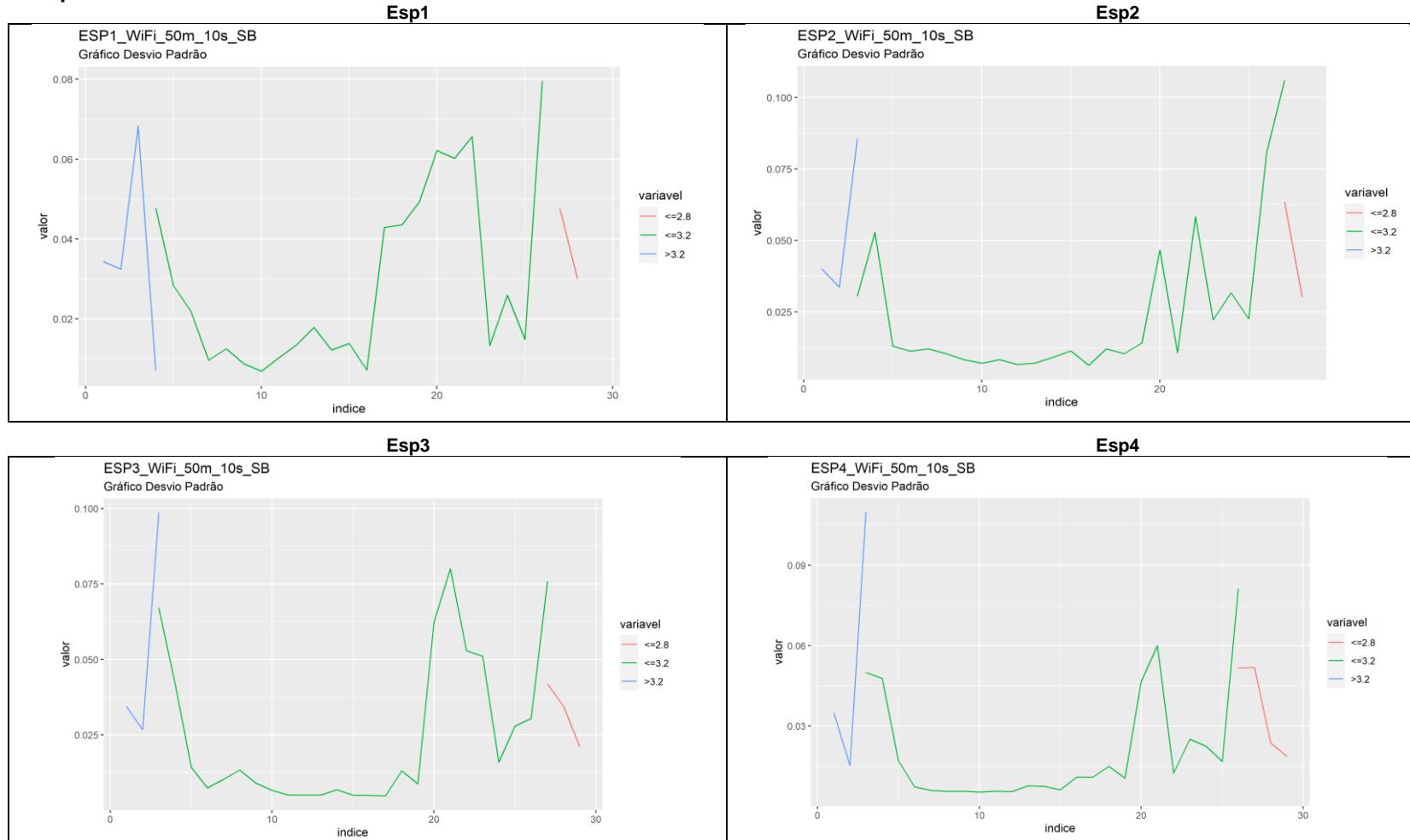
**Graph 23 - Standard Deviation Scenario WiFi 50m 10s CB**



Source: Prepared by the author (2021)

Graph 24 presents the Standard Deviation result in the WiFi 50m 10s SB Scenario for each of the sensors.

