Controller for Remote Car Starter

BY: Nazmul Hoque, Samuel Elgert & Kieren O'Neil

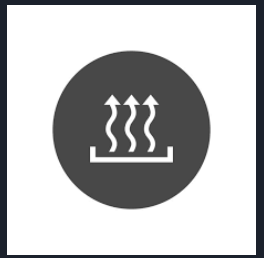
Introduction

- Cars have to put up with a lot in Canada
  - Cars must work in freezing cold temperatures during the winter
  - Canadians drive their cars further than the OECD (Organisation for Economic Co-operation and Development) average distance per car per year

- Remote Car Starters
  - Many Canadians use remote car starters to combat these conditions
  - Remote Car Starters allow owners to start their cars engine, heaters, and control the car locks from the comfort of a warm building
- Problem Definition: Design and create an automatic remote car starter whose operations are data-driven.

Functions

- Must lock and unlock the car doors
- Must lock and unlock the car trunk
- Must start and turn off the engine of the car
- Must start and turn off the heater of the car
- Must indicate the status of the trunk, doors, engine, and heater of the car

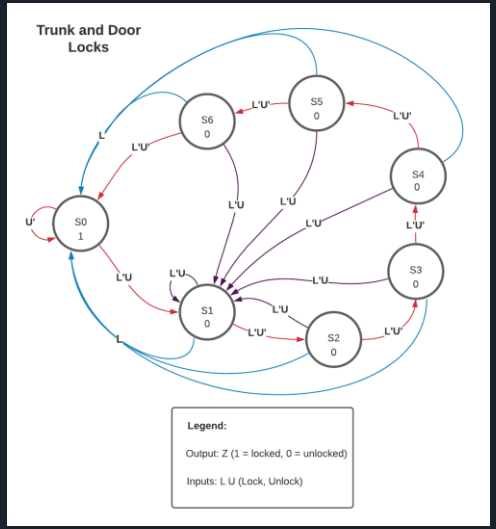


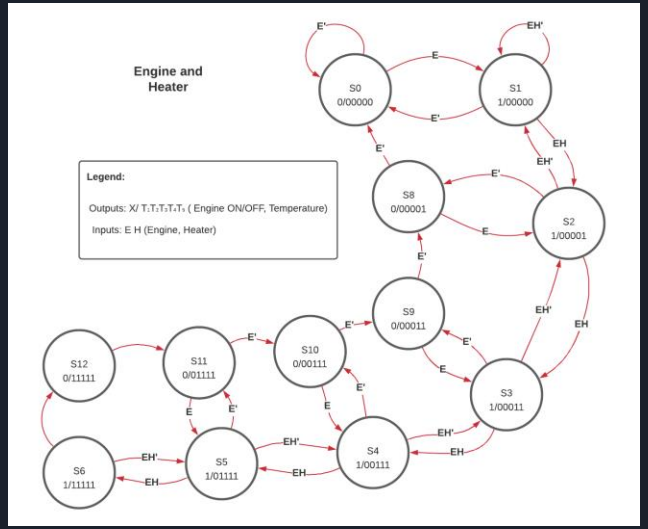
Objectives, Quality Attributes and Constraints

- Efficiency: The remote control must consume minimal fuel by automatically turning off the engine when the car is idle for 2 minutes.
- Reliability: The controller must work 24/7, 365 days without any issues.
- Security: The controller must lock the car automatically if the user did not enter the car within 30 seconds.
- Usability: The remote control must be easy to navigate by the user with minimal effort.
- Scalability: The remote control must be able to be modified and upgraded in the future to add more features.
- Robustness: The remote control must be able to respond accordingly to unexpected input from the user.
- Safety: The remote control engine must turn off automatically if the engine heats up too much.
- Latches: Avoid unnecessary latches by making sure the conditions for each state are fulfilled

Solution 1

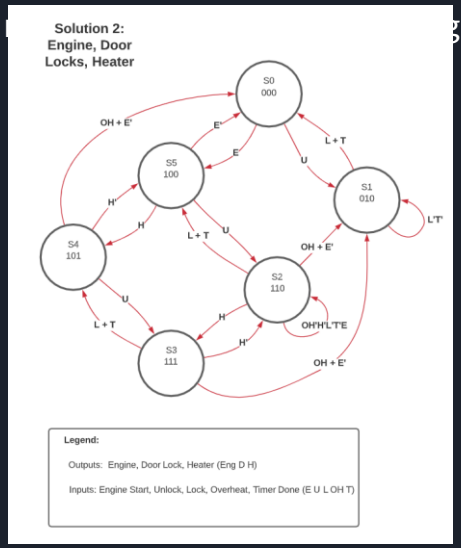
- Two separate state diagrams, one for Trunk and Door Locks and one for Engine and Heater control
- We upgraded to solution 2 because this design requires a lot of states to have a fast input response precision and sufficient timer length.

