Traffic Light System - CECS 346 Embedded Systems Project 1

- Embedded Systems Project written in C and designed on ARM Cortex-M4F Based MCU TM4C.
- Designed a traffic light controller for the intersection of two equally busy one-way streets.
- Developed an optimized Finite State Machine data structure to maximize traffic flow, minimize waiting time at a red light, and avoid accidents.
- Implemented SysTick timers to accurately transition states.
- Buttons' inputs represent car(s) and determine the next state of the Traffic Light System.
    - South button detector: Car heading South. South button is connected to Port A-3 (1=car present).
    - West button detector: Car heading west. West button is connected to Port A-2 (1=car present).
    - South right turn button detector: Car pointing south and turning right at the intersection. South right turn button is connected to Port F-4 (0=car present; negative logic).
- LEDs' color outputs represent the state of the traffic light(s).
    - South LEDs represent the traffic light when heading South and are connected to Port B-2:0.
    - West LEDs represent the traffic light when heading West and are connected to Port B-5:3.
        - West LEDs use negative logic.
    - South right turn LED represents a protected right turn traffic light when facing South and turning right at the intersection. South right turn LED is a 3-pin controlled onboard RGB LED and is connected to Port F-3&1.
        - South right turn LED is negative logic.
- Signal Logic:
    - Assume signals start out with red LED on for the South signal, red LED on for the Rt Turn signal, green LED on for the West signal.
    - When none of the three sensors is true, stay in the current state (if a green LED is on) or finish the transition to a green LED lit state.
    - If south or west sensor is true (but not both), turn on the green for traffic light of that direction and stay on as long as only that sensor is true.
    - The Rt Turn sensor is linked to South sensor in the following way: if Rt Turn sensor is true, the South and Rt signals will cycle together. (If South is true and Rt Turn is not, Rt Turn signal does not turn green with South signal does.)
    - If both South and West sensors are true, cycle through the sensors. In other words, let both directions take turns.
- The time duration for each light is:
    - Green - 6 seconds
    - Yellow - 2 seconds
    - Red - 8 seconds.

Simplified schematic:

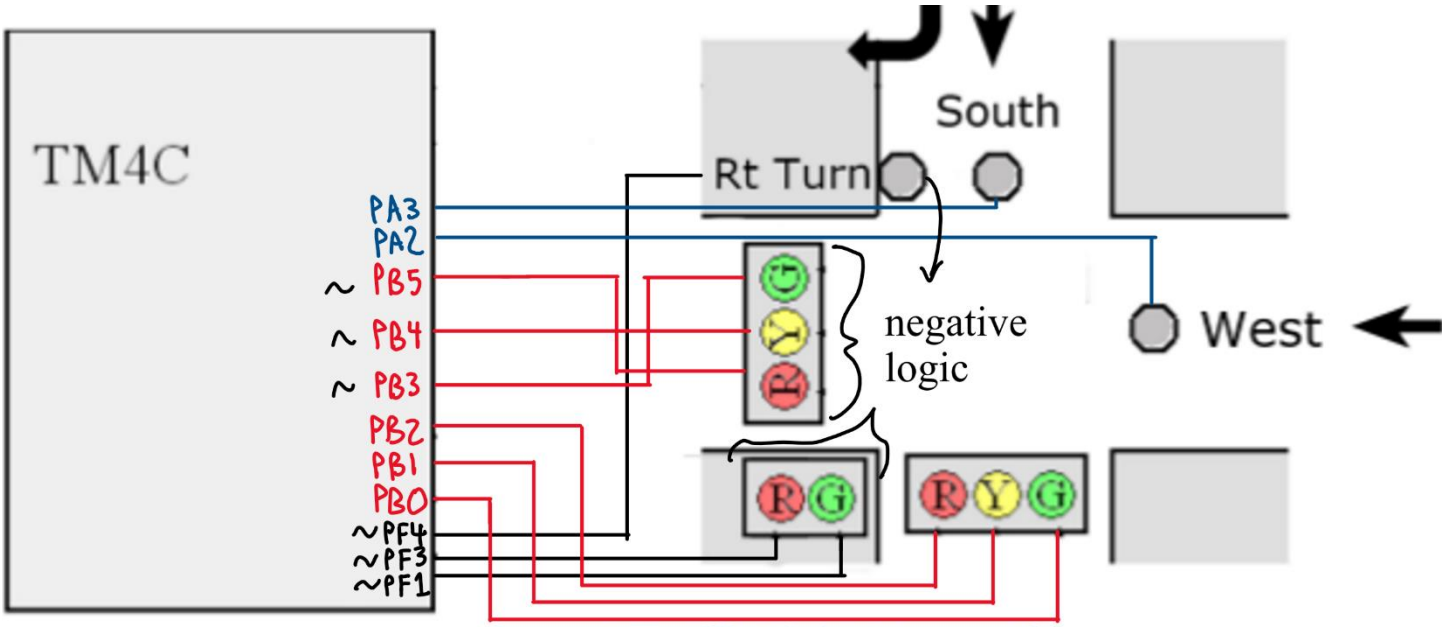

Figure 1 Traffic Light Intersection

Input combinations:

PF4 = 0	PA3 = 0	PA2 = 0	Cars on **south right turn** section
PF4 = 0	PA3 = 0	PA2 = 1	Cars on **south right turn** and **west** road
PF4 = 0	PA3 = 1	PA2 = 0	Cars on **south right turn** and **south** road
PF4 = 0	PA3 = 1	PA2 = 1	Cars on **both south** sections and **west** road
PF4 = 1	PA3 = 0	PA2 = 0	**No cars** on either road
PF4 = 1	PA3 = 0	PA2 = 1	Cars on **west** road
PF4 = 1	PA3 = 1	PA2 = 0	Cars on **south** road
PF4 = 1	PA3 = 1	PA2 = 1	Cars on **south** and **west** road

State output combinations:

State	West LED (negative)	South LED	Total Port B register	South right turn LED	Port F register
goS	PB5-3 = ~(100) = **011** makes it **red on west**	PB2-0 = **001** makes it **green on South**	PB = 0001 1001 = **0x19**	PF 3&1 = **0 & 1** makes it **red on South right turn**	PF = 0001 0010 = **0x12**
goSRt	PB5-3 = ~(100) = **011** makes it **red on west**	PB2-0 = **001** makes it **green on South**	PB = 0001 1001 = **0x19**	PF 3&1 = **1 & 0** makes it **green on South right turn**	PF = 0000 1000 = **0x08**
waitS	PB5-3 = ~(100) = **011** makes it **red on west**	PB2-0 = **010** makes it **yellow on South**	PB = 0001 1010 = **0x1A**	PF 3&1 = **0 & 1** makes it **red on South right turn**	PF = 0001 0010 = **0x12**
goW	PB5-3 = ~(001) = **110** makes it **green on west**	PB2-0 = **100** makes it **red on South**	PB = 0011 0100 = **0x34**	PF 3&1 = **0 & 1** makes it **red on South right turn**	PF = 0001 0010 = **0x12**
waitW	PB5-3 = ~(010) = **101** makes it **yellow on west**	PB2-0 = **100** makes it **red on South**	PB = 0010 1100 = **0x2C**	PF 3&1 = **0 & 1** makes it **red on South right turn**	PF = 0001 0010 = **0x12**
waitSRt	PB5-3 = ~(100) = **011** makes it **red on west**	PB2-0 = **010** makes it **yellow on South**	PB = 0001 1010 = **0x1A**	PF 3&1 = **1 & 1** makes it **yellow on South right turn**	PF = 0001 1010 = **0x1A**

Finite State Machine diagram: