|  |  |
| --- | --- |
| **DESIGN PROJECT REPORT COVER SHEET** | **ANU College of Engineering and Computer Science** Australian National University Canberra ACT 0200 Australia **www.anu.edu.au**  **+61 2 6125 5254** |
| Submission and assessment is anonymous where appropriate and possible. Please do not write your name on this coversheet.  This coversheet must be attached to the front of your assessment when submitted in hard copy. If you have elected to submit in hard copy rather than Turnitin, you must provide copies of all references included in the assessment item.  All assessment items submitted in hard copy are due at 5pm unless otherwise specified in the course outline. |

|  |  |  |  |
| --- | --- | --- | --- |
| Student ID  For group assignments, list each student’s ID | U 6366102 | | |
| Course Code | ENGN 6223 | | |
| Course Name | Control Systems | | |
| Assignment number |  | | |
| Assignment Topic | Design of Controller for Cruise Control | | |
| Lecturer | Dr. Guodong Shi | | |
| Tutor |  | | |
| Tutorial (day and time) |  | | |
| Word count |  | Due Date | 17/09/2018 |
| Date Submitted | /09/18 | Extension Granted |  |

I declare that this work:

* upholds the principles of academic integrity, as defined in the ANU Policy[: Code of Practice for Student Academic Integrity](https://hkxprd0610.outlook.com/owa/redir.aspx?C=pkUS4AqeVkC0OHXUsRYzk8JcJE65y9AI4r3Mqfll_bLO9DXo_dFgmbuC6N5TOcnRwCb-AmVT460.&URL=https%3a%2f%2fpolicies.anu.edu.au%2fppl%2fdocument%2fANUP_000392);
* is original, except where collaboration (for example group work) has been authorised in writing by the course convener in the course outline and/or Wattle site;
* is produced for the purposes of this assessment task and has not been submitted for assessment in any other context, except where authorised in writing by the course convener;
* gives appropriate acknowledgement of the ideas, scholarship and intellectual property of others insofar as these have been used;
* in no part involves copying, cheating, collusion, fabrication, plagiarism or recycling

Table of Contents

[Introduction 1](#_Toc524190492)

[Systems Modelling and Simulations 1](#_Toc524190493)

[Controller Design and Validations 1](#_Toc524190494)

[Discussions and Conclusions 1](#_Toc524190495)

[Appendix: Models and Graphs 3](#_Toc524190496)

# Introduction

The Cruise control is one of the most used control systems in automobile industry to ensure the safety of the vehicle and cruise at any desired speed that can be achieved by a given vehicle. This report discusses the design of controllers for an average car, Audi A4 2.0 TDI, and BMW 520d.

The necessity of cruise control is to improve the driving experience, reduce fatigue, and advance the overall efficiency of the car. There are various techniques to attain a desirable solution for this problem. This report focuses on PD, PID based cruise controller design and Fuzzy P based controller design. The document also analyzes the advantages and disadvantages of each of the controllers and modelling of each of the above-mentioned cars and the performance of each of the controller in various scenarios that are experienced on roads.

# Systems Modelling and Simulations

Analyzing the given equation gives us an insight that the equation has non-linearity induced by the which in turn produces uncertainty over the system responses. The system is linearized over a specific point . Here the system is linearized over the point 50 kmph (13.88 ms-1).

The first step in achieving cruise control is to linearize and compute transfer function of the plant which generates the following equation,

The parameters chosen for each of the cars are tabulated below,

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Cars / Parameters |  | ms-1 |  | kg |
| Average car | 0.23 | 13.88 | 1.1839 | 1000 |
| BMW 520d | 0.52 | 13.88 | 1.1839 | 1743 |
| Audi A4 2.0 TDI | 0.51 | 13.88 | 1.1839 | 1650 |

The systems modelling involves substitution of values to the transfer function to generate the plant transfer function. This function is substituted to the transfer function block of Simulink.

When the open-loop transfer function of the plant is simulated for unit step input, the plant response keeps rising as it does not have any reference value to settle. This confirms the need of controller design for this problem. Also, analyzing the transfer function also validates this stand as poles of the system remains close to the imaginary axis (in the order of 10-3).

# Controller Design and Validations

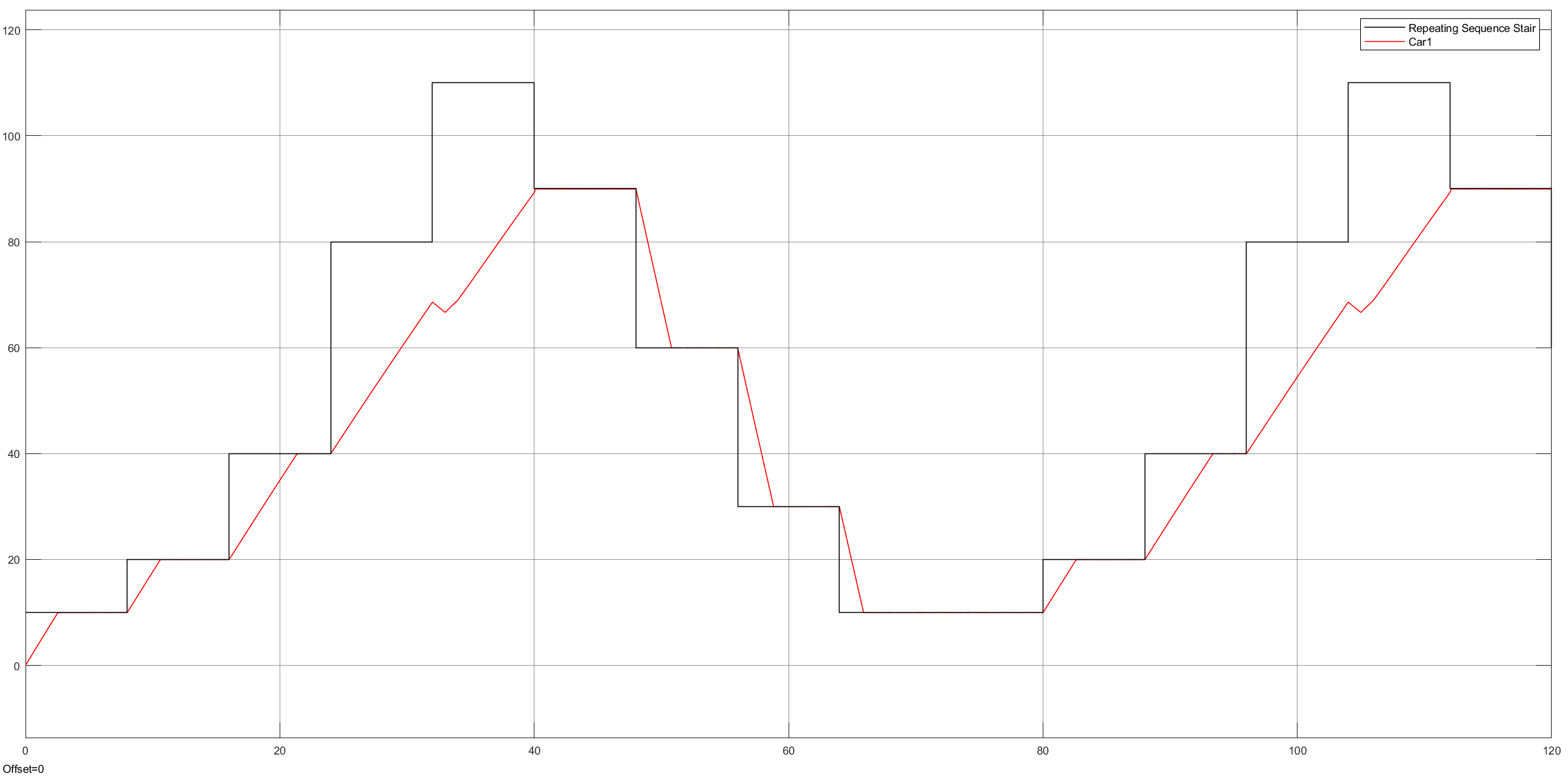
The design of PID/ PD controller

# Discussions and Conclusions

# Appendix: Models and Graphs

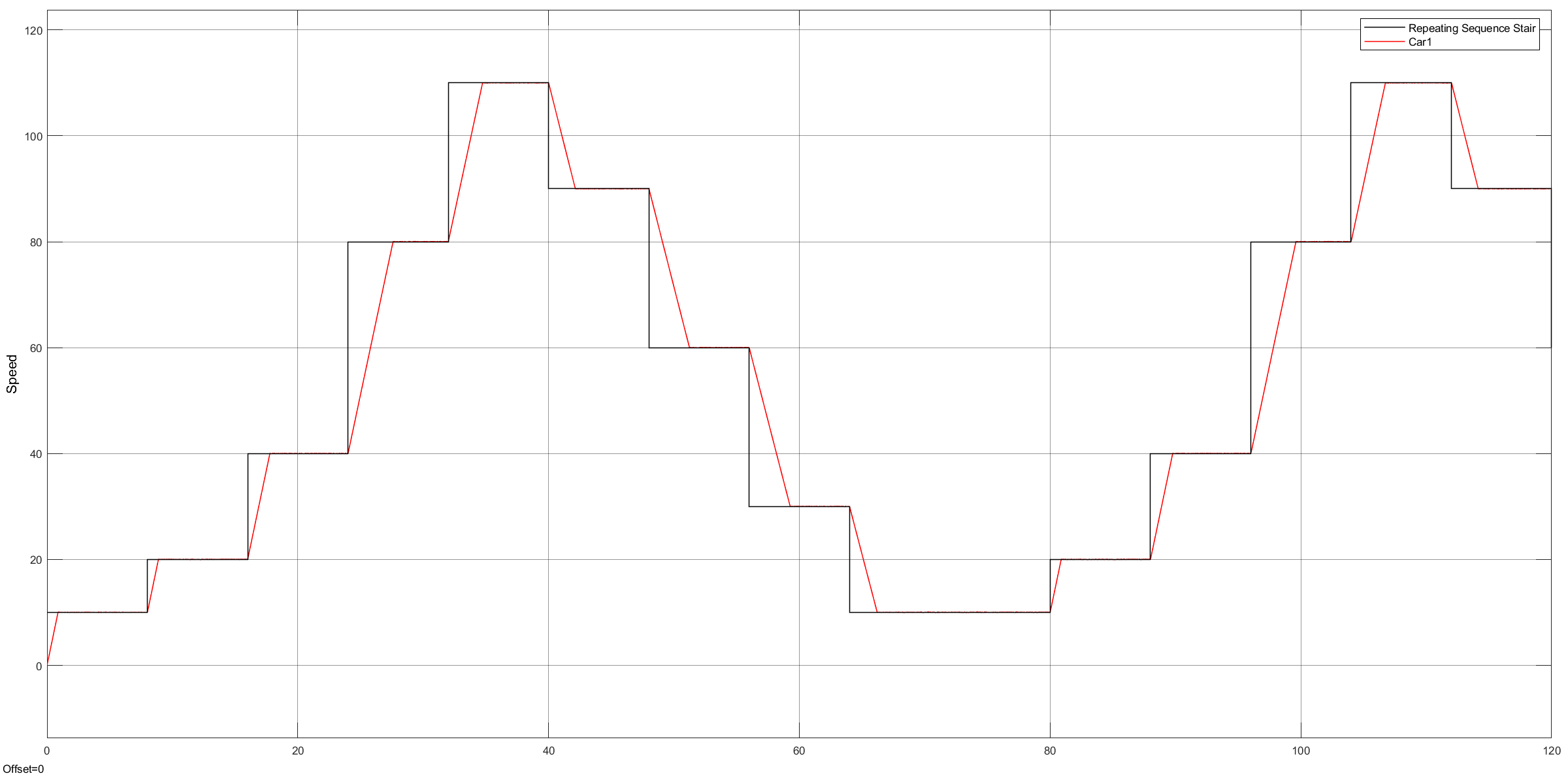
## Fuzzy P Controller design for an average car

