



**Michigan
Technological
University**

MEEM 5812: Automotive Control Systems

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Project – 3

Optimal Idle Speed Control of a Spark Ignition Engine

By

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1. What are the equilibrium states for the idle speed control system?

Ans. The equilibrium states for the idle speed control system are as follows:

1. Throttle input (U_a) = 0.06213
2. Intake Manifold Pressure (P_i) = 38900

2. What is the final linearized plant model?

Ans. The final linearized plant model is:

$$X = \begin{bmatrix} 0.2168 & 0.02329 & 0 & 0 \\ -140 & -2.1911 & 0 & 0 \\ -1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

$$Y = \begin{bmatrix} 0 & 15 \\ 1.4e6 & 0 \\ 0 & 0 \\ 0 & -1 \end{bmatrix}$$

3. What happens when the state weighting matrix is increased by a factor of 2. What happens to the state trajectories? What happens to the control trajectories?

Ans. When the state weighting matrix is increased by a factor of 2, we observe the following effects:

- a) The Spark timing changes by a minimal amount from the range of [-19.5 to -20.07] to [-19.9 to -20.05] that is, the spark timing decreases
- b) The throttle input remains the same, that is there is no effect
- c) Engine speed increases from 605 to 620.

4. What happens when the control weighting matrix is increased by a factor of 10. What happens to the state trajectories? What happens to the control trajectories?

Ans. When the control weighting matrix is increased by a factor of 10, following changes are observed:

- a) The Spark timing changes drastically and becomes unstable and gets out of range.
- b) There are no changes in observed in throttle input.
- c) Engine speed range changes drastically in the range of 850 to 450