ATM MACHINE

EMP Final Assignment

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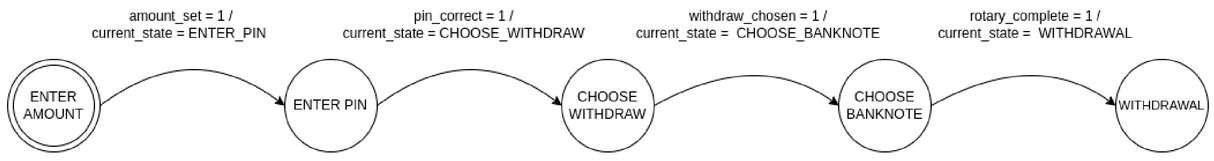
System control FSM

The following finite state machine (FSM) is implemented in the FSM task and serves as the "brain" of the ATM's control system, ensuring that user interactions follow a logical sequence. Each transition is driven by specific flags, set by the corresponding task for that state. This ensures secure and orderly processing of ATM transactions. The design creates a linear and predictable user experience.



The transitions are driven by the flags “amount_set, pin_correct, withdraw_chosen, and rotary_complete”. These are set within the task responsible for operations in the current state. For example, when the system is in the “ENTER AMOUNT” state, the task responsible for receiving the withdrawable amount from the user has control of the system until it sets the “amount_set” flag. This indicates to the control FSM that the task is finished, which subsequently transitions the system to the “ENTER PIN” state.

Task control system

The current state from the system control is what decides if a task is allowed to run. Each time a task starts an execution cycle it checks if the current state matches the one where the task is supposed to run. This is implemented using a getState method as shown in the figure below. The getState method works by taking the mutex, protecting the current state and returning the state. If the state is not the one intended for that task, it breaks out of that execution cycle immediately. Otherwise, it allows the execution to continue as normal.

```
state getState()
{
    state outp;
    if (xSemaphoreTake(xStateMutex, portMAX_DELAY) == pdTRUE)
    {
        outp = current_state;
        xSemaphoreGive(xStateMutex);
    }
    return outp;
}
```

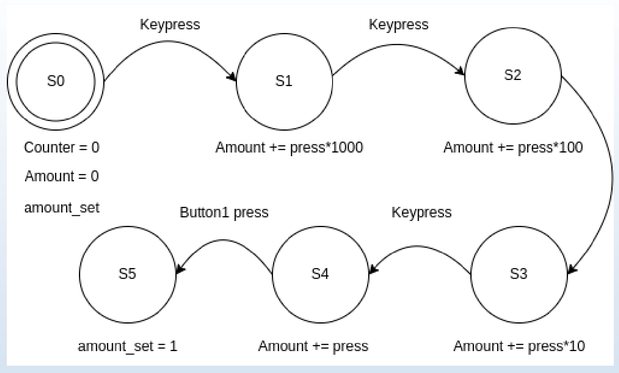
```
149  void rotary_task(void *pvParameters)
150  /*****************************************************************
151   *   Input    :  -
152   *   Output   :  -
153   *   Function :
154   *****************************************************************/
155  {
156      while (1)
157      {
158          if (getState() == CHOOSE_BANKNOTE)
159          {
160              if (first_run_banknote)
161              {
162                  clr_LCD();
163                  set_cursor(0x0C);
164                  INT8U banknote_text[] = "Choose banknote:";
```