Uphill scenario

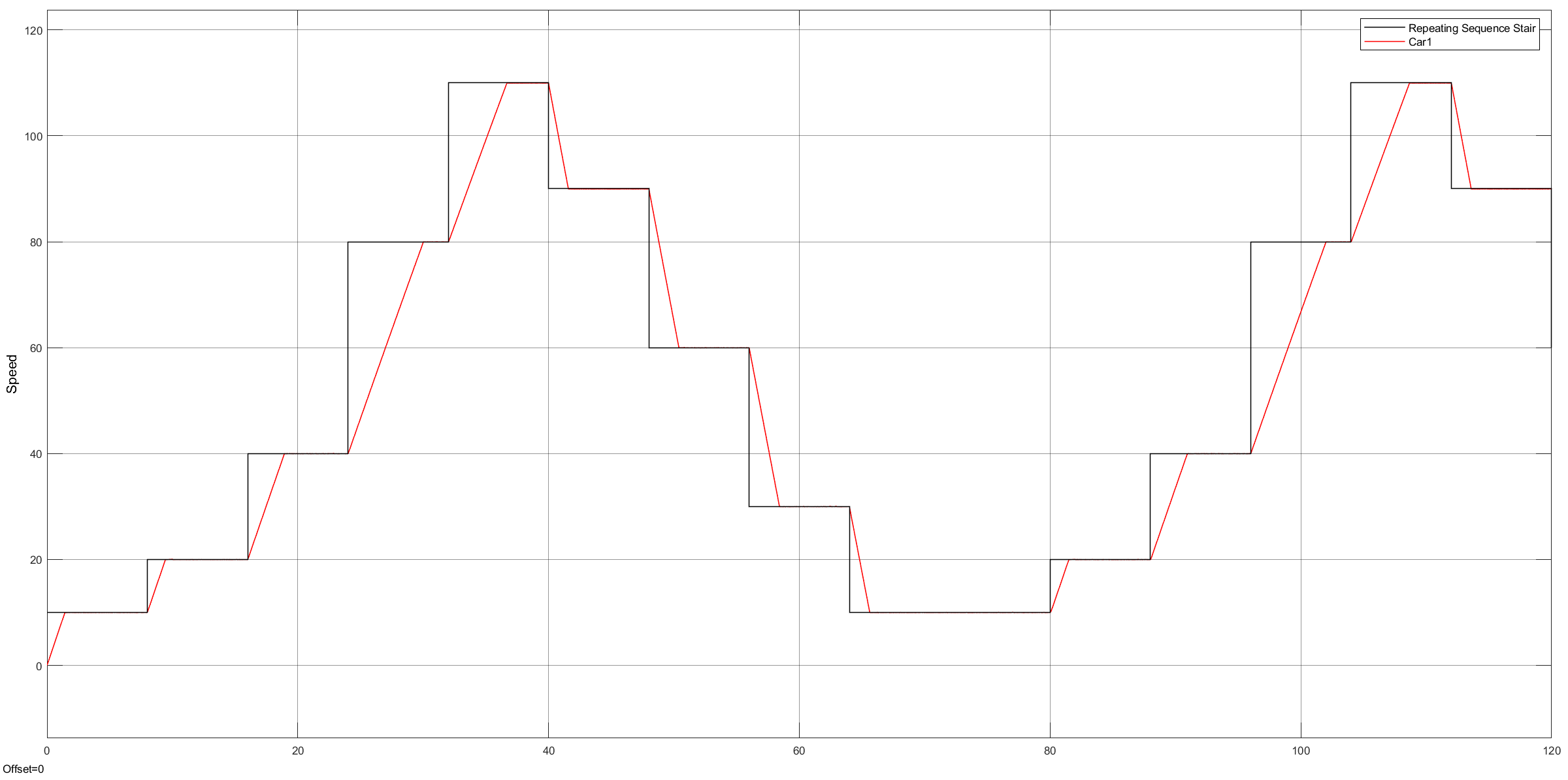


## Fuzzy P Controller design for an average car - Optimized (Triangular Membership functions)

Flat road scenario

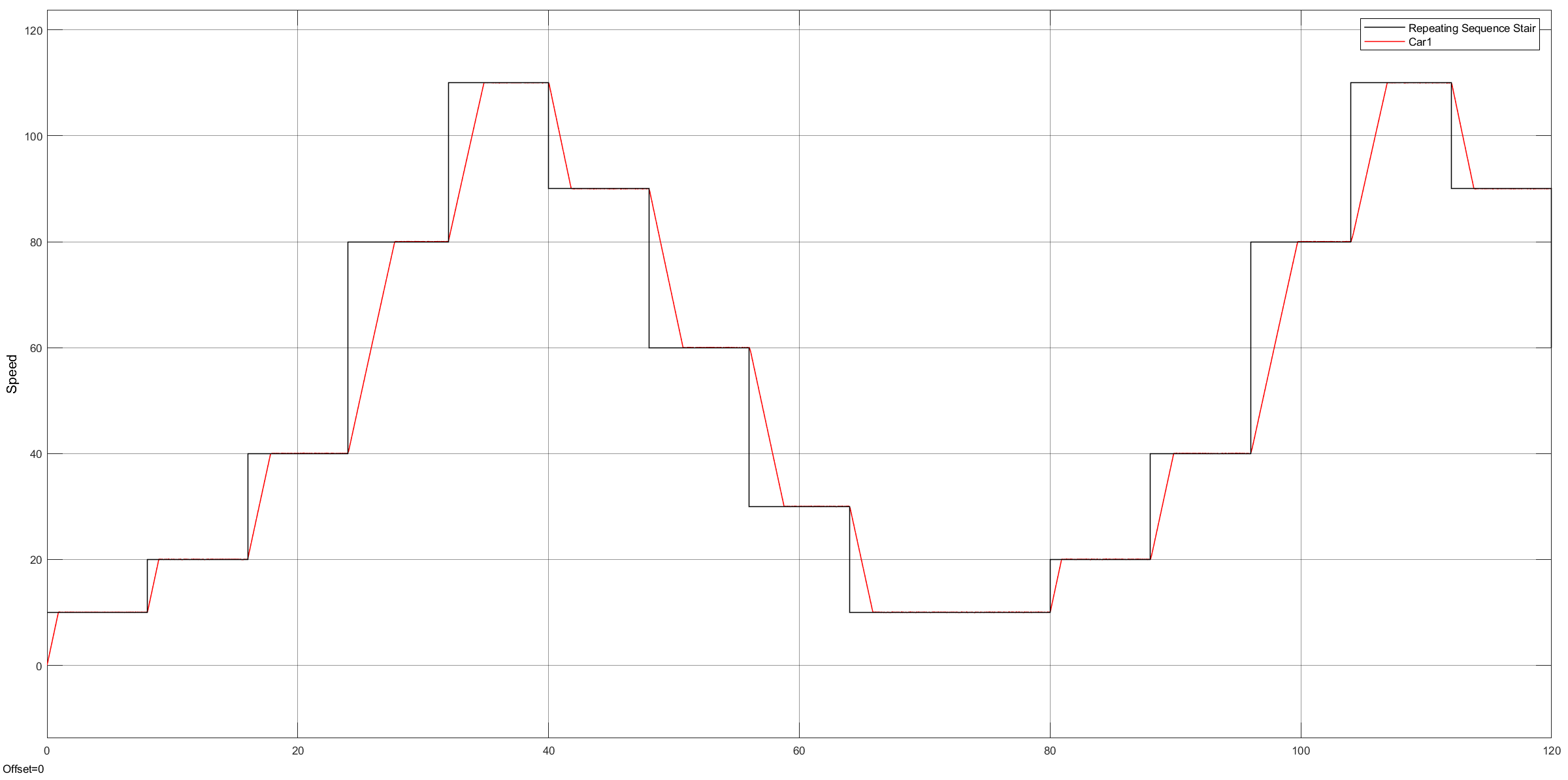


Uphill scenario

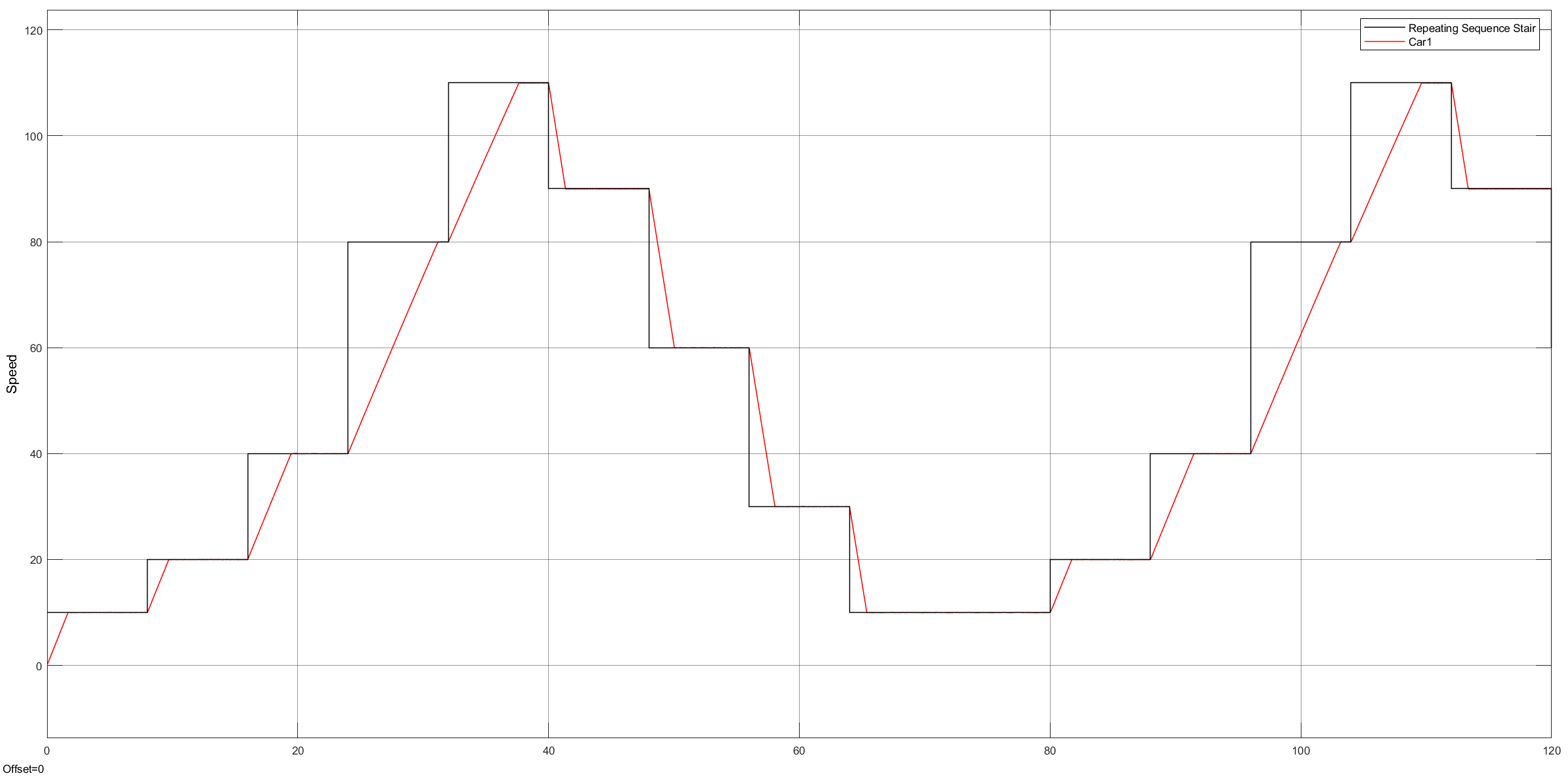