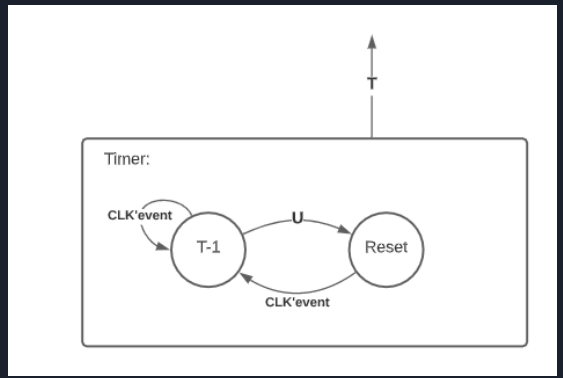




Solution 2

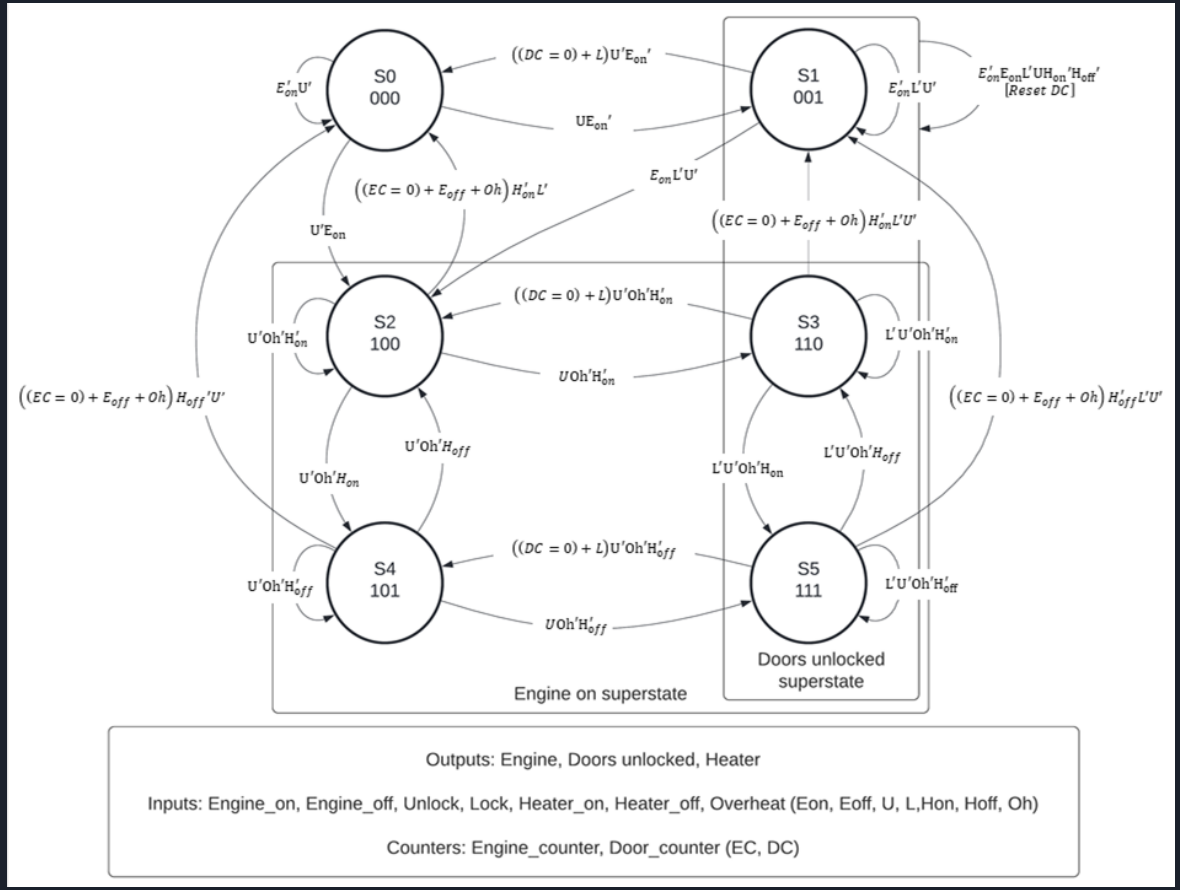
- Combined the two state graphs and added a common timer to trigger car lock and engine shut down.
- This solution does not have a way to shut the engine off after a certain period of time. It also less [illegible]ghly interconnected timer.





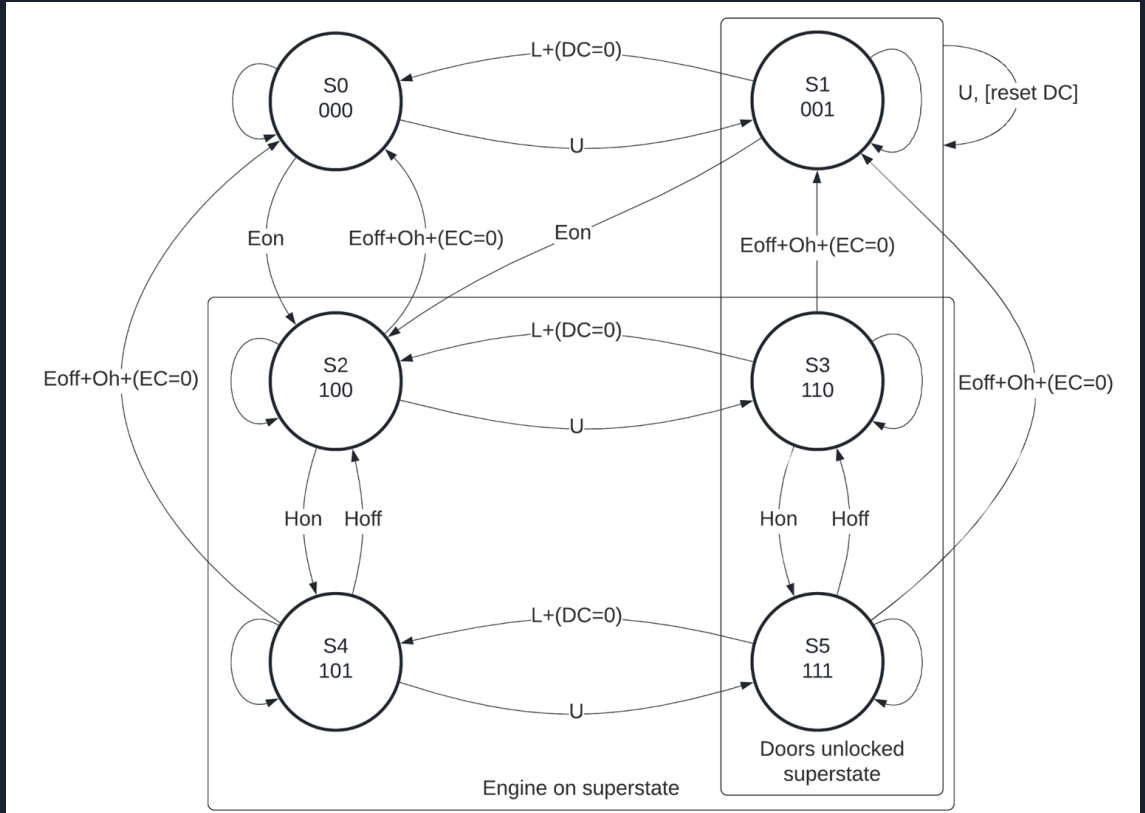
Final Solution

- Moore machine
  - Simplified implementation
  - Sped up testing
- Eliminated issues with previous solutions
  - Allowed the engine to be turned on from state 1
  - Added counter to shut engine off if it has been idling for more than 2 minutes
  - Counters run in superstates and are not reset on state transition
- Improved implementation
  - OR superstates run counters for locking doors and shutting off engine
  - Overlapping superstates improve counter functionality