**Graph 24 - Standard Deviation Scenario WiFi 50m 10s SB**



Source: Prepared by the author (2021)

## 2. ***Markov Stochastic Matrices Graphs***

The graphs that visually reproduce the Stochastic Markov matrix were generated from the averages of the four sensors present in each of the scenarios.

The tables with the data are in the following repository:

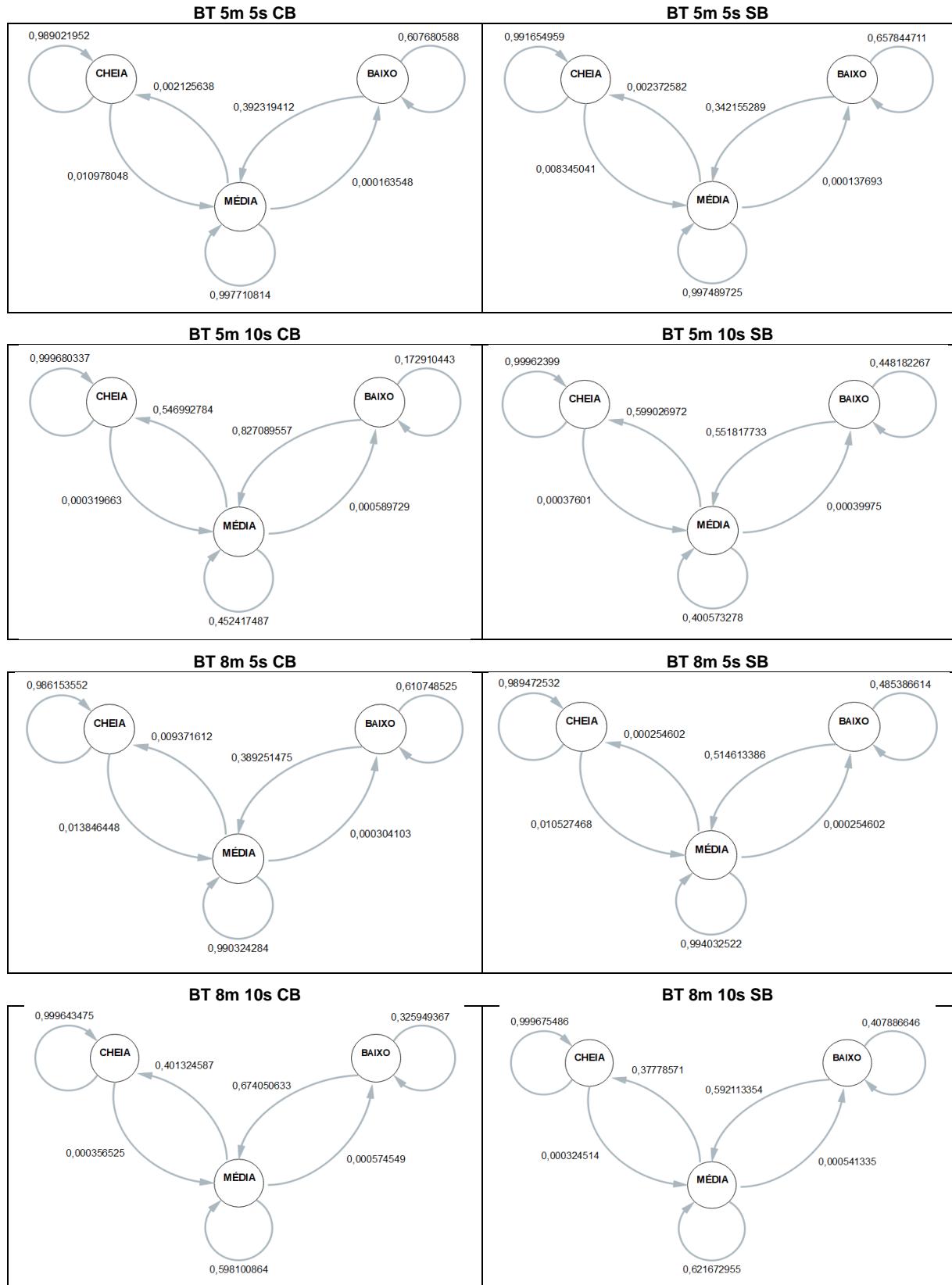
[https://github.com/rogeriobcosta/Documents\\_Article.git](https://github.com/rogeriobcosta/Documents_Article.git)