## Fuzzy P Controller design for an average car (Gaussian Membership functions)

Flat road scenario

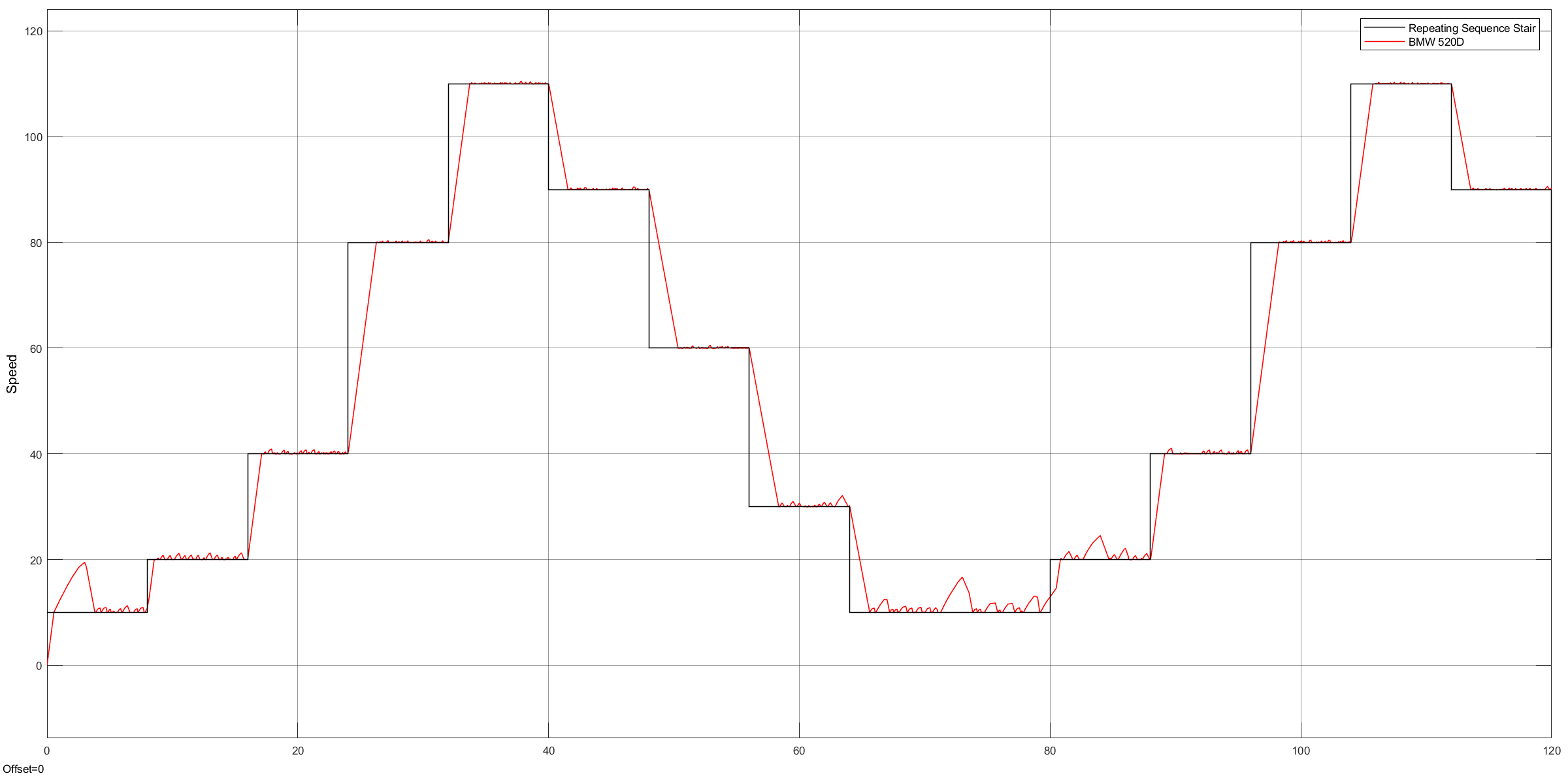


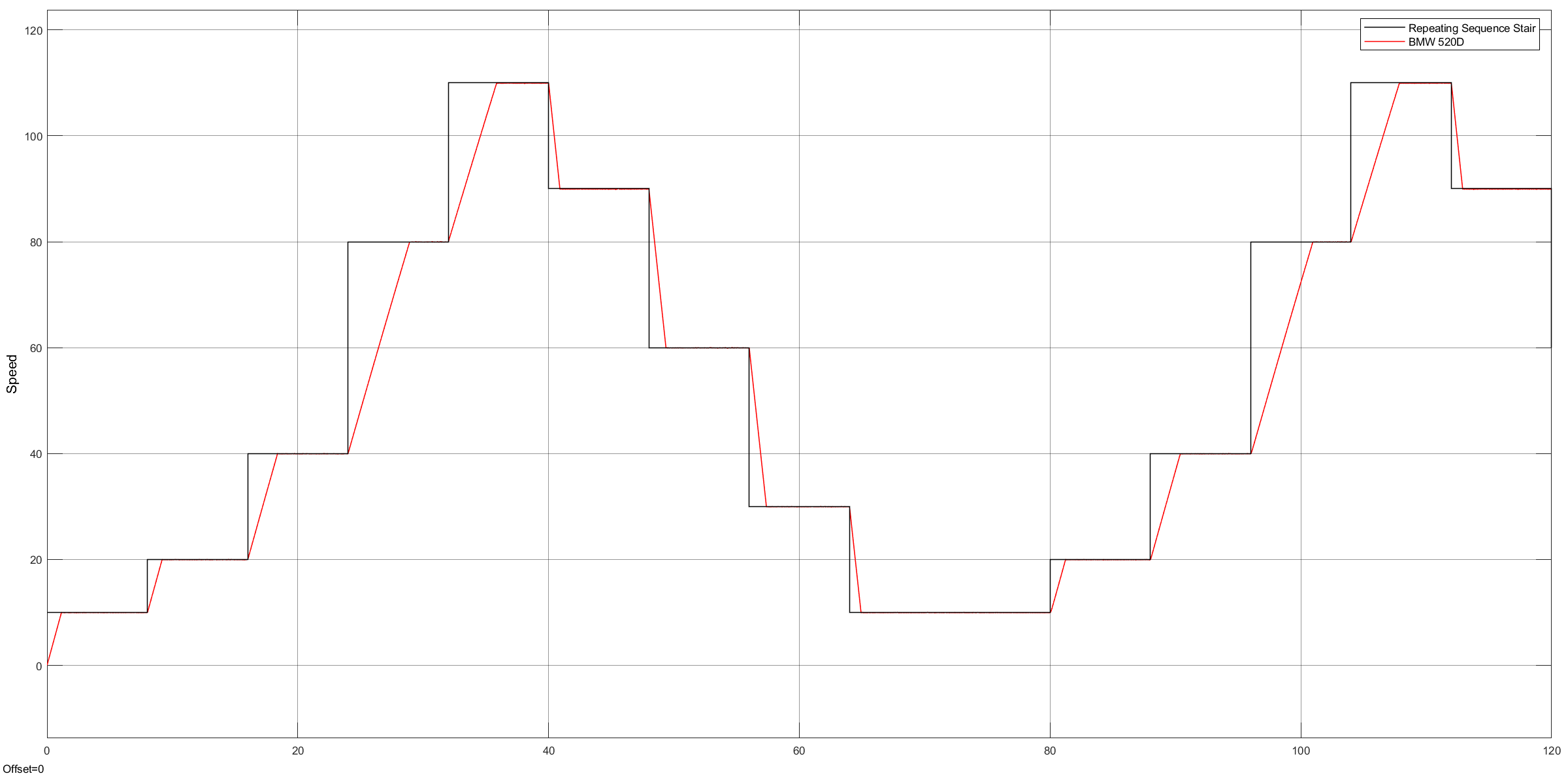
Uphill scenario



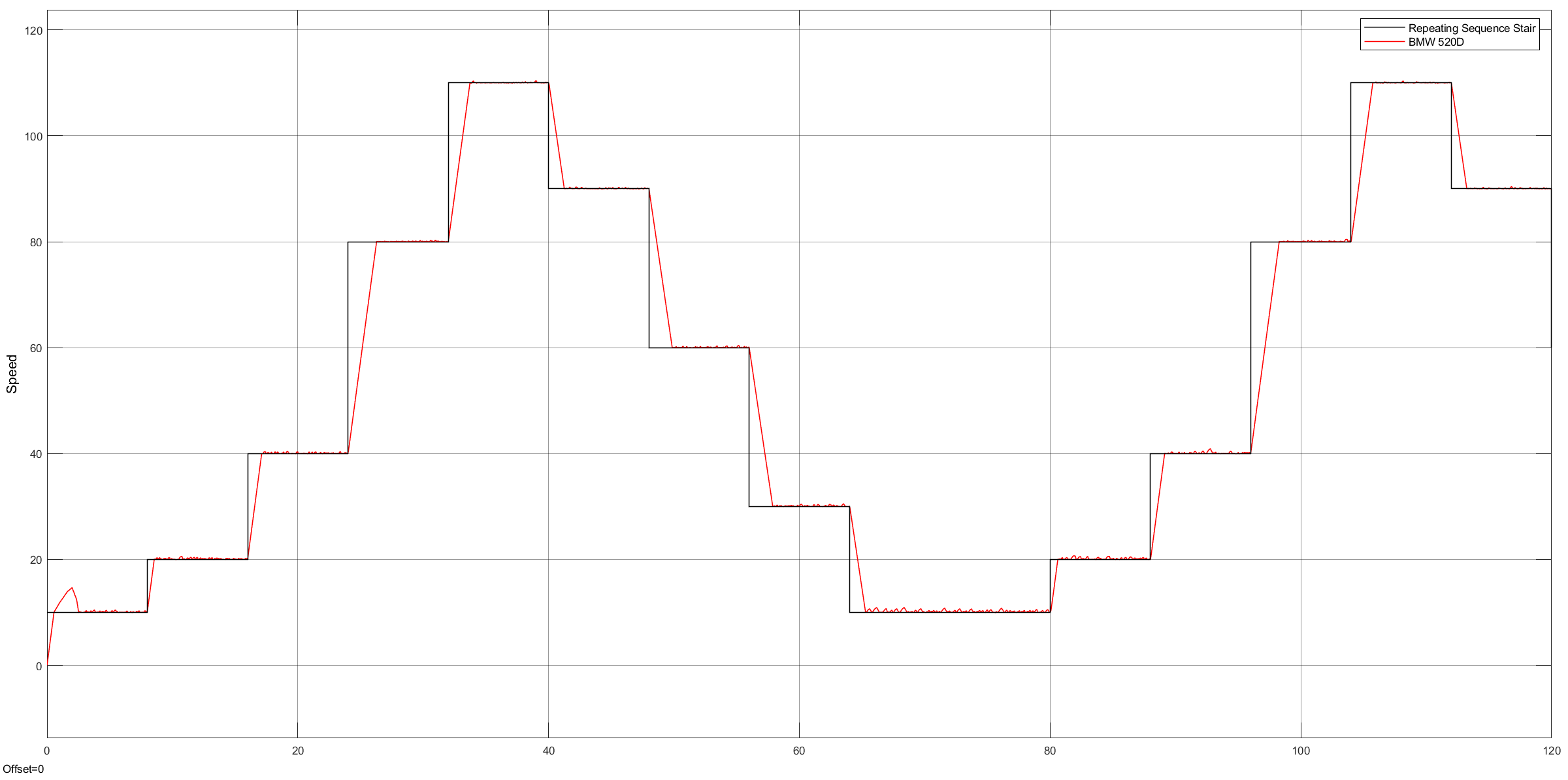
## Fuzzy P Controller design for BMW 520D (Gaussian Membership functions)