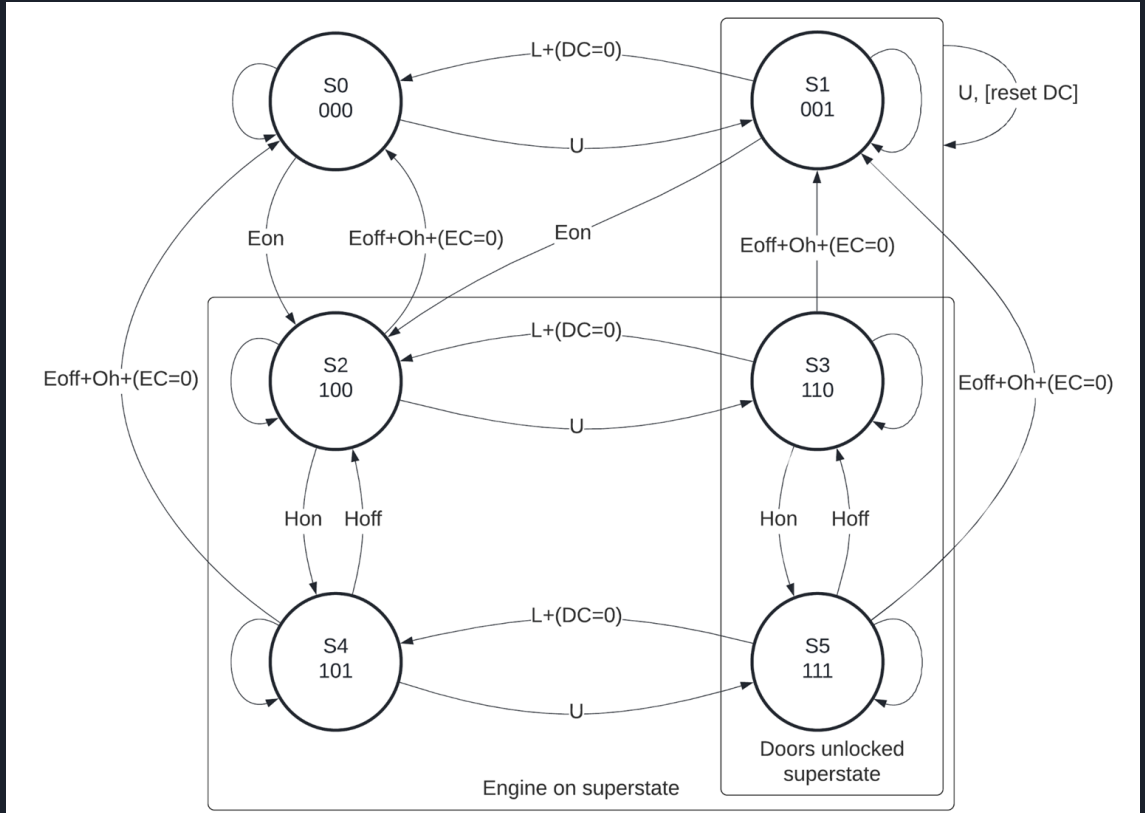
Simplified State-graph

- For clarity only inputs that need to be high to trigger a state transition are shown
- Substates and the basic state are number for the total number to simplify implementation
- Superstates are shown as boxes around their component substates
- Doors unlocked also unlocked the trunk



Use of Superstates

- Two OR superstates were used in the final solution
- Both run a Moore counter when the system is in a substate of them
- On entry the counter is set to a number of clock cycles
- Every clock cycle after entry the counter goes down by 1
- When counter reaches 0 the system exits the superstate
- Counter is unaffected by the substate the machine is in, or transitions between substates
- User can manually exit the superstate independently of the counter



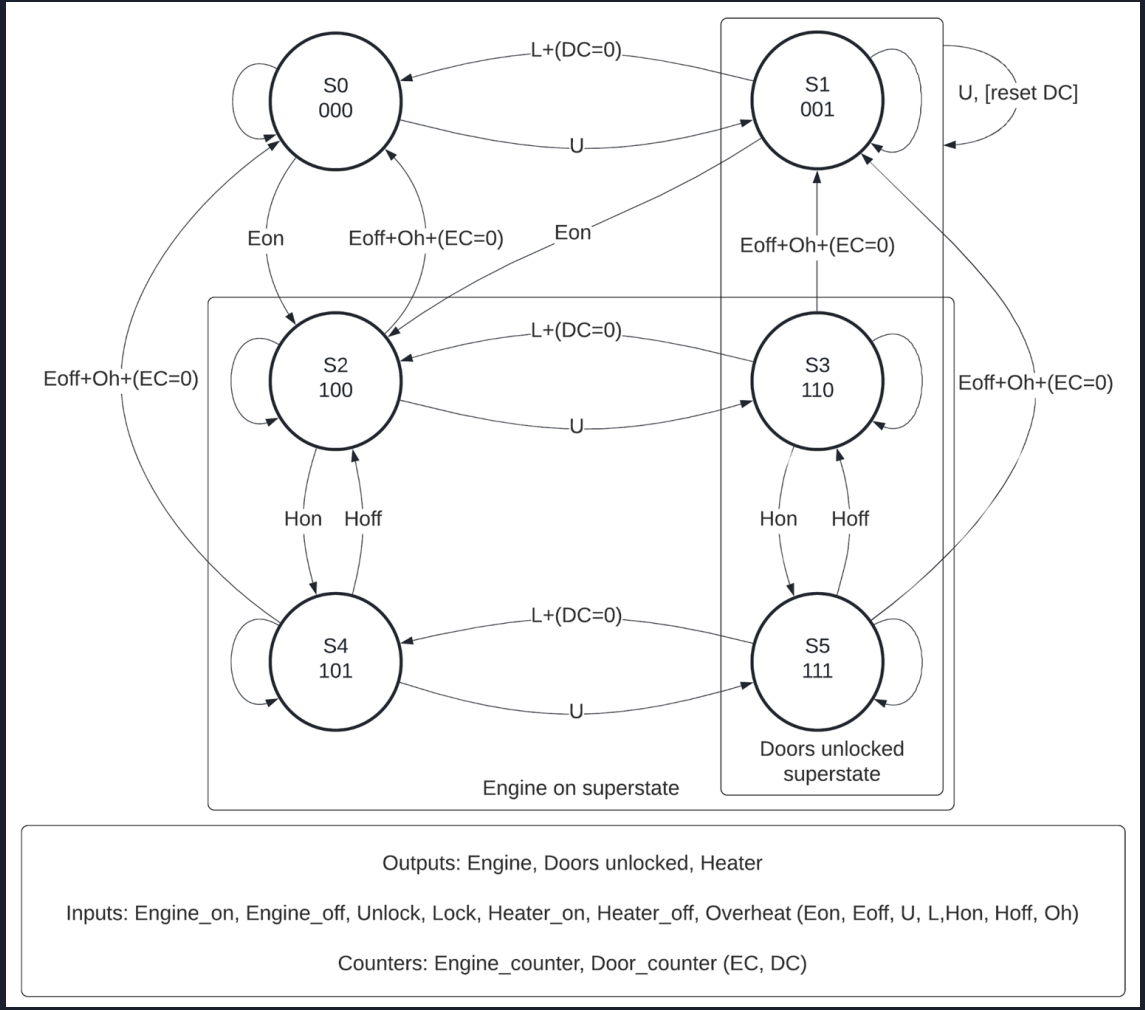
Outputs: Engine, Doors unlocked, Heater

Inputs: Engine_on, Engine_off, Unlock, Lock, Heater_on, Heater_off, Overheat (Eon, Eoff, U, L,Hon, Hoff, Oh)