The Cenarios\_Bluetooth, Cenarios\_EspNow and Cenarios\_WiFi folders contain the worksheets with the collected data.

At the root of each folder are worksheets that begin with the name, <scenario readings worksheet.....>, plus the name of the specific scenario. Within them there is the Markov and MTTF spreadsheet, which is composed of the table with the average of the states CC, CM, CB, MC, MM, MB, BC, BM and BB.

Graph 25 shows the averages for each of the scenarios for Bluetooth technology.

#### Graph 25 – Stochastic Markov Matrix Graphs Bluetooth Scenarios

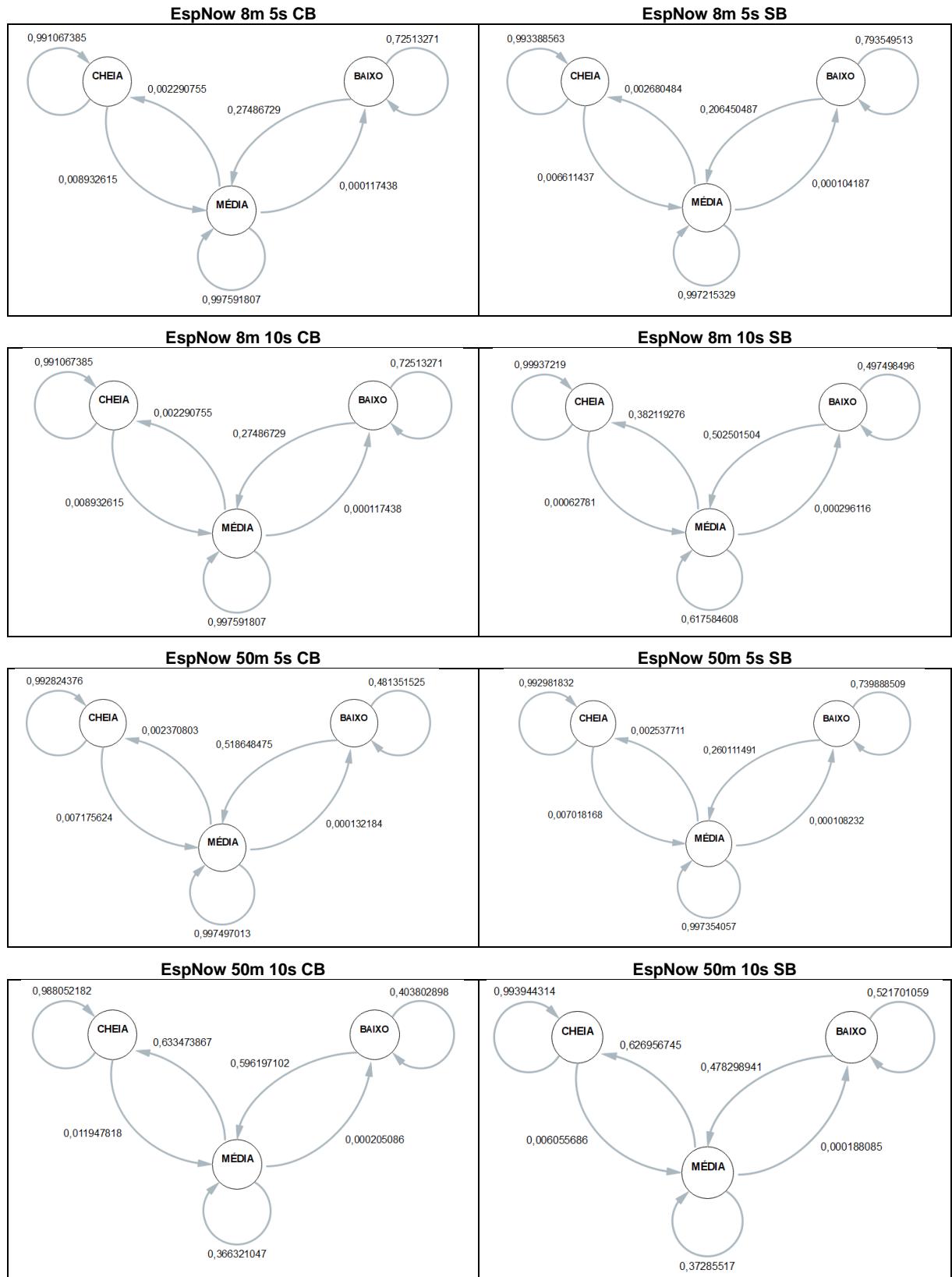


Source: Prepared by the author (2021)

Graph 26 presents the averages of each of the scenarios for the EspNow technology.

### Graph 26 - Stochastic Markov Matrix Graphs EspNow Scenarios

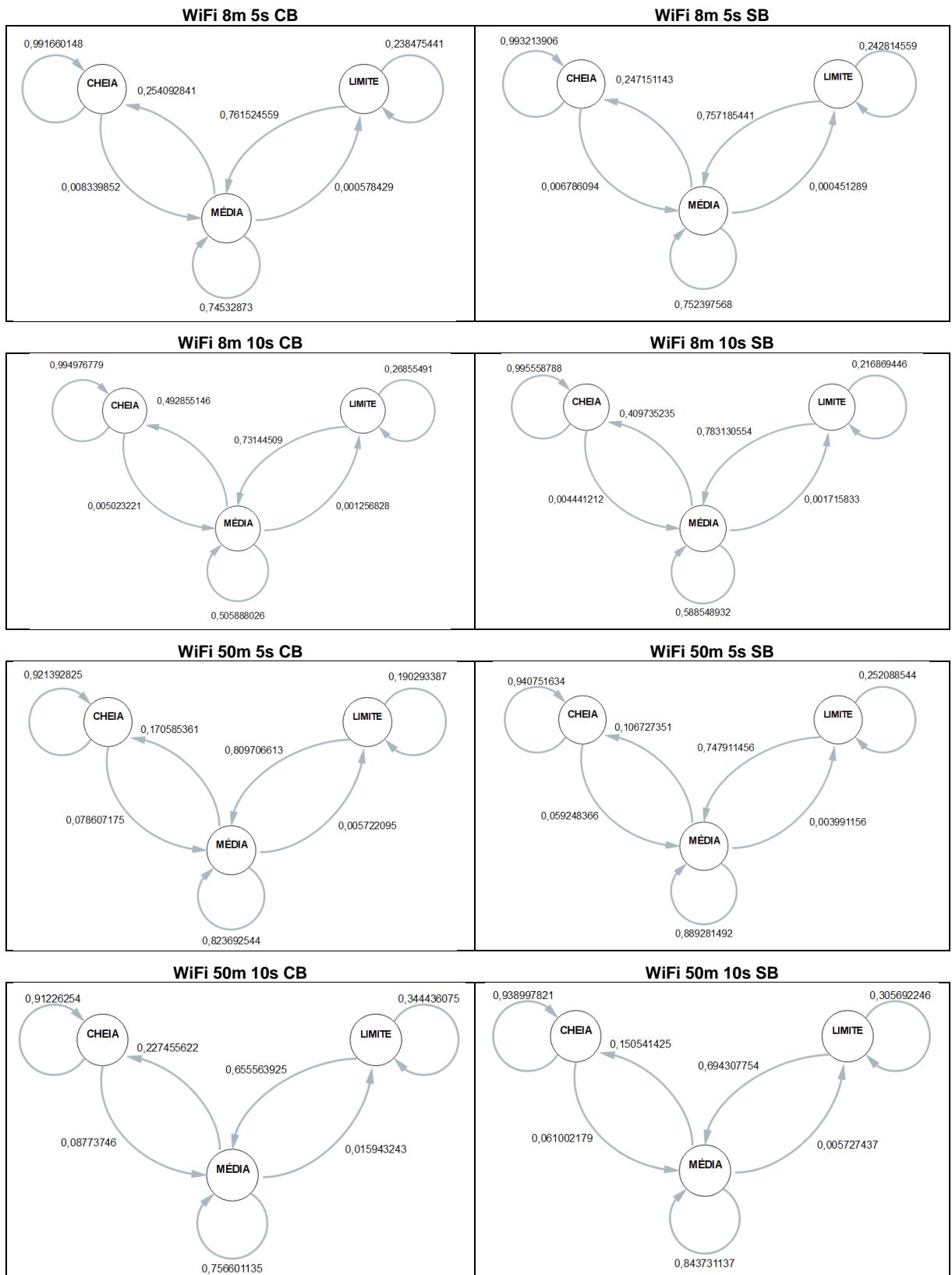
**Gráfico 26 - Grafos Matriz Estocástica de Markov Cenários EspNow**