Flat road scenario

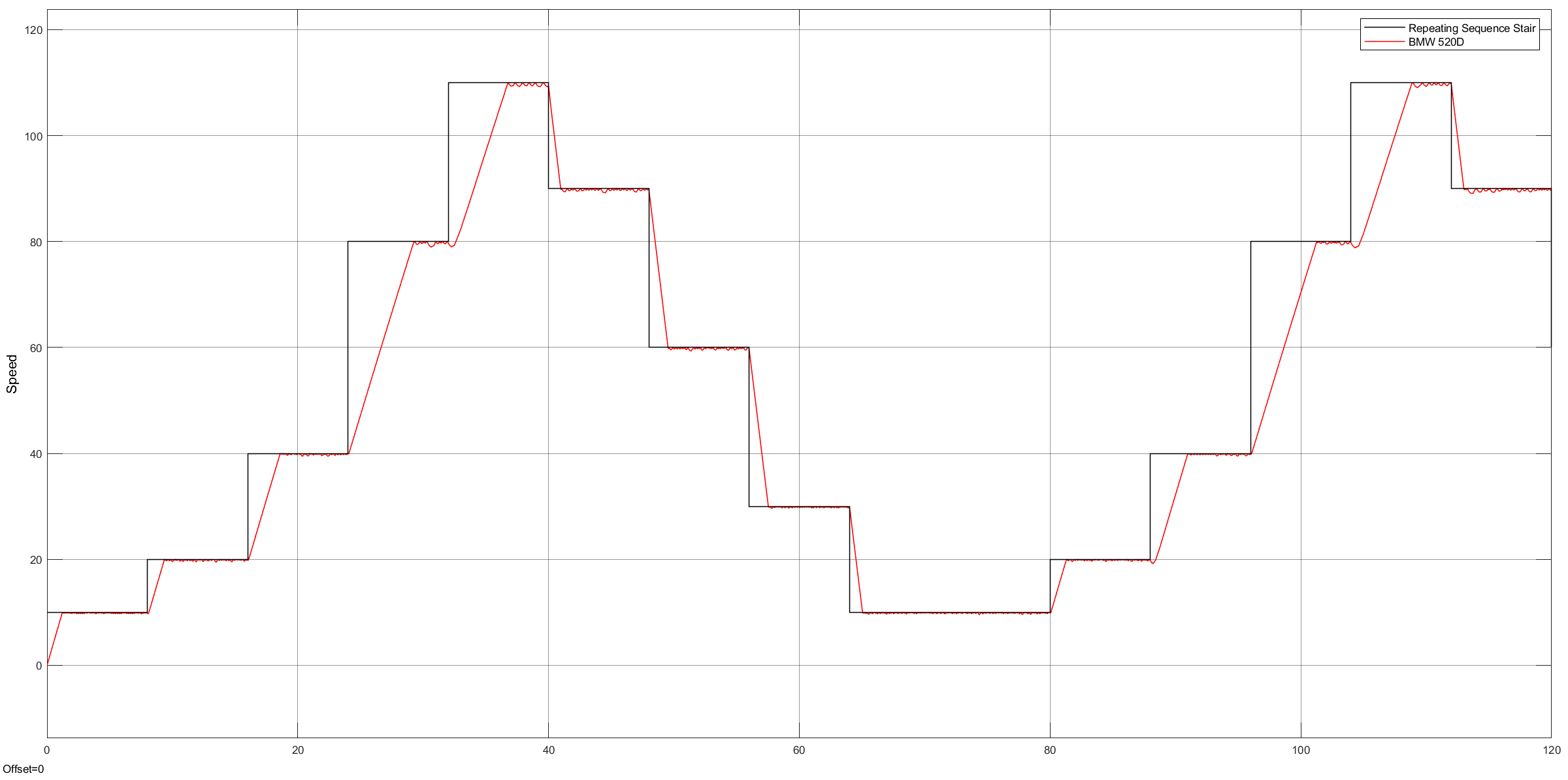


Uphill scenario

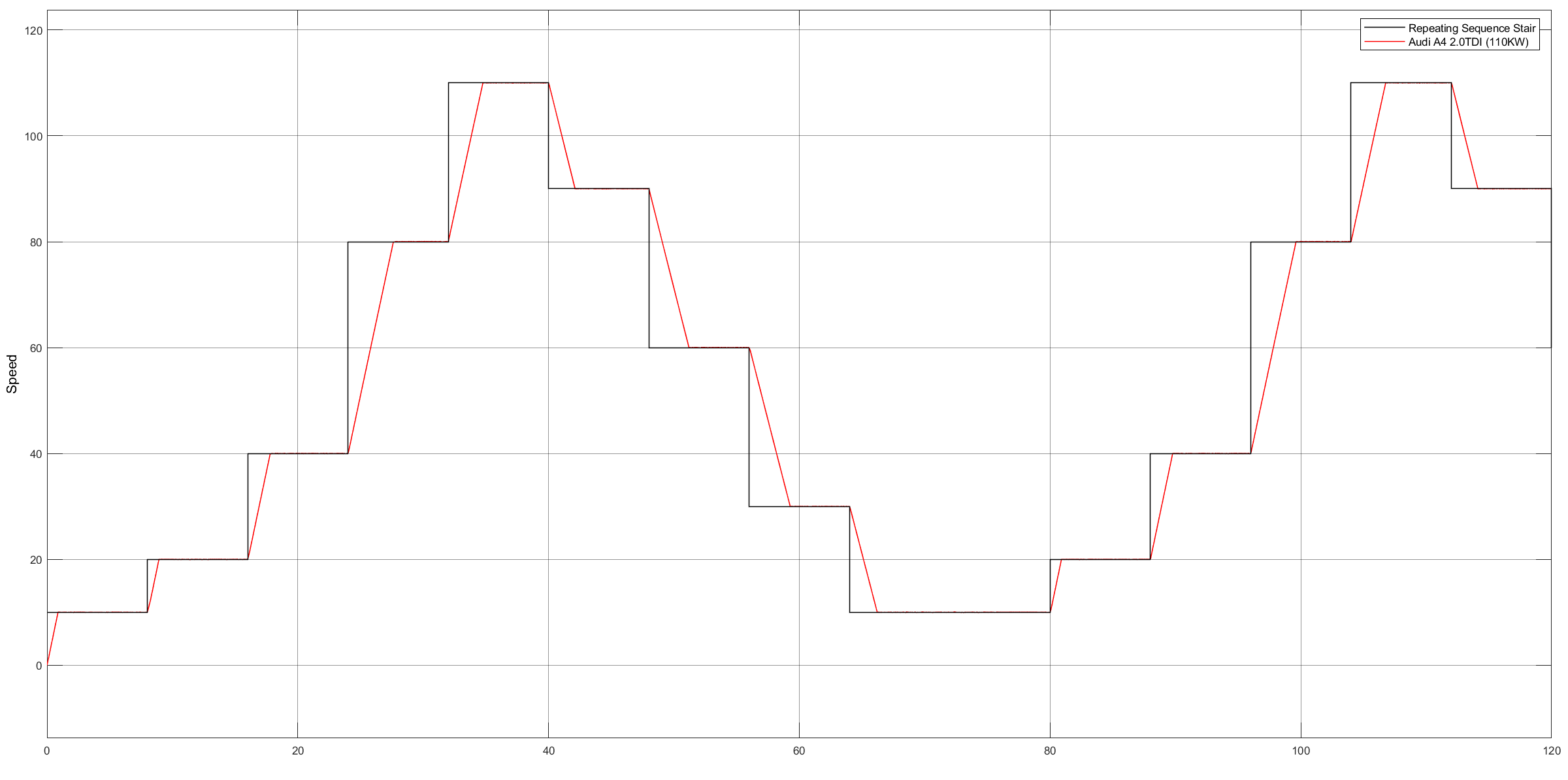
## Fuzzy P Controller design for BMW 520D (Triangular Membership functions)