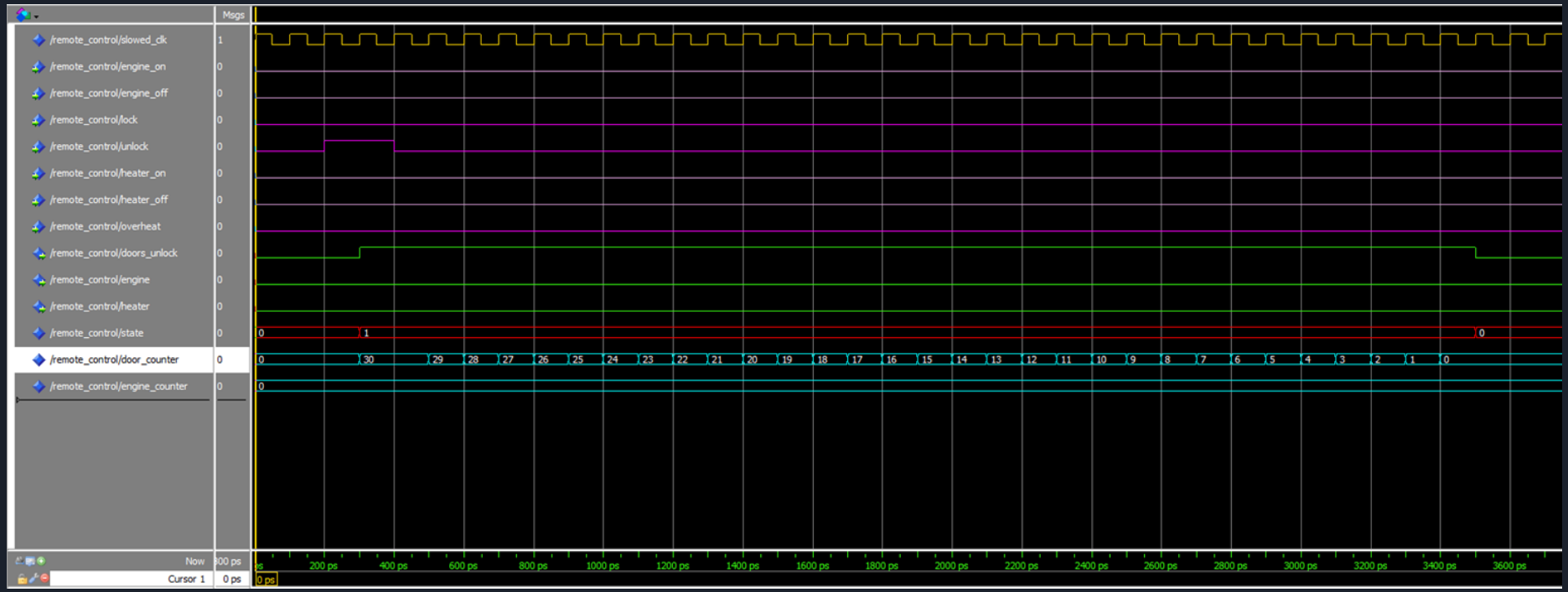
Counters: Engine_counter, Door_counter (EC, DC)

