

## Shuttle Cycle Time

*Purpose: This application note presents the results of measuring the amount of time it takes a vehicle to navigate a shuttle node.*

### Introduction

The time it takes for a vehicle to move through a shuttle node depends on many parameters, including position and velocity arrival tolerances, control loop settings, friction of the system components, and others. The results listed in this application note are for a specific system with specifically defined parameters. Each system is unique and the shuttle cycle time for your track system should be determined separately.

### Details

Time measurements were taken using the log files of the High Level Controller, with Vehicle and Info turned on. The log files report the time and position of a vehicle at every 100 milliseconds, and also report when the vehicle has arrived at its commanded destination.

The shuttle system used to take measurements consists of two straight paths with 3 x 1 meter QuickStick 100's, two shuttle drive paths with 1 x 1 meter QuickStick 100's and two move paths with 1 x ½ meter QuickStick 100's. (See Figure 1)

The shuttle move path moves a distance of 0.4995 m between points A and B. Point A is at position 0.730 m on the drive path and Point B is at position 0.2305 m. (See Figure 1)

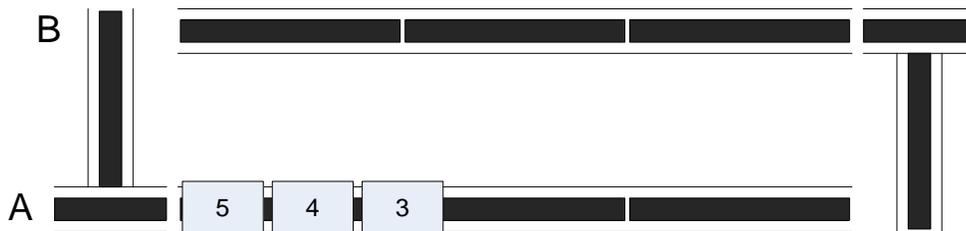


Figure 1: Top view of the shuttle system used for measurements

### Vehicle movement

All vehicles were commanded to position 2.8 m on Path 1, then to position 0.202 m on Path 2 (the move path) and finally position 2.8 m on Path 3. When the first vehicle (Vehicle 5) arrived at position 2.8 m on Path 1, it was commanded to wait several milliseconds so that the remaining vehicles could queue behind it.

The position of 0.202 m on Path 2 was calculated to be the shortest distance into the move path that the vehicle could move and be considered “clear” of the node so that the move path could move to position B.

Once Vehicle 5 moved onto the shuttle, the remaining vehicles continued their movements through the shuttle node (see Figure 2).

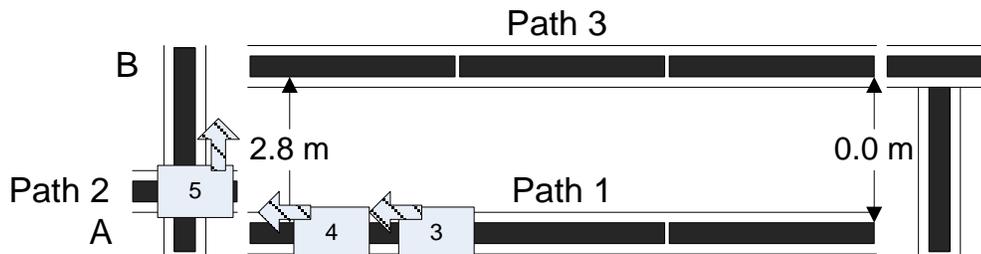


Figure 2: Vehicles moving

### Node Controller Configuration Settings

The following tables show the parameter settings that were defined to achieve the move times reported in the results section. Different parameter settings would achieve different results.

Table 1: General Parameter Settings

Parameter	Value
Shuttle Auto Return	True
Node Look Ahead Count	1
Move on Vehicle Clearance (shuttle nodes)	True

Table 2: Shuttle System Drive Path Parameter Settings

Parameter	Value	Units
Acceleration Limit	10	m/s <sup>2</sup>
Velocity Limit	5	m/s
Arrival Position Tolerance	0.001	m
Arrival Velocity Tolerance	0.010	m/s
Shuttle (move path) Mass	31.75	Kg
Shuttle (move path) Length	0.420	m

Magnet Array Type	8 cycle, Standard F	
Control Loop, Kp	200	N/m
Control Loop, Ki	1	N/(m-s)
Control Loop, Kd	12	N/(m/s)

**Table 3: Shuttle System Move Path and Main Path Parameter Settings**

Parameter	Value	Units
Acceleration Limit	10	m/s <sup>2</sup>
Velocity Limit	5	m/s
Arrival Position Tolerance	0.010	m
Arrival Velocity Tolerance	0.010	m/s
Vehicle Length	0.360	m
Vehicle Mass	7.8	Kg
Magnet Array Type	5 cycle, Standard F	
Control Loop, Kp	600	N/m
Control Loop, Ki	3	N/(m-s)
Control Loop, Kd	37	N/(m/s)
Keepout Area (Paths 1 and 3)	After 0.960 on motor 3	m

## Results

The time was measured for Vehicle 4 and Vehicle 3 from the time point where they were reported as arrived at position 2.8 m on Path 1 to the time point where they were reported as arrived at position 2.8 m on Path 3. (See figure 2)

The time for Vehicle 4 and Vehicle 3 to navigate from position 2.8 m on path 1 to 2.8 m on path 3 through the shuttle node ranged from 1.5 seconds to 2.1 seconds.

## Summary

The time for a vehicle to navigate a shuttle node depends on many parameters, as seen in the previous sections. The time can be improved or by changing any one of these parameters. If you have not optimized your system by finding the best control loop parameters, minimum keepout areas, minimum distance the vehicles need to move into the moving path, as well as other parameters, you will not be able to achieve the best move time through a shuttle node for your system.

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### More Information

MagneMotion Website: [www.magnemotion.com](http://www.magnemotion.com)

Questions & Comments: <http://www.magnemotion.com/about-magnemotion/contact.cfm>