Flat road scenario

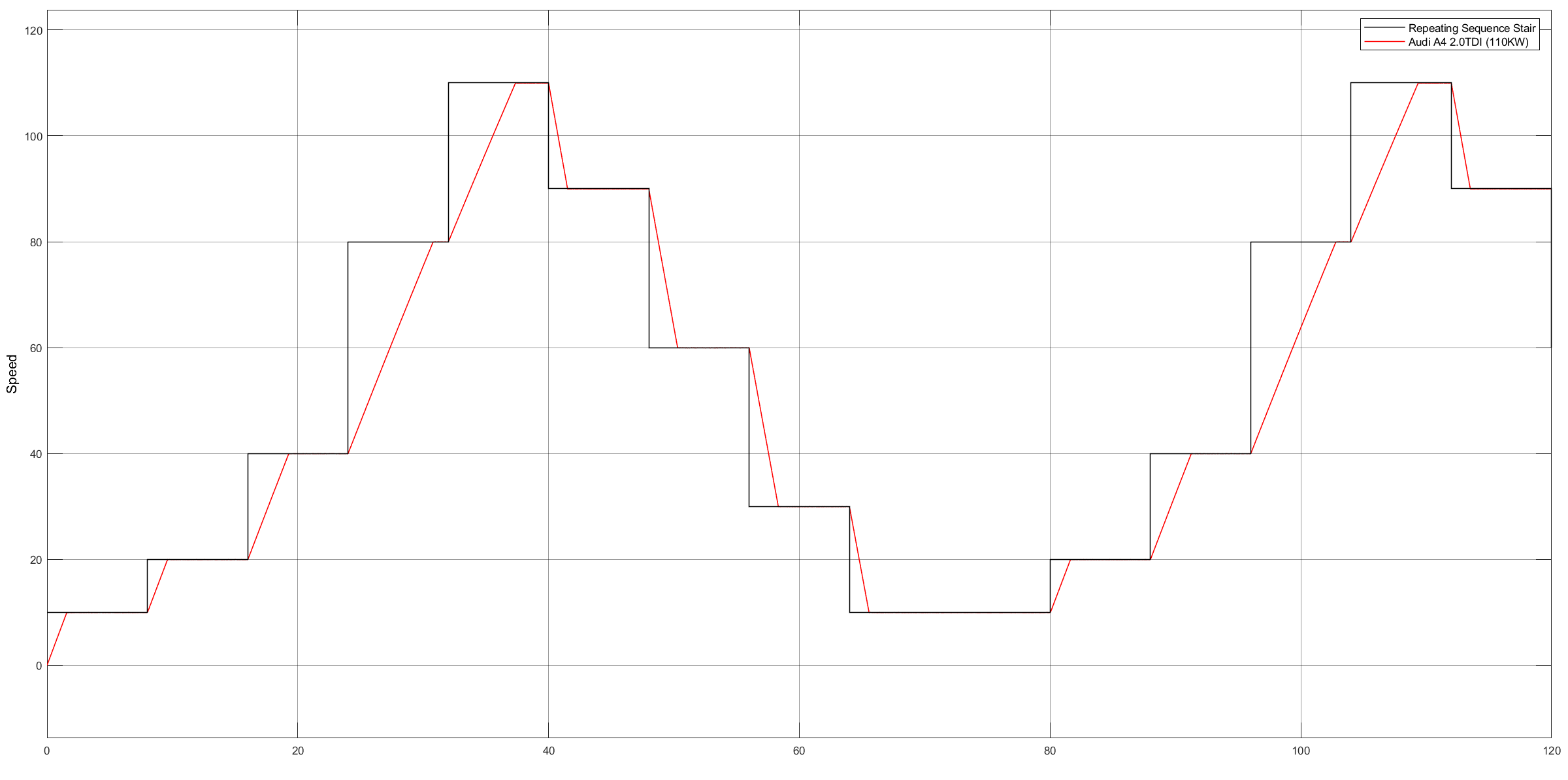
Uphill scenario



## Fuzzy P Controller design for Audi A4 2.0 TDI (Triangular Membership functions)

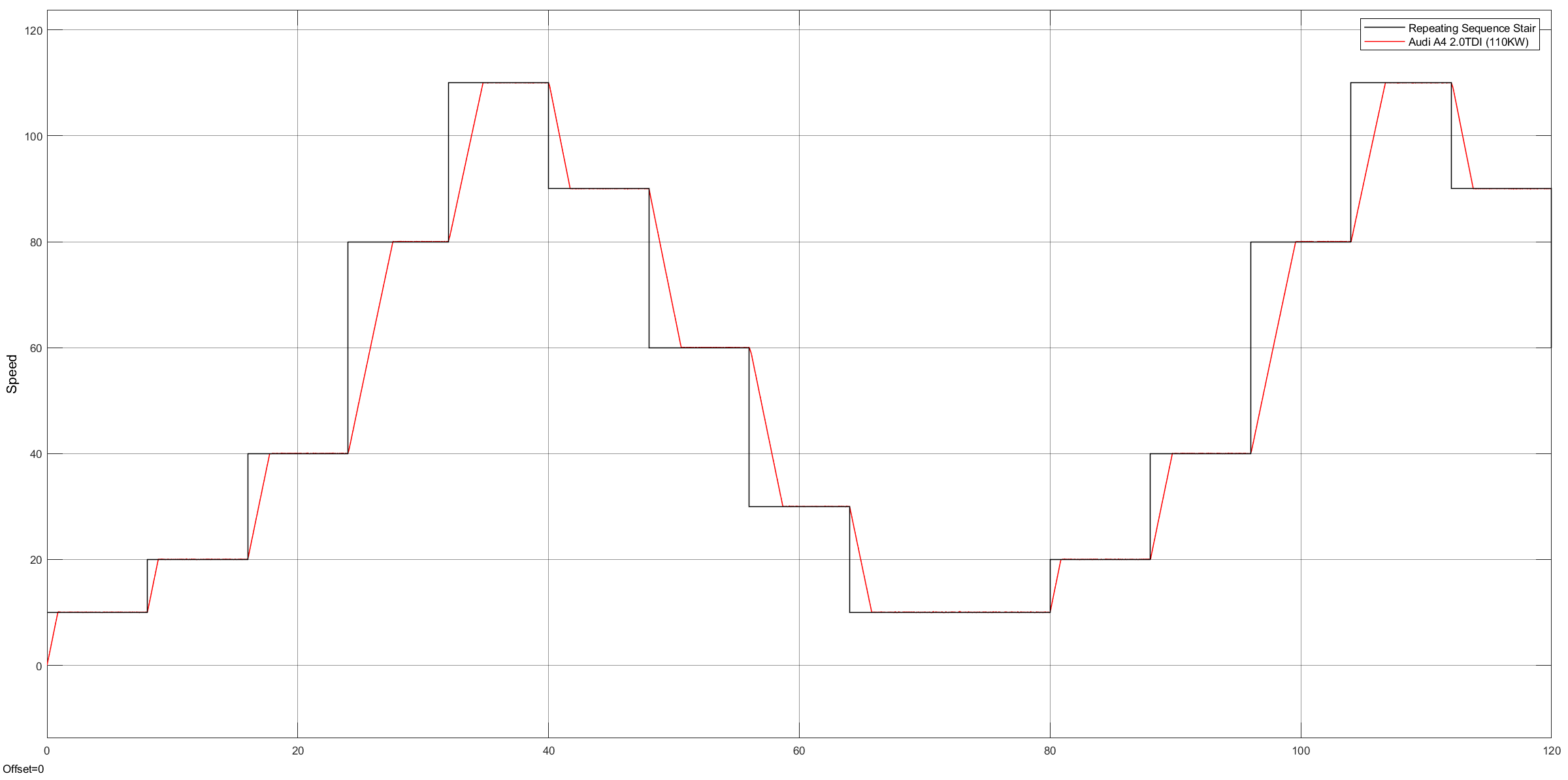
Flat road scenario 

Uphill scenario

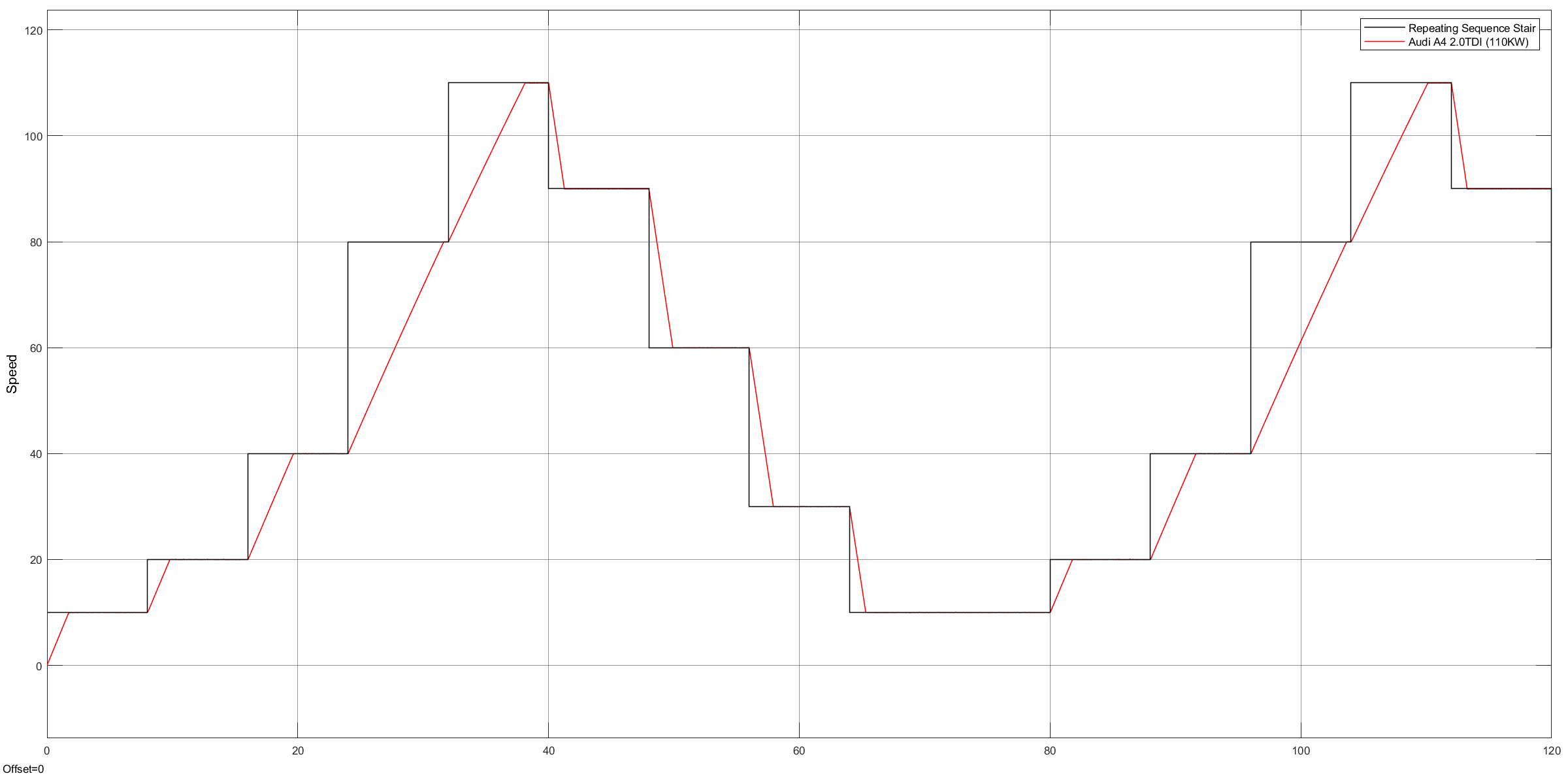


## Fuzzy P Controller design for Audi A4 2.0 TDI (Gaussian Membership functions)

Flat road scenario



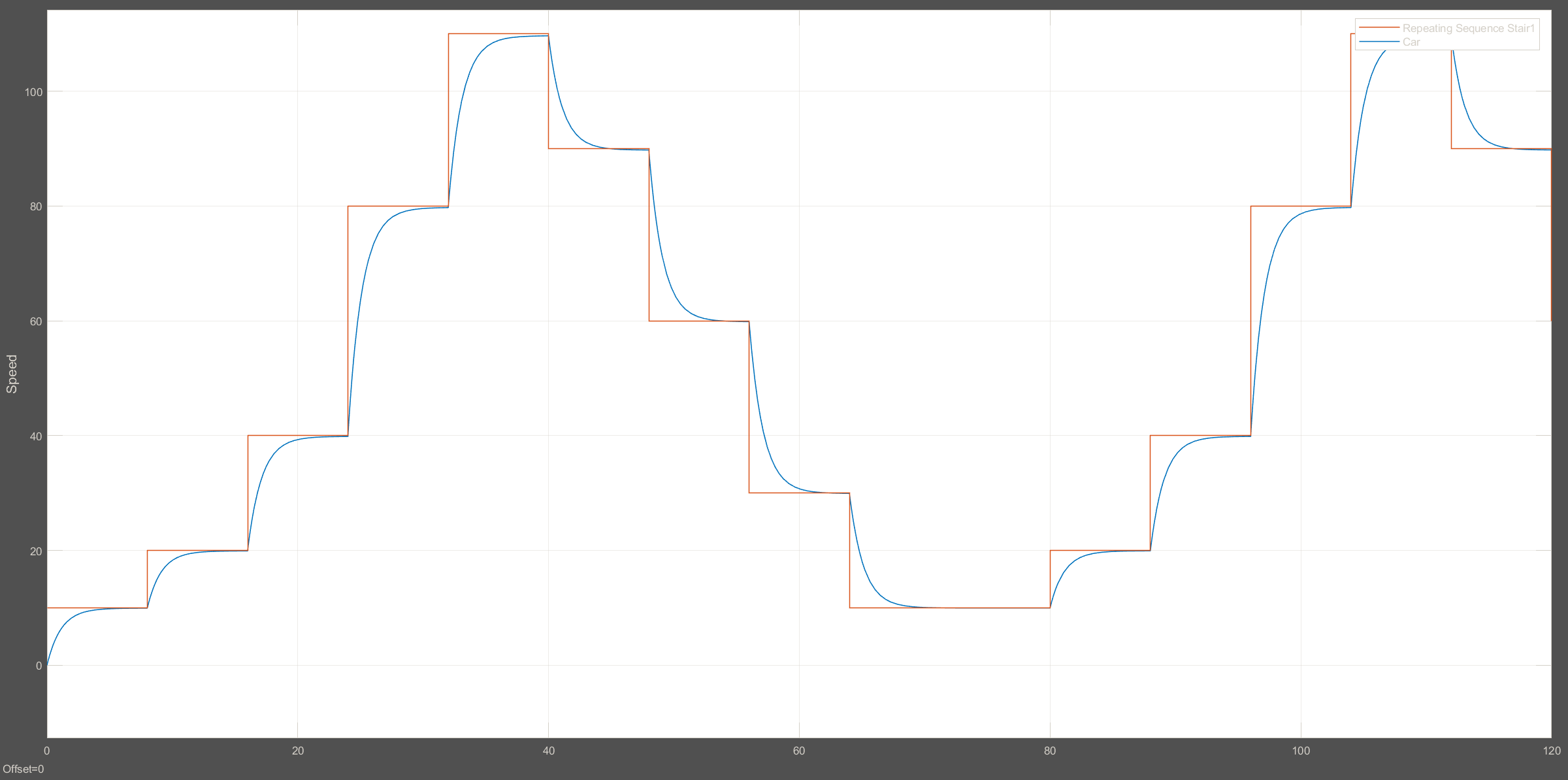
Uphill scenario



PID Controller in average car

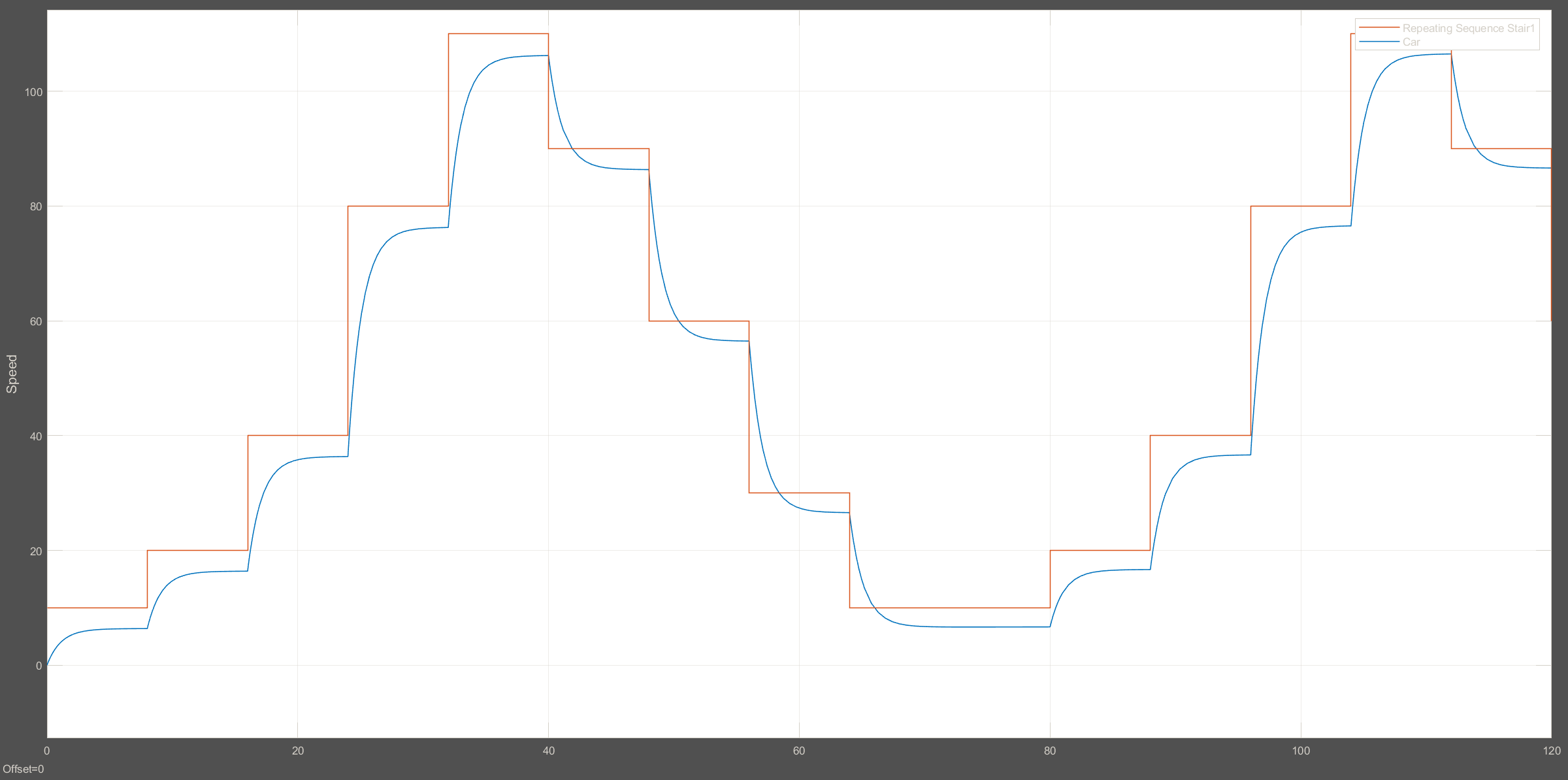
Flat road scenario

[Kp, Ki, Kd] = [900, 1, 5]