Use of Superstates

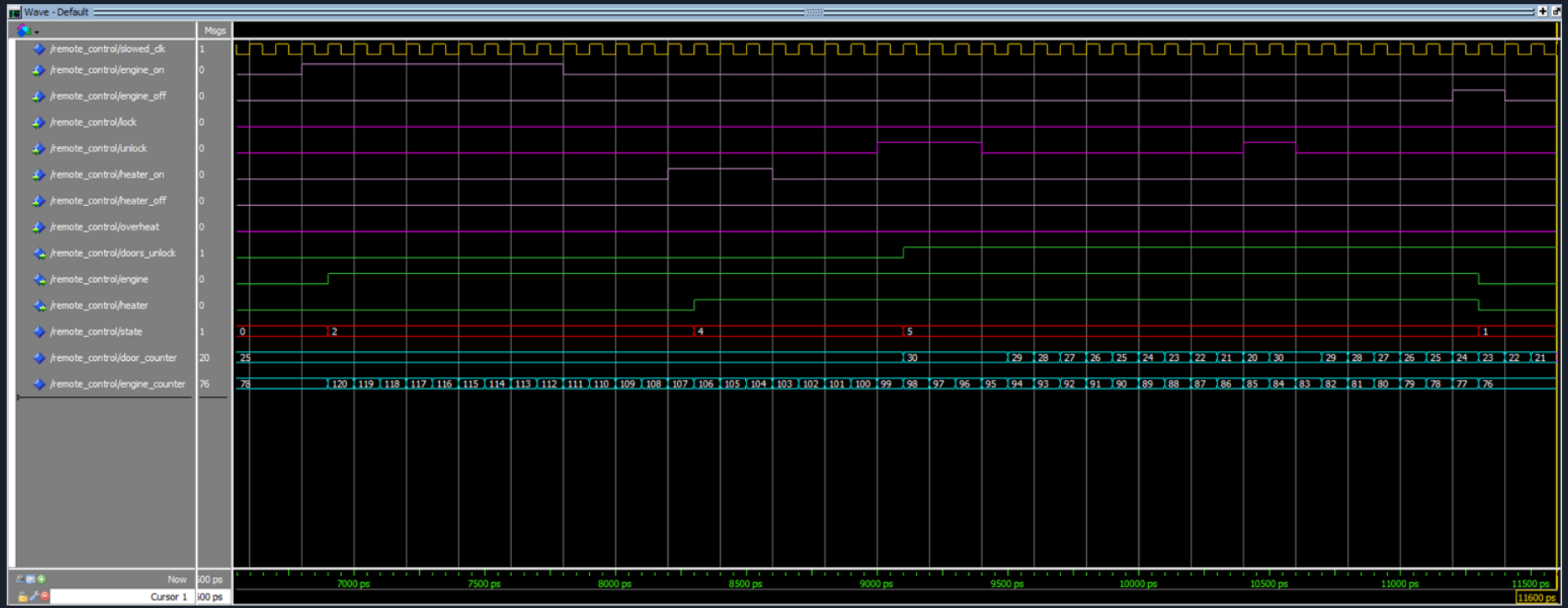
- Engine on superstate
  - When entered a counter is started that will count 120 seconds
  - This counter cannot be reset by the user to prevent idling
  - If the system is in both superstates at once it will stay in the doors unlocked superstate on exit
- Doors unlocked superstate
  - Counter counts for 30 seconds starting on entry
  - Counter can be reset if unlock button is pressed again
  - If the system is in both superstates at once it will stay in the engine on superstate on exit