Source: Prepared by the author (2021)

Graph 27 presents the averages of each of the scenarios for the EspNow technology.

**Graph 27 - Stochastic Markov Matrix Graphs WiFi Scenarios**



Source: Prepared by the author (2021)

### **3. Kaplan-Meier survival charts**

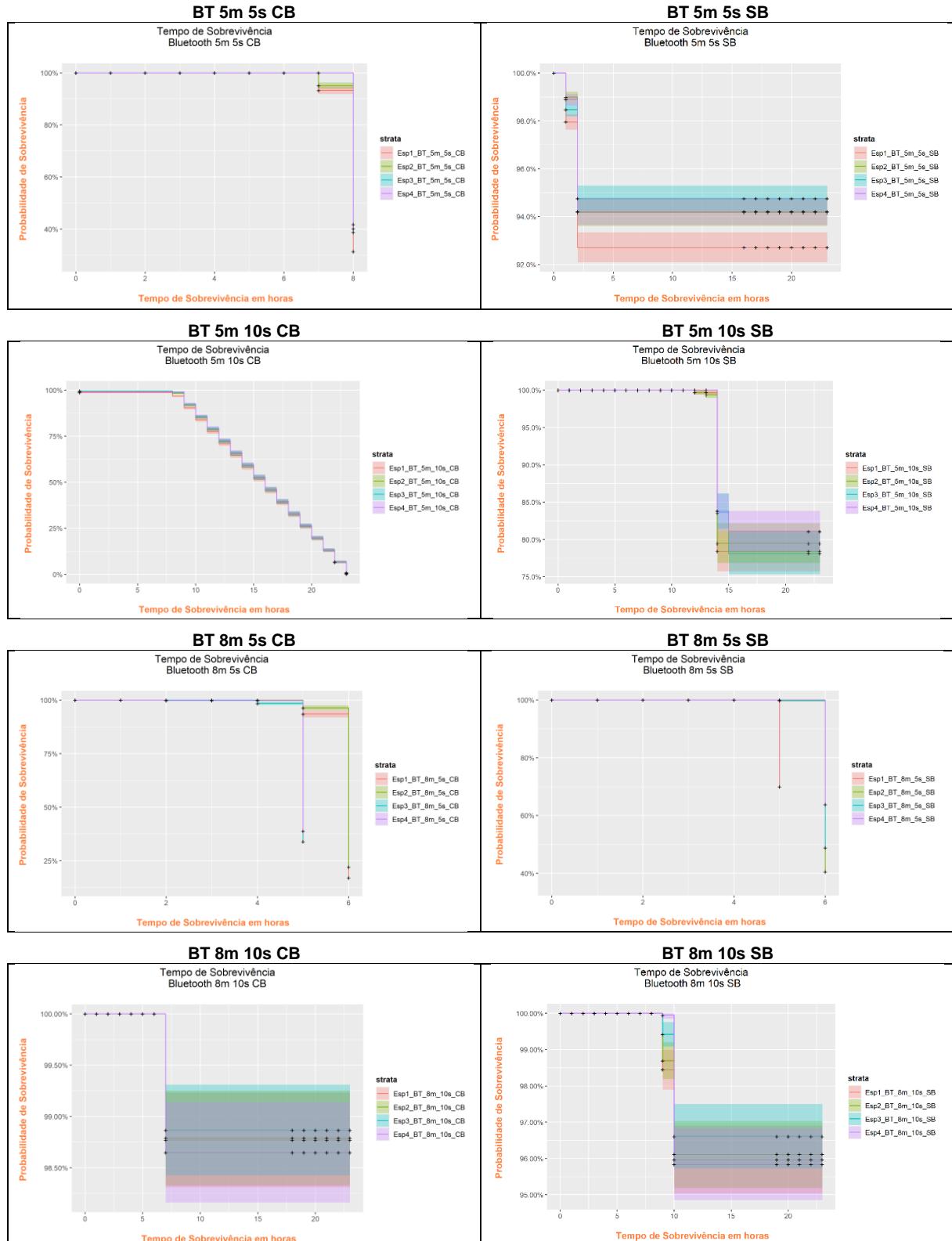
Kaplan-Meier survival charts were generated on the R platform using the Survival library, the script and spreadsheets used are in the following repository:

[https://github.com/rogeriobcosta/Documents\\_Article.git](https://github.com/rogeriobcosta/Documents_Article.git)

Inside the Cenarios\_Bluetooth, Cenarios\_EspNow and Cenarios\_WiFi folders there are other folders with the names of the scenarios with the projects in R that generated the graphics.

Graph 28 shows the lines and steps of the Kaplan-Meier estimator survival analysis for Bluetooth technology.