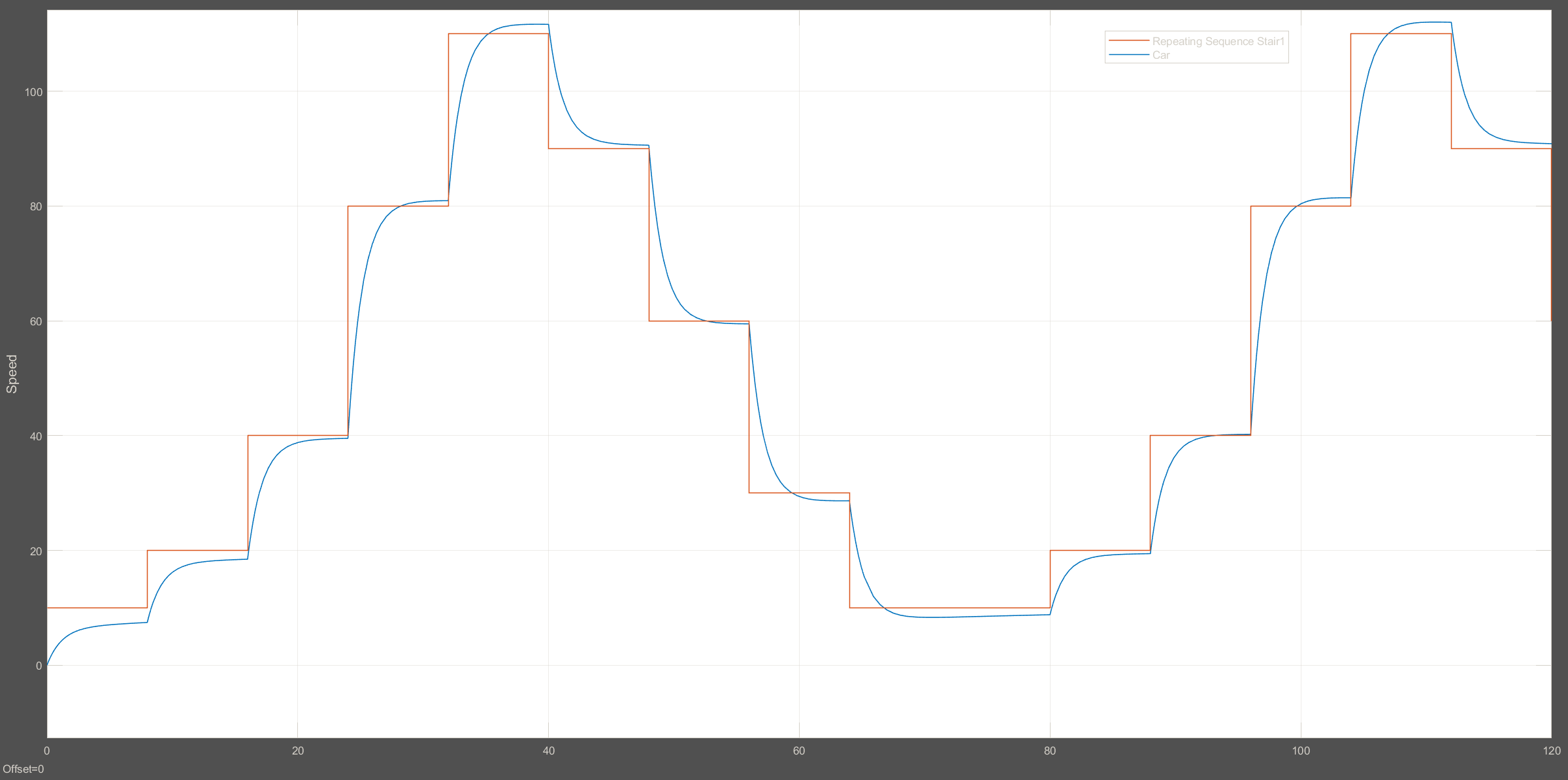


Uphill Scenario

[Kp, Ki, Kd] = [900, 1, 5]



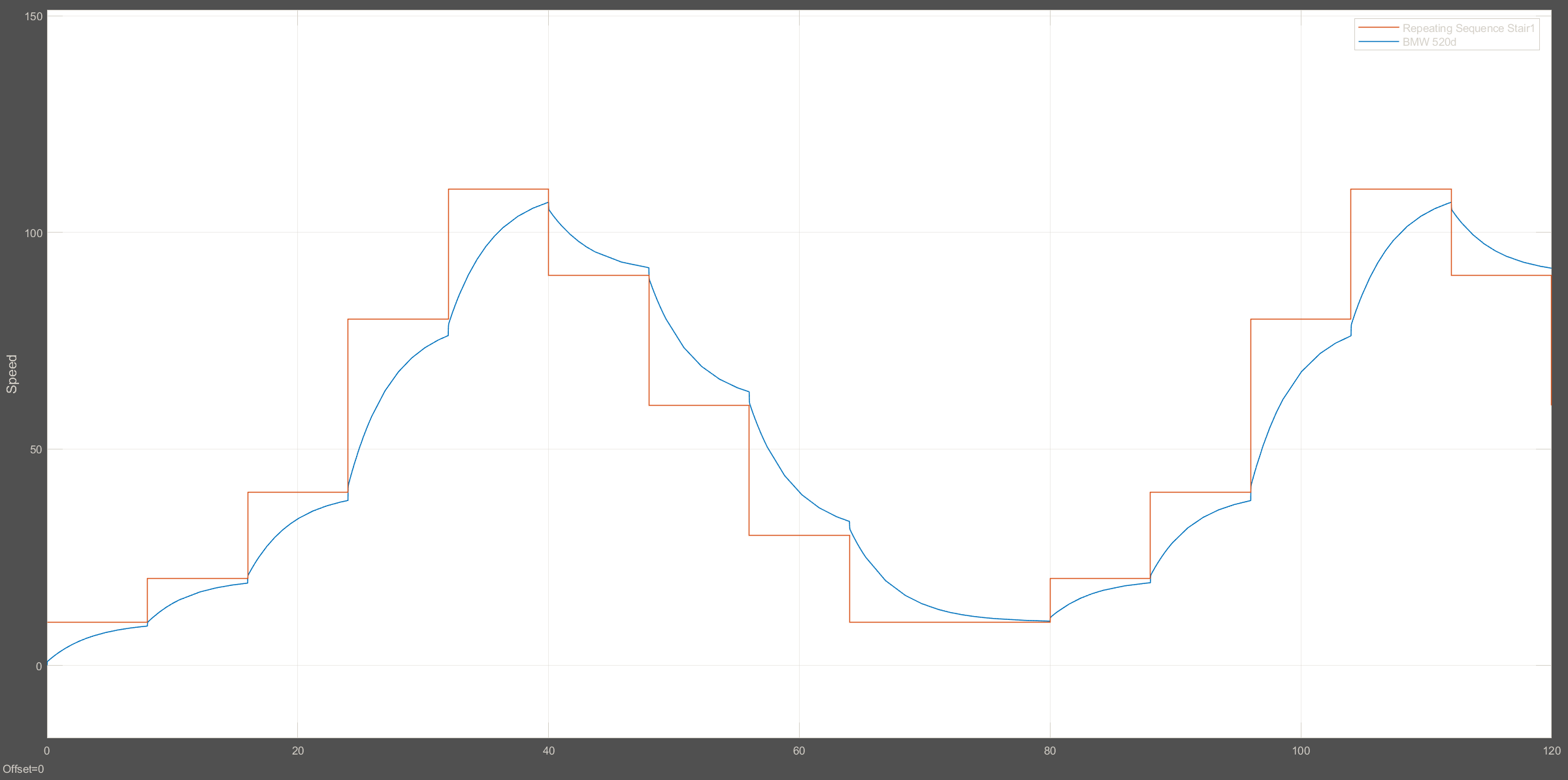
[Kp, Ki, Kd] = [900, 35, 5]



PID Controller design for BMW 520D

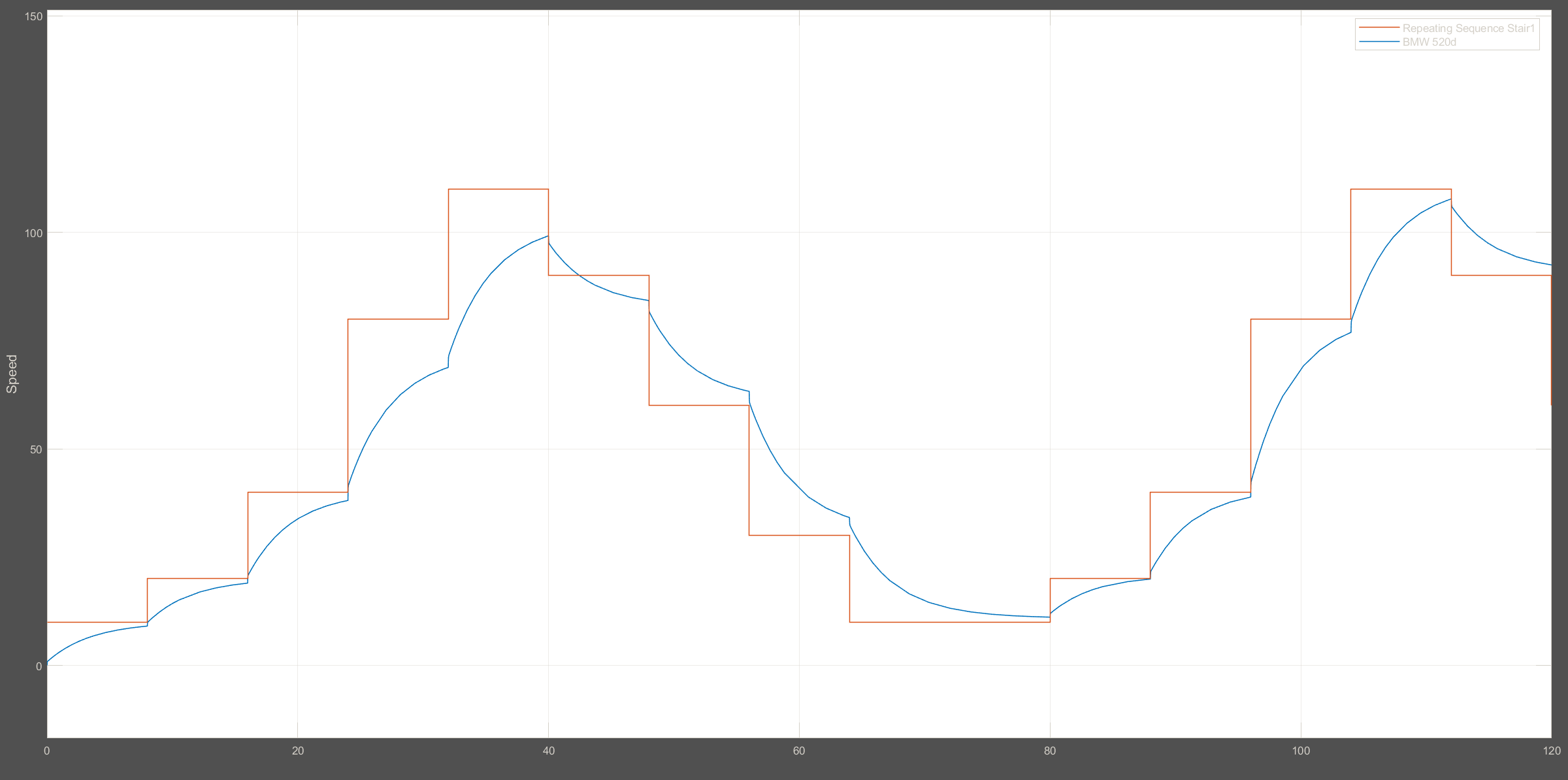
Flat road scenario

[Kp, Ki, Kd] = [178, 1, 50]



Uphill Scenario

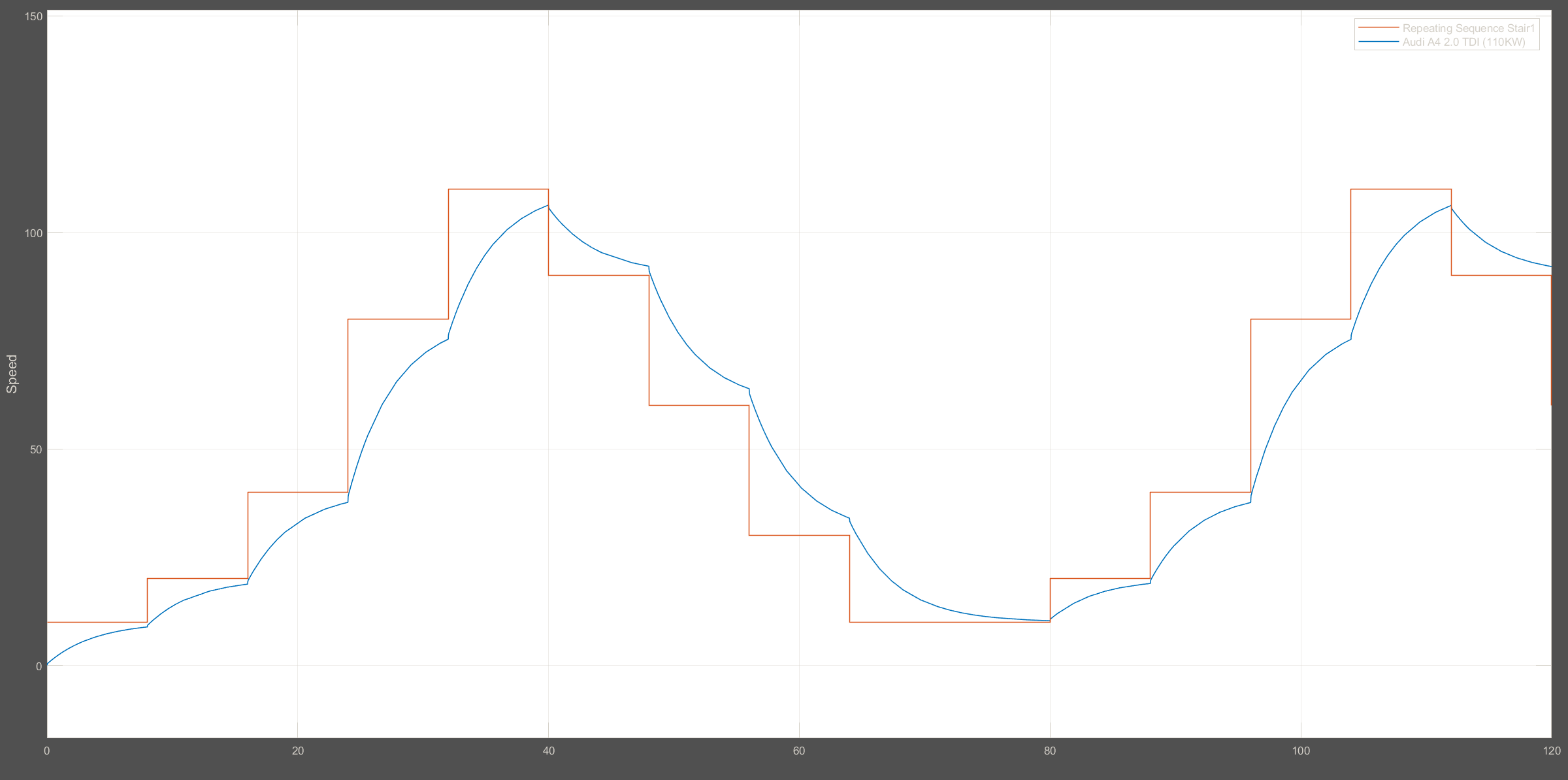
[Kp, Ki, Kd] = [178, 1, 50]