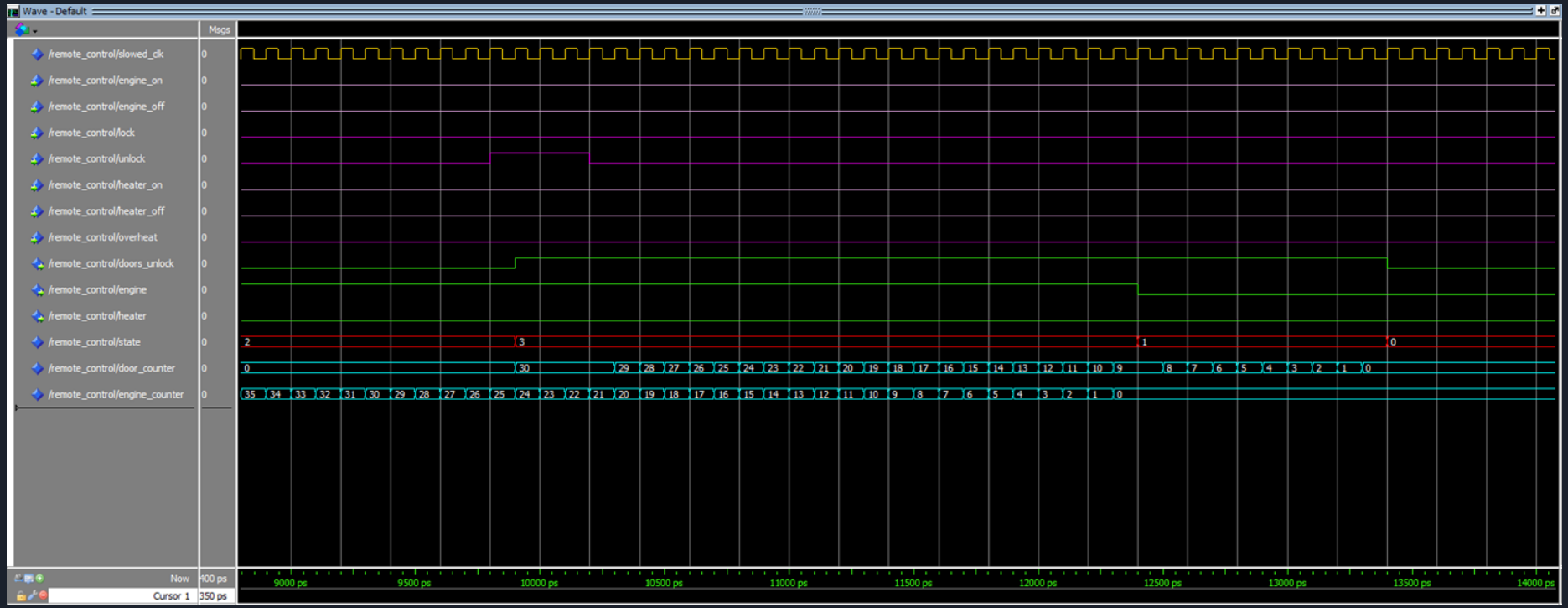
Waveform Example 1



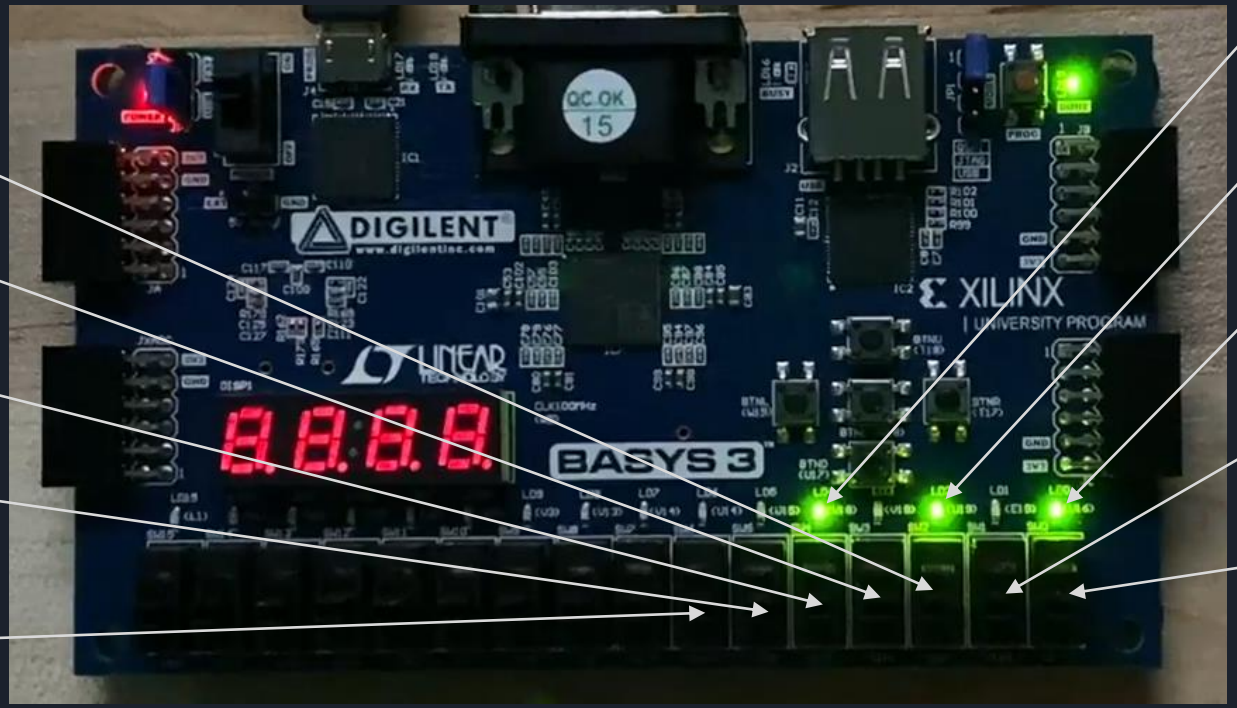
Waveform Example 2



Waveform Example 3



Mapping on FPGA



Features

- Doors and trunk can be locked and unlocked using the remote
- Engine can be turned on and off using the remote
- Heater can be turned on and off using the remote
- On overheat the engine will shut down
- Indicator LEDs show status of doors & trunk, engine and heater on remote
- Engine will shutoff after idling for more than 120 seconds
- Doors and trunk will lock if it has been more than 30 seconds since unlock was pressed
- Starting engine automatically locks the doors and trunk

Environmental, Societal, Safety, and Economic Considerations

- Reduce - Reuse - Recycle
- Cost - Power Usage
- Automatic engine turn off

- User Friendly
- Minimized accidents
- Easy to carry

- Engine turns off - if heats up
- Automatic trunk and door closing
- Components sealed properly, controller operates on low voltage