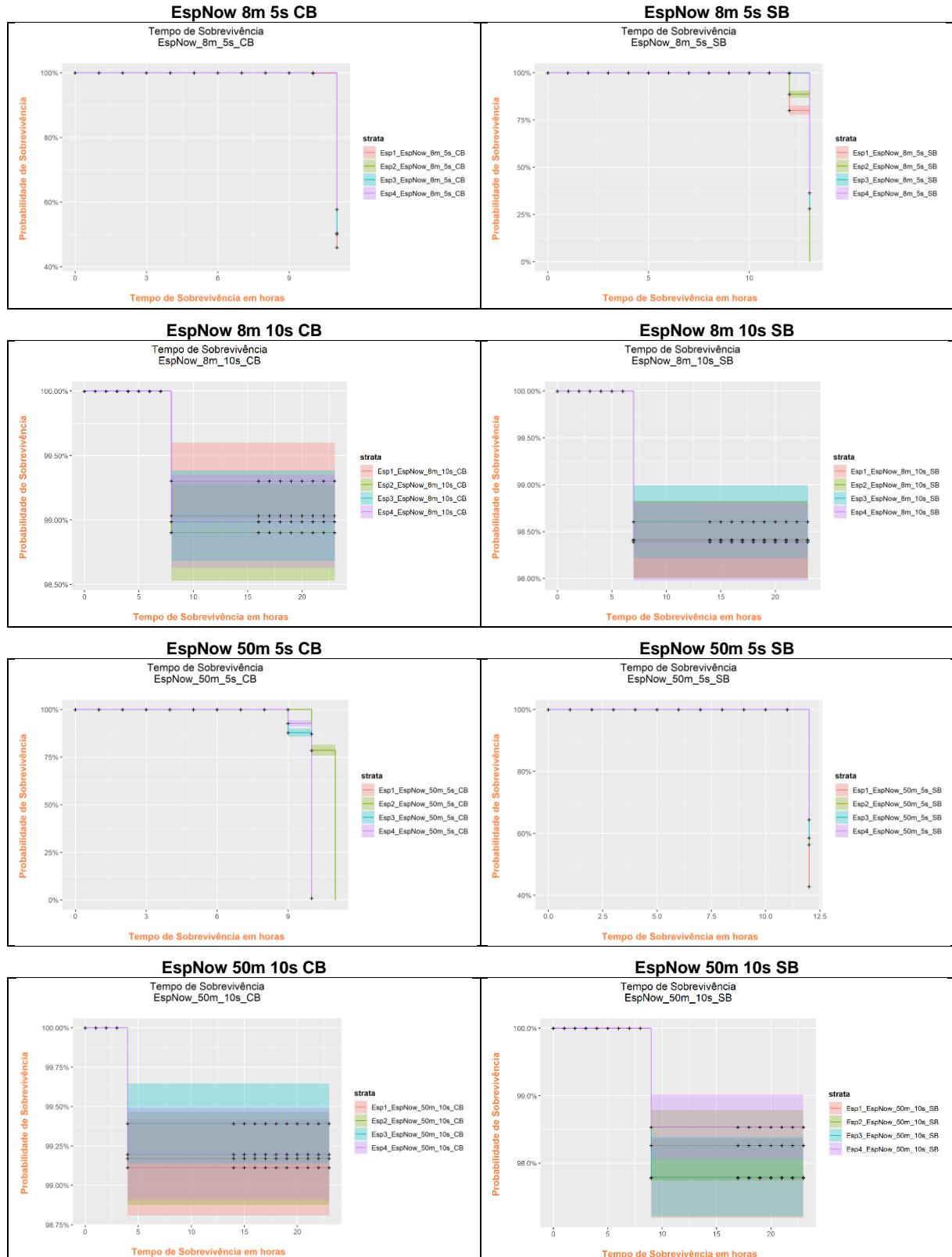
**Graph 28 - Kaplan-Meier Survival Graph Bluetooth Scenarios**



Source: Prepared by the author (2021)

Graph 29 shows the lines and steps of the Kaplan-Meier estimator survival analysis for EspNow technology.