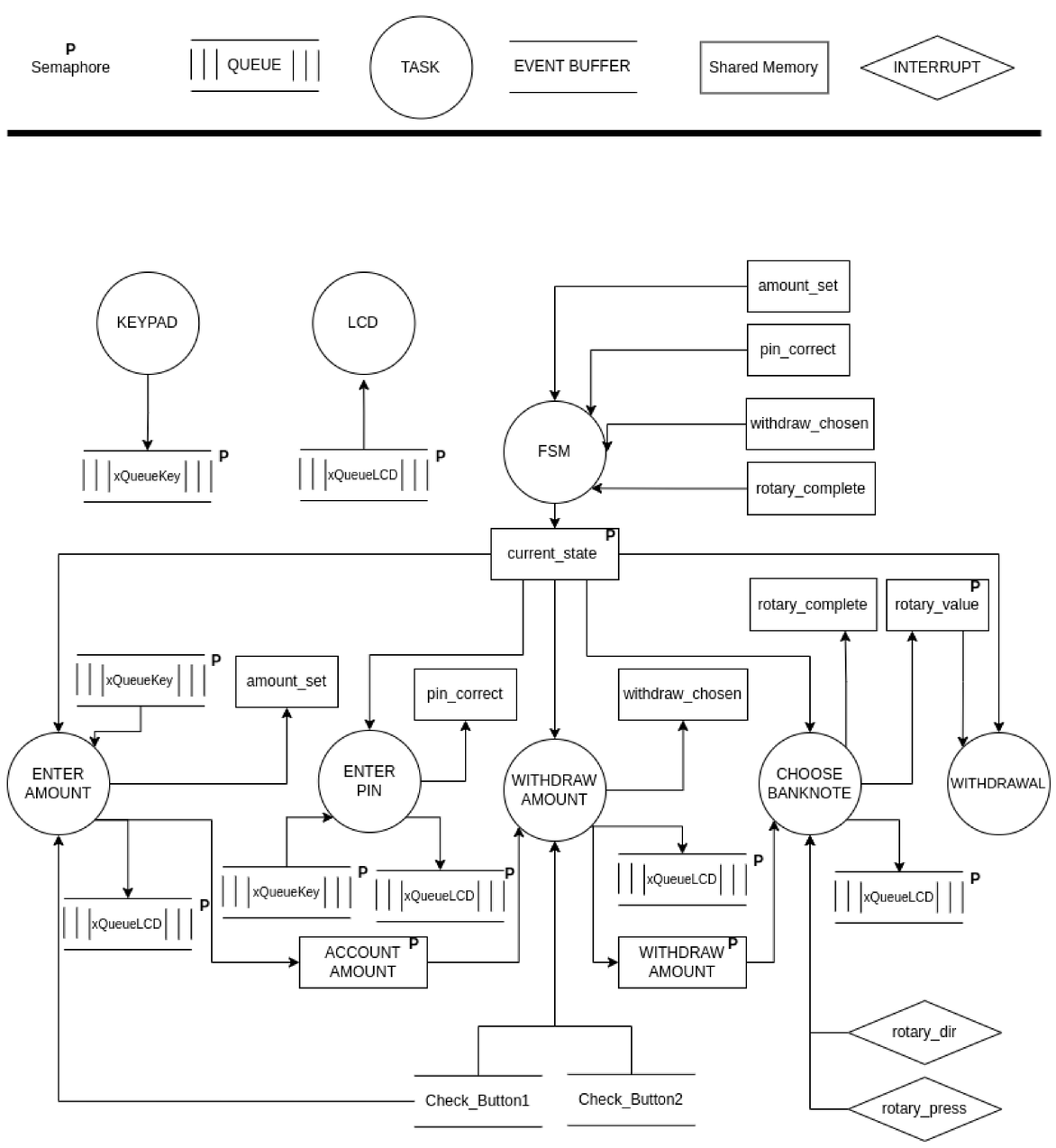
The figure to the right shows an if statement in the start of the task that makes sure the current state is correct before proceeding with execution.
The same approach is used for all five tasks that correspond to a state.