- Inexpensive but reliable components
- Economically beneficial in the long run

Limitations & Future Work

Limitations

- Components available
- Use of sensors
- Use of buzzers
- Use of buttons

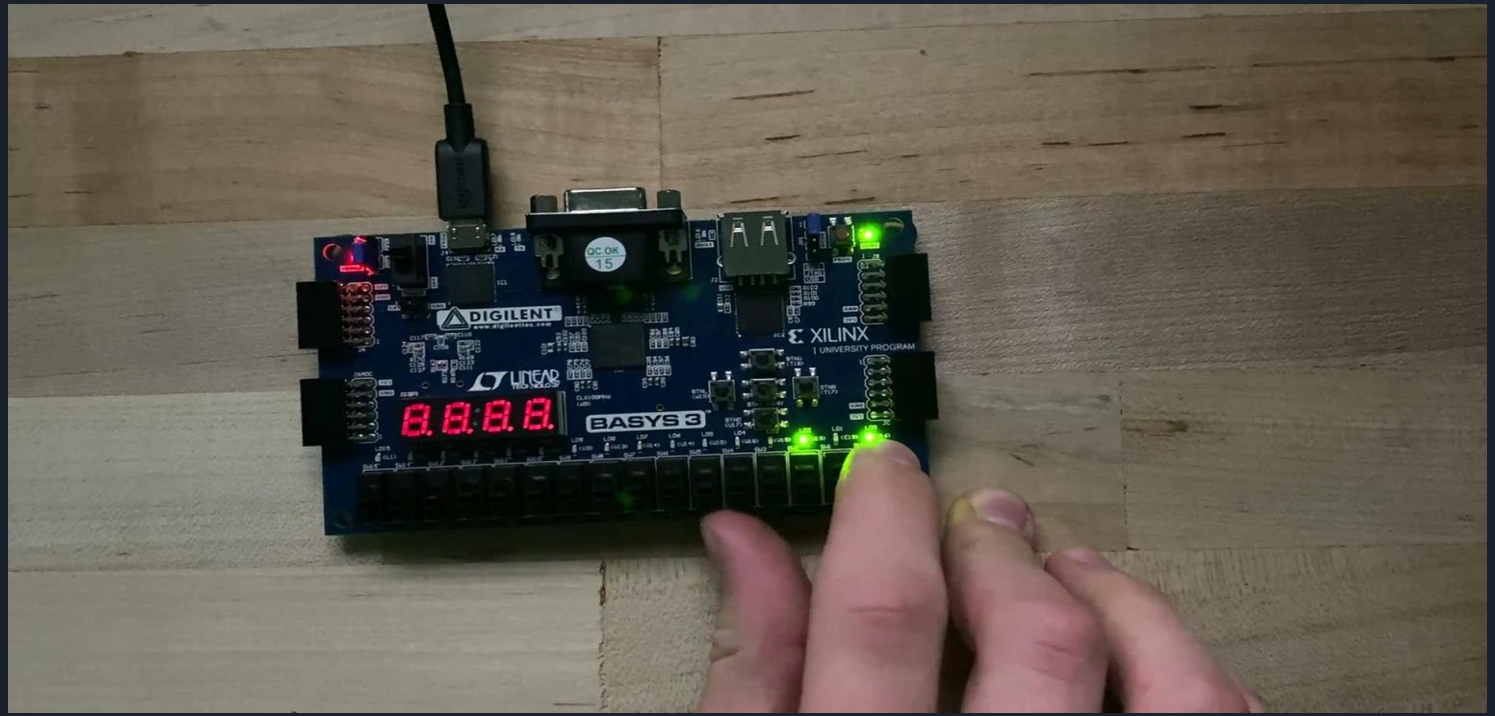
Future Works

- Involving Sensors
- Alarm
- Buttons rather than switch
- Use 7-segment display
- Connect to smartphone

Conclusion

- Utilize different components and implement
- State graph
- Behavioral modeling
- Project goal accomplished
- Environmental, Societal, Safety and Economical aspects
- Engineering attributes into considerations
- Room for improvement

Video demonstration of the prototype



https://media.tru.ca/media/Controller+for+Remote+Car+Starter/0_60hb6xlf

References

Curiocity. “8 Wild Facts about Canadian Winter That You Might Not Know.” *Curiocity*, Curiocity, 13 Apr. 2021, https://curiocity.com/8-wild-facts-about-canadian-winter-that-you-might-not-know/

“Cold Got You down? Install a Remote Starter!” *Waxwerks & Audio+*, 17 Feb. 2019, https://www.waxwerks.com/blog/cold-got-you-down-install-a-remote-starter/

“Remote Car Starters in Sarnia on: DC Car Audio.” *Dccaraudio*, https://www.dccarsarnia.com/sarnia--remote-car-starters

“Lock Clipart Doodle - Lock Line Icon PNG Transparent PNG (#1086044) - Pinclipart.” *PinClipart.com*, https://www.pinclipart.com/pindetail/TxwoxR_lock-clipart-doodle-lock-line-icon-png-transparent/

~Userba9fe9ab_931. “Heat Icon Three Arrow up Concept. Vector.” *IStock*, https://www.istockphoto.com/vector/heat-icon-three-arrow-up-concept-vector-gm1184589629-333515890

SelectScience, “Reduce, Reuse, recycle: Sustainability in the lab,” *SelectScience*. https://www.selectscience.net/editorial-articles/reduce,-reuse,-recycle-sustainability-in-the-lab/?artID=53701

Thank You!

Any Questions?