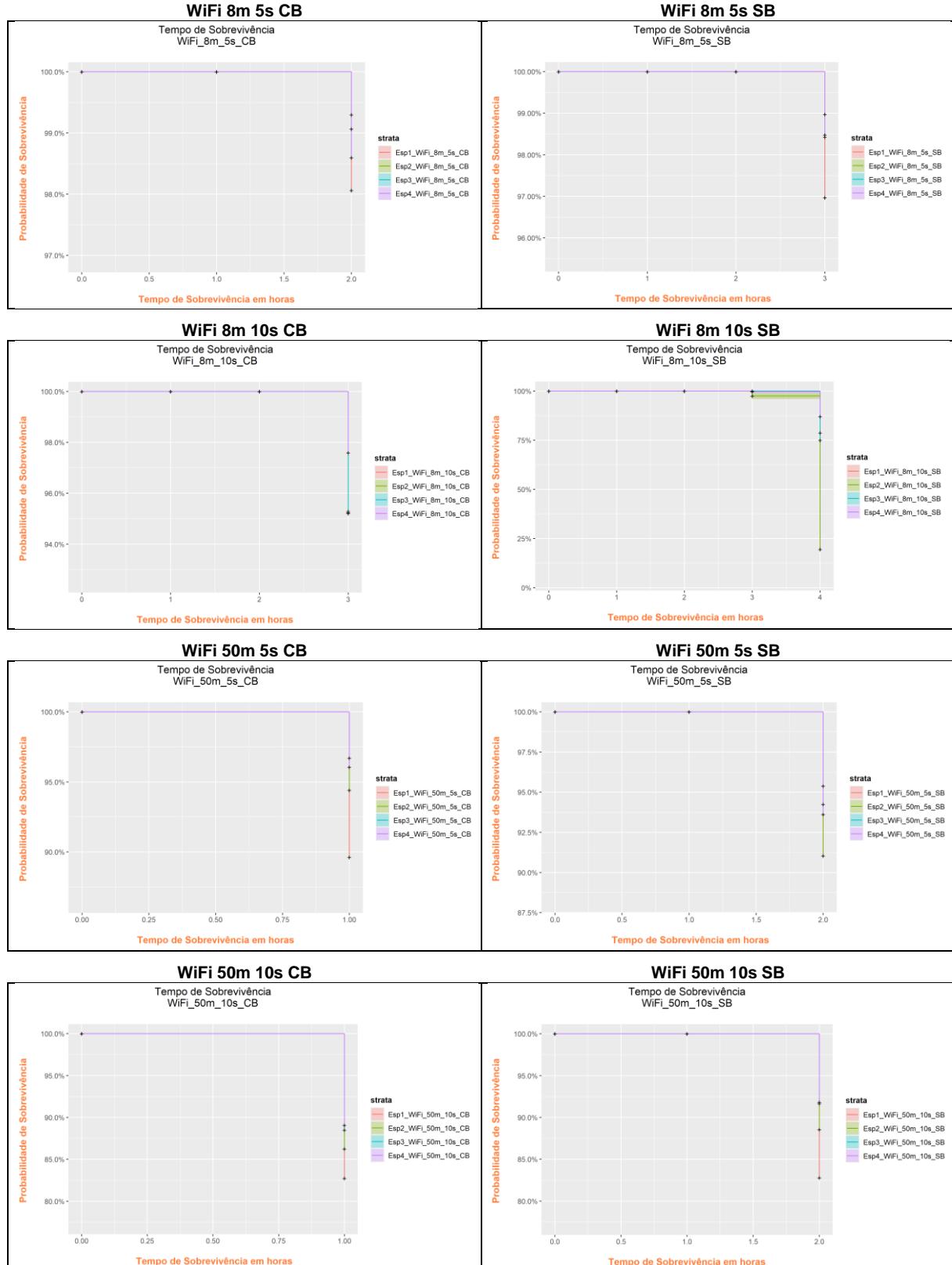
**Graph 29 - Kaplan-Meier Survival Graph EspNow Scenarios**



Source: Prepared by the author (2021)

Graph 30 shows the lines and steps of the Kaplan-Meier estimator survival analysis for EspNow technology.

**Graph 30 - Kaplan-Meier Survival Graph WiFi Scenarios**



Source: Prepared by the author (2021)

#### **4. Spreadsheets with data captured in the experiments**

All spreadsheets with captured data, by sensor, can be found in the following directory:

[https://github.com/rogeriobcosta/Documents\\_Article.git](https://github.com/rogeriobcosta/Documents_Article.git)

The Cenarios\_Bluetooth, Cenarios\_EspNow and Cenarios\_WiFi folders contain the worksheets with the collected data.

At the root of each folder are worksheets that begin with the name, <scenario readings worksheet.....>, plus the name of the specific scenario. Within them there are the sheets Esp1, Esp2, Esp3 and Esp4, plus the name of the scenario.