PID Controller design for Audi A4 2.0 TDI

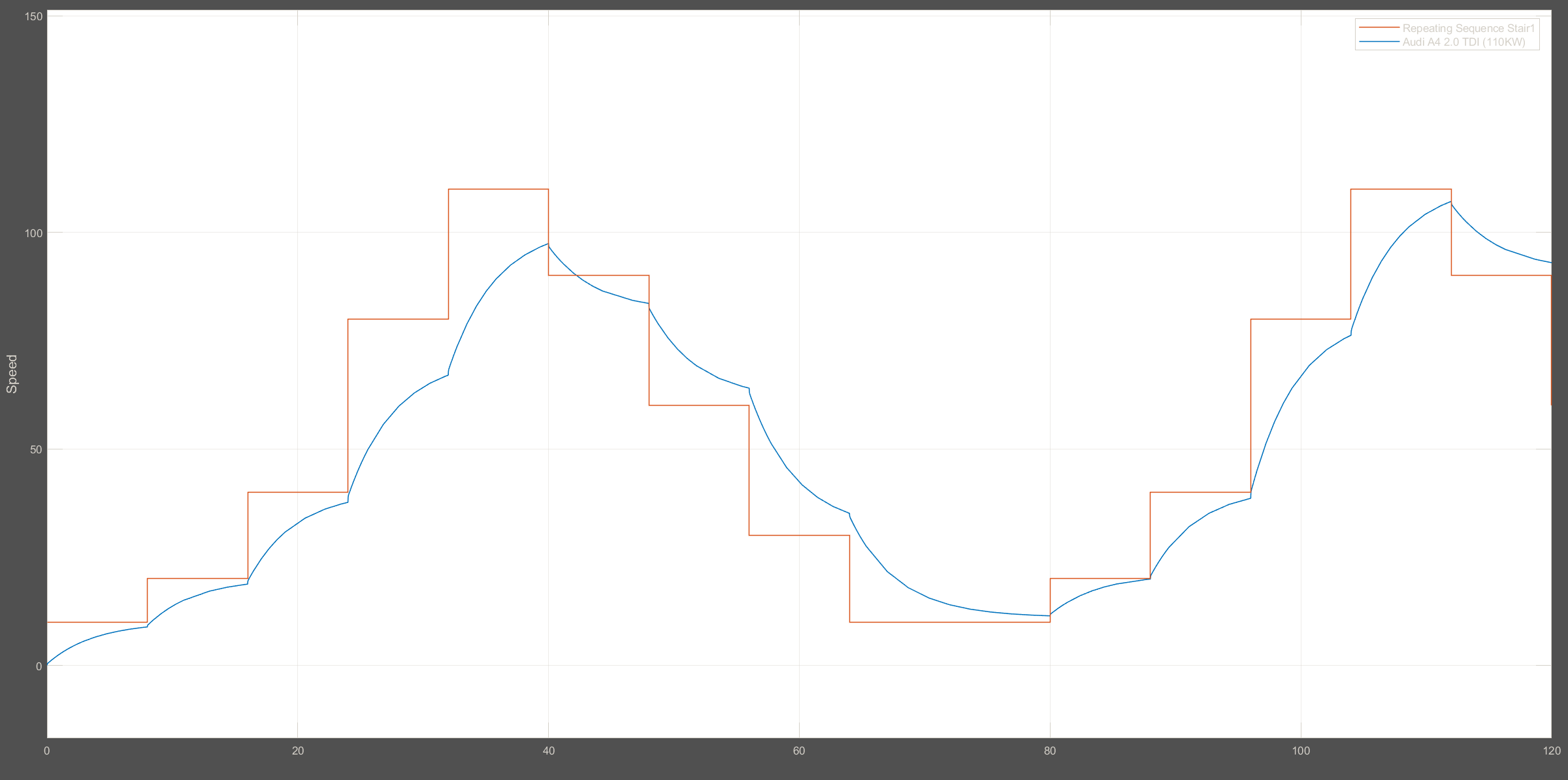
Flat road scenario

[Kp, Ki, Kd] = [165, 1, 20]



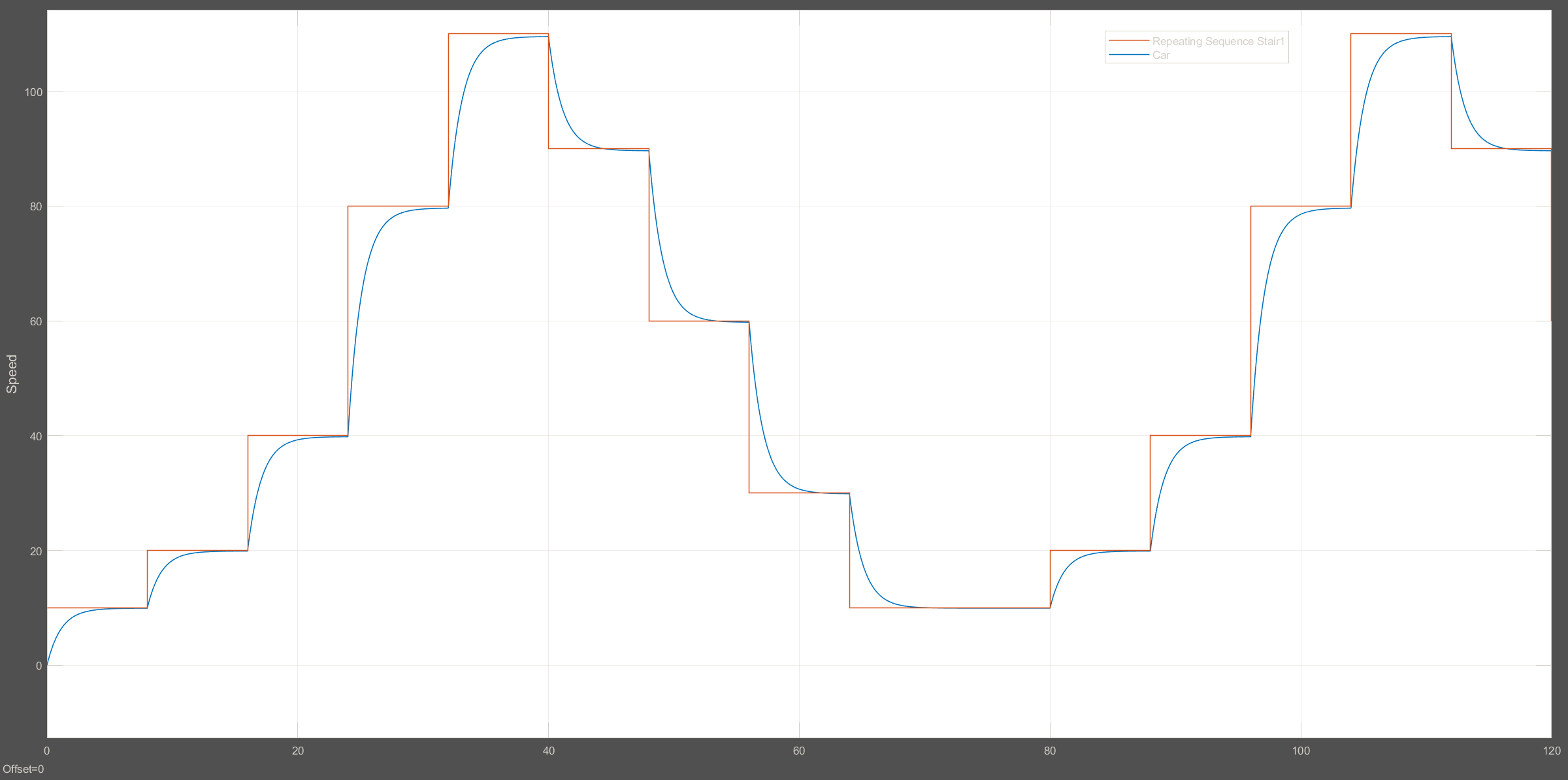
Uphill Scenario

[Kp, Ki, Kd] = [165, 1, 20]



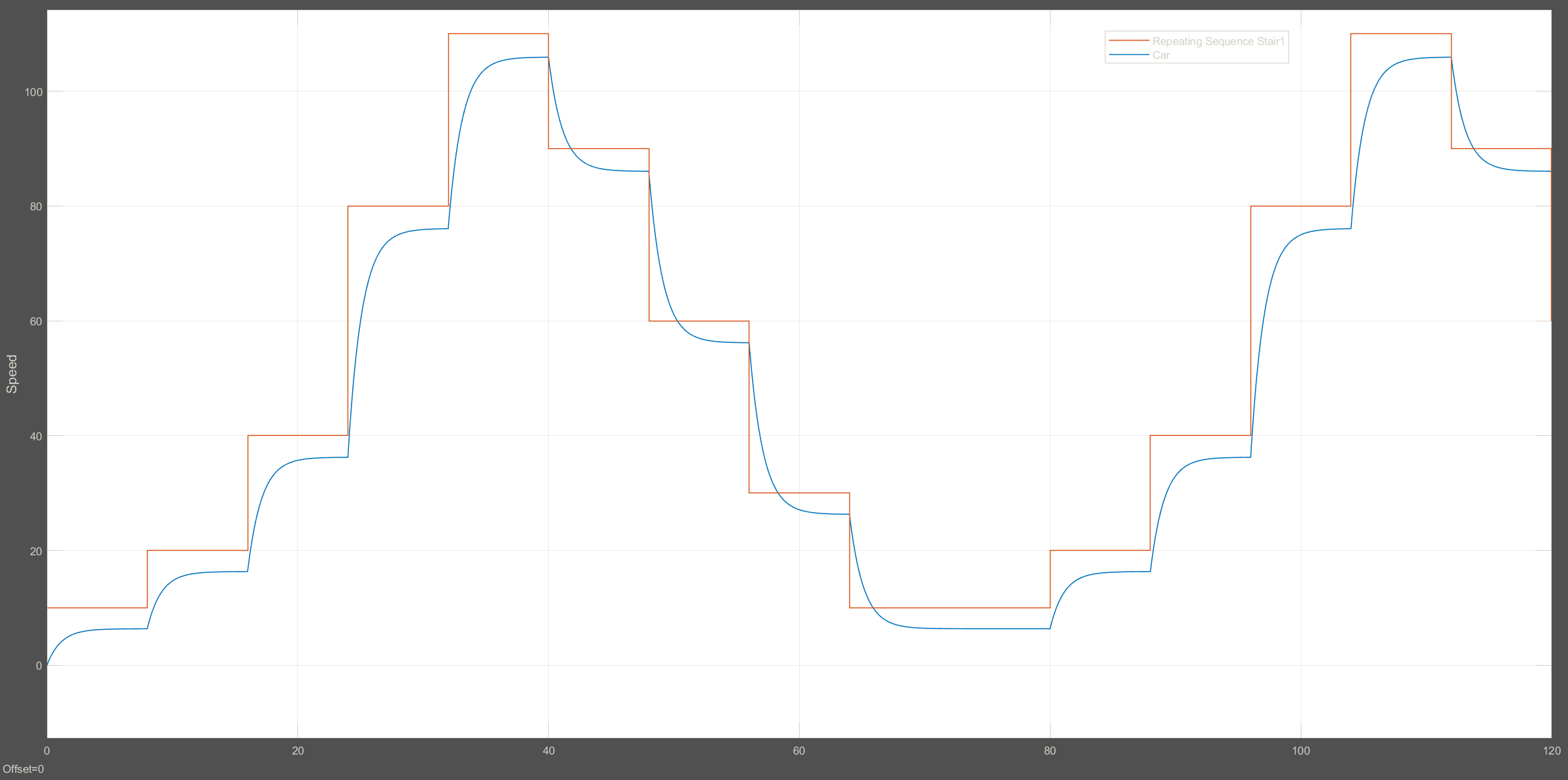
## PD Controller design for an average car

Flat road scenario



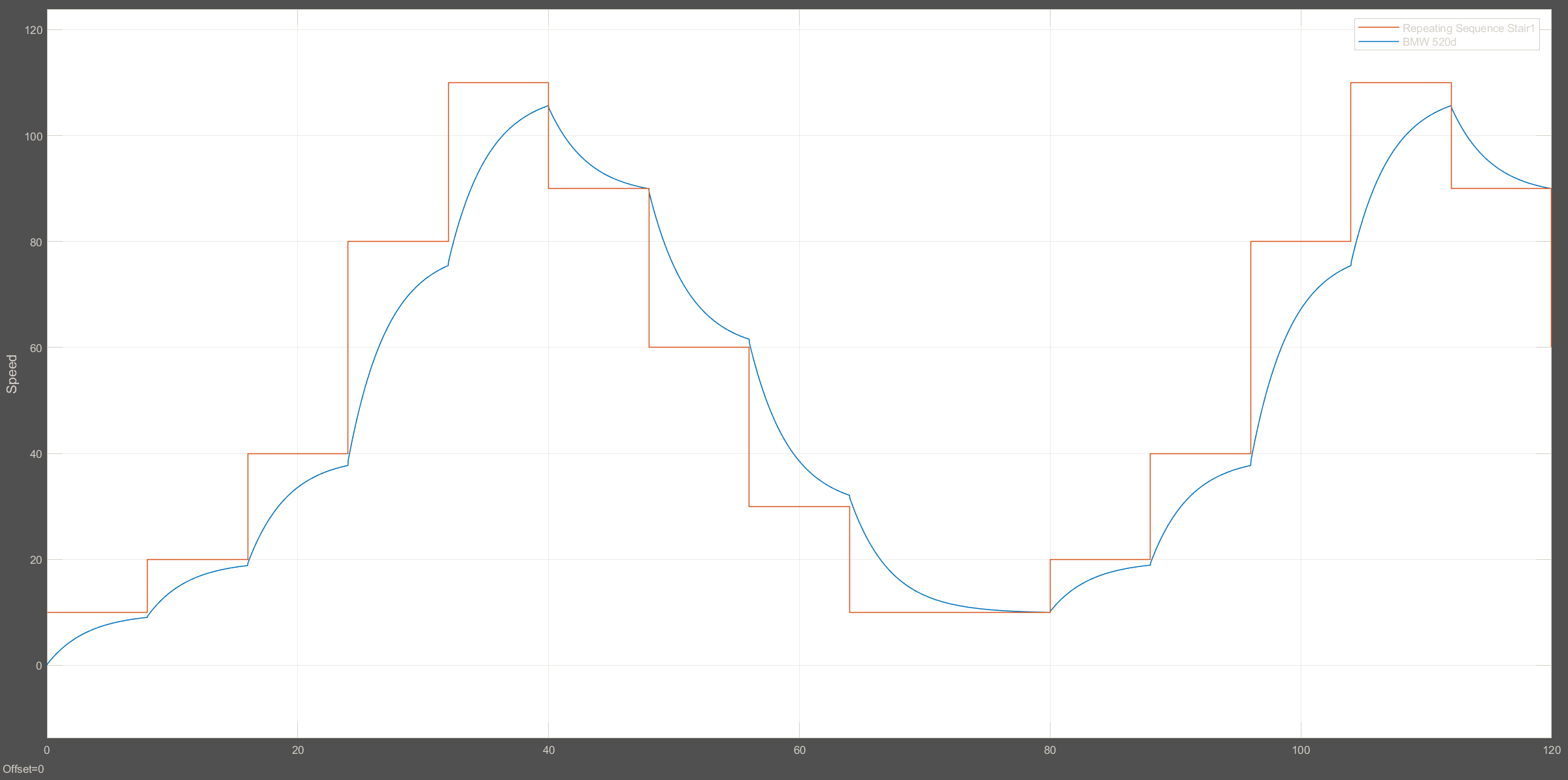
Uphill scenario

[Kp, Kd] = [900, 5]



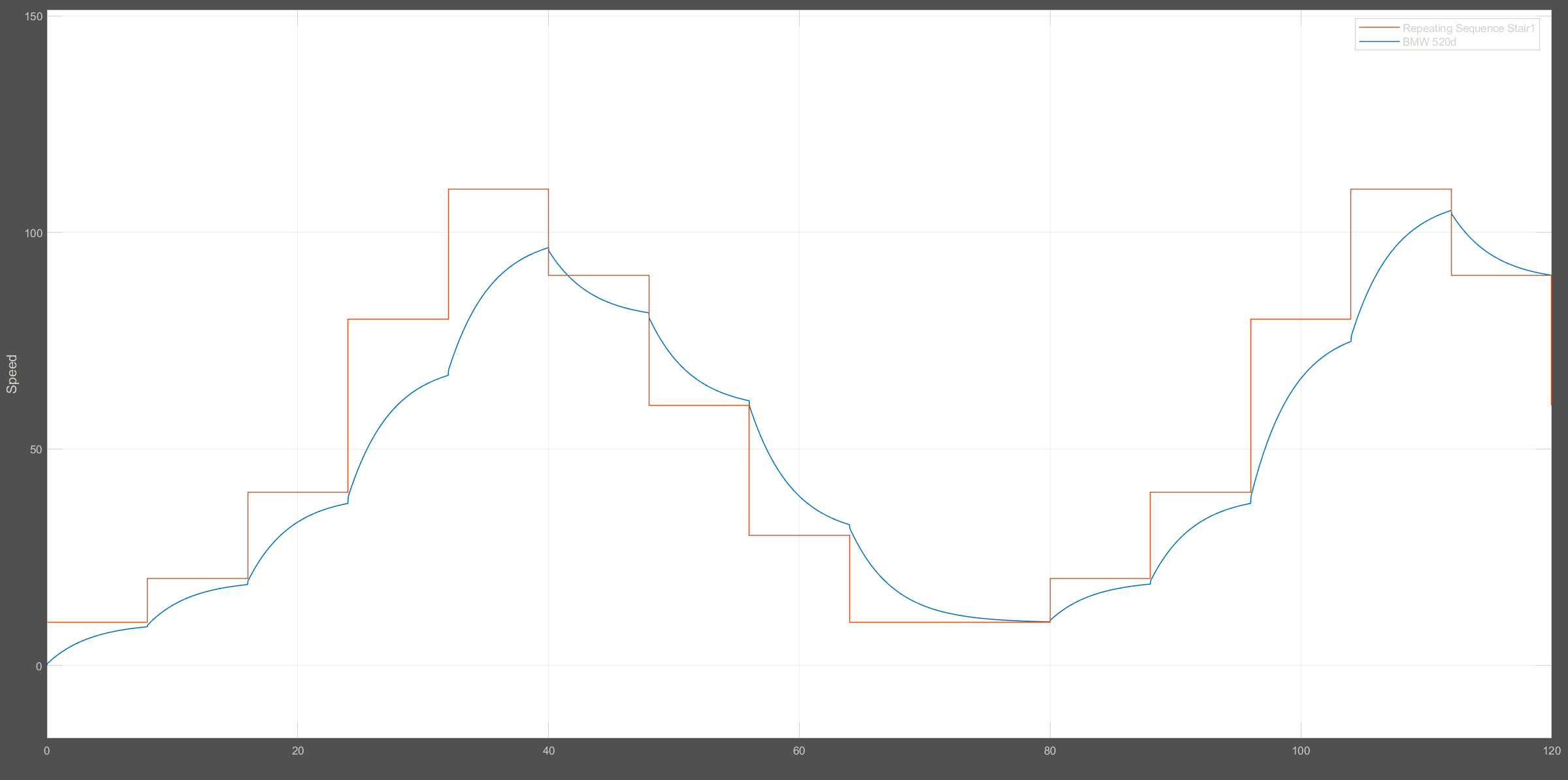
PD Controller design for BMW 520d

Flat road scenario

[Kp, Kd] = [180, 10]

Uphill scenario

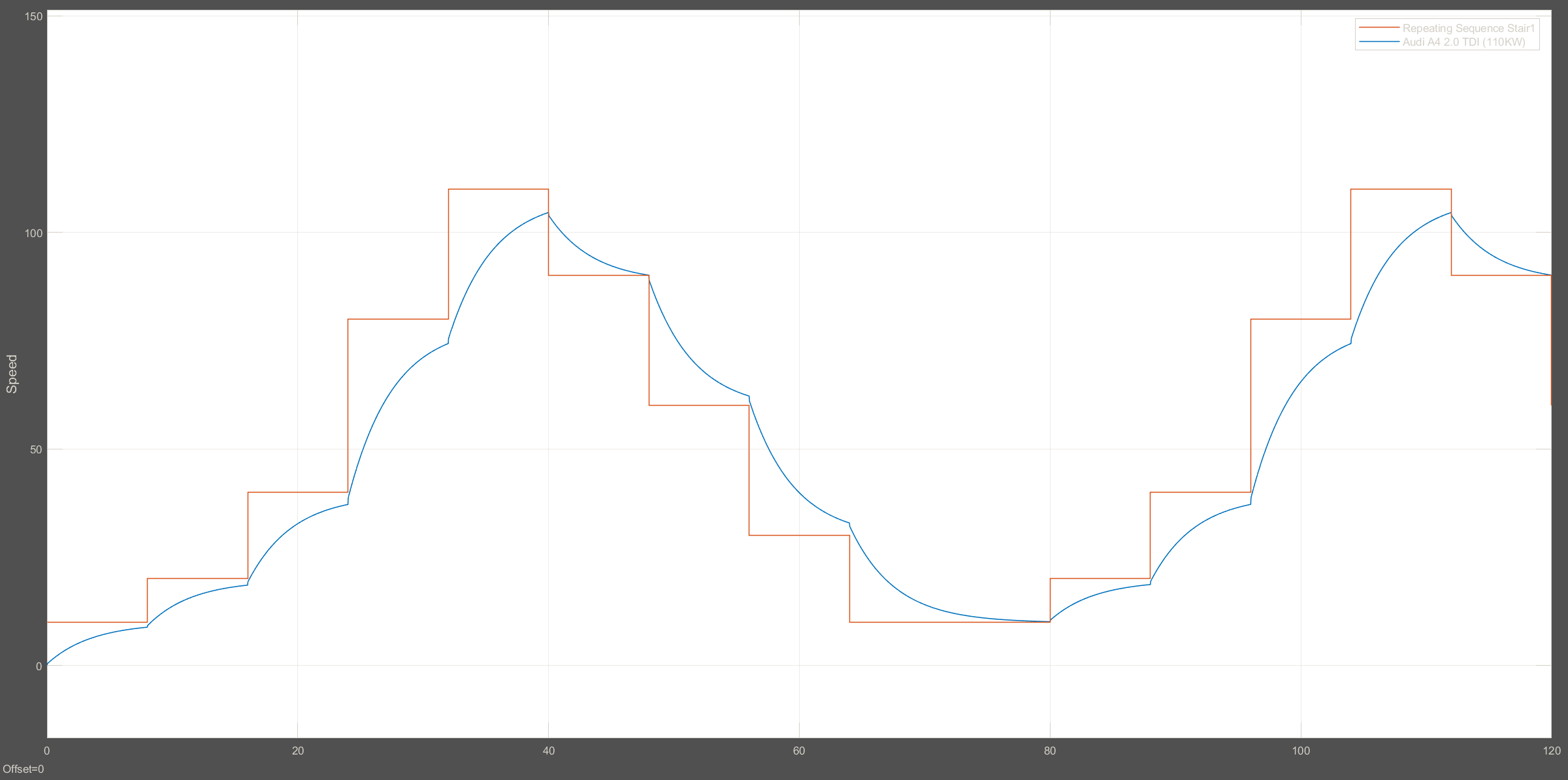
[Kp, Kd] = [180, 10]



PD Controller design for Audi A4 2.0 TDI

Flat road scenario

[Kp, Kd] = [170, 20]



Uphill scenario

[Kp, Kd] = [170, 20]