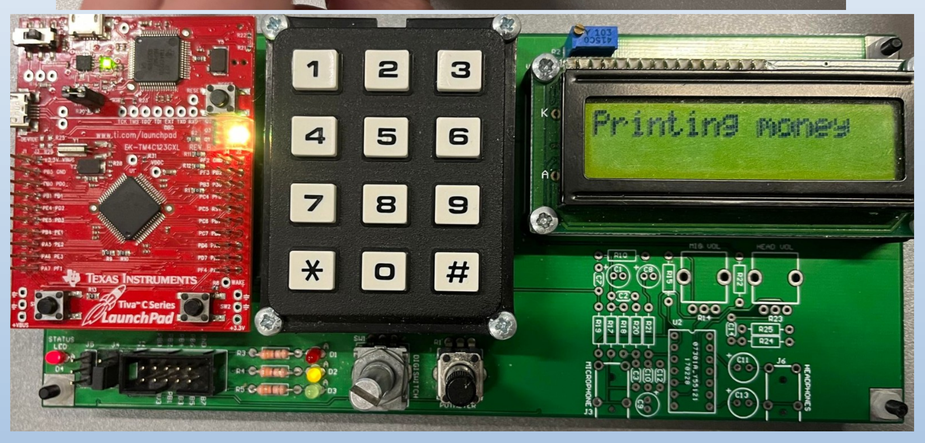
Enter amount & enter pin tasks

The “enter amount task” and “enter pin” tasks work similar to each other. In each execution cycle they take an input from the keypad queue. It is made sure that it is an appropriate key before entering a switch case. The switch statement is dependent on what the current cycle number is. For all cases the key will be converted from an ASCII character to an integer. Depending on the cycle number, the integer will be multiplied by a thousand, a hundred, ten or one before being summed to the “amount_value” or “pin_value”. After four runs, the value is stored. If it is the amount task that is running, it starts looking for a button press to set the transition flag.
If it is the pin task that is running it checks if the four inputs add up to a number divisible by 8. If so, the pin correct flag is set.

```
181  void enter_amount_task(void *pvParameters)
182  {
183
184    while (1)
185    {
186
187      if (getState() == ENTER_AMOUNT)
188      {
189
190        if (first_run)
191        {
192          clr_LCD();
193          INT8U enter_amount[] = "Enter amount:";
194          wr_str_LCD(enter_amount);
195          move_LCD(0, 1);
196          vTaskDelay(100 / portTICK_RATE_MS);
197          first_run = 0;
198        }
199
200        INT8U key_press = 0;
201
202        if (get_keyboard(&key_press))
203        {
204
205          if (key_press == '#' || key_press == '*')
206          {
207          }
208          else
209          {
210            if (i < 4)
211            {
212              xQueueSend(xQueueLCD, &key_press, portMAX_DELAY);
213              switch (i)
214              {
215              case 0:
216                tmp_amount = (key_press - ASCII_TO_INT) * 1000;
217                break;
218              case 1:
219                tmp_amount = tmp_amount + (key_press - ASCII_TO_INT) * 100;
220                break;
221              case 2:
222                tmp_amount = tmp_amount + (key_press - ASCII_TO_INT) * 10;
223                break;
224              case 3:
225                tmp_amount = tmp_amount + (key_press - ASCII_TO_INT);
226                setAmount(tmp_amount);
227                break;
228              default:
229                break;
230              }
231            }
232            i++;
233          }
234        }
235
236        if (button_pushed() && i > 3)
237        {
238            amount_set = 1;
239        }
240       }
241     }
242  }
```







Rotary encoder

The rotary encoder is implemented using interrupts. It is setup to send an interrupt on the rising edge of switch pin A (PA5) and on a press on the digiswitch (PA7).

```
// Interrupt stuff
GPIO_PORTA_IS_R &= ~PA5;       // PA5 is edge-sensitive
GPIO_PORTA_IBE_R &= ~PA5;      // PA5 is not both edges
GPIO_PORTA_IEV_R |= PA5;       // Trigger on rising edge for PA5
GPIO_PORTA_ICR_R |= PA5 + PA7; // Clear any prior interrupts on PA5
GPIO_PORTA_IM_R |= PA5 + PA7;  // Enable interrupt on PA5
NVIC_EN0_R = 1 << 0;           // Enable IRQ for GPIO Port A
```

```
116  void GPIOA_Handler(void)
117  {
118
119      if (GPIO_PORTA_RIS_R & PA7) // Check if interrupt was caused by PA7 (rotary press)
120      {
121          rotary_pressed = 1;
122          set_rotary_complete();
123
124          GPIO_PORTA_ICR_R |= PA7; // clear interrupt flag
125      }
126      else if (GPIO_PORTA_RIS_R & PA5 && !rotary_pressed) // Check if interrupt was caused by PA5
127      {
128          rotary_dir = ((GPIO_PORTA_DATA_R & (1 << 6)) != 0) ? CW : CCW; // if PA6 is high => CW, PA6 is low => CCW
129          xSemaphoreGiveFromISR(xRotaryDirectionSemaphore, NULL);
130
131          GPIO_PORTA_ICR_R |= PA5; // Clear the interrupt flag for PA5
132      }
133  }
```

The “else if” on l. 127 is responsible for handling interrupts from the digiswitch turning. It works by checking the value of switch pin B to determine if the interrupt came from turning clockwise or counter clockwise. It then uses a semaphore to signal the task that is responsible for keeping track.

```
173                  if (xSemaphoreTake(xRotaryDirectionSemaphore, portMAX_DELAY) == pdTRUE)
174                  {
175                      if (xSemaphoreTake(xRotaryValueMutex, portMAX_DELAY) == pdTRUE)
176                      {
177                          if (rotary_dir == CW)
178                          {
179                              rotary_value = (rotary_value + 1) % 3;
180                          }
181                          else
182                          {
183                              rotary_value = (rotary_value - 1 + 3) % 3;
184                          }
185                          move_LCD(0, 1);
186                          wr_banknote_str(rotary_value);
187                          vTaskDelay(100 / portTICK_RATE_MS);
188
189                          xSemaphoreGive(xRotaryValueMutex);
190                      }
191                  }
```

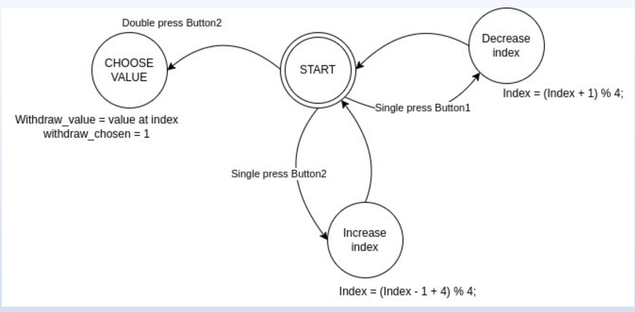
This task takes the semaphore signal and updates the rotary value based on the direction. It cycles through the values 0, 1, and 2 depending on the direction set by the interrupt handler. This rotary value is protected by a mutex and is used as an index in an array consisting of the different banknote options.

LED flickering based on ADC

```
220              if (is_final_selected)
221              {
222                  switch (final_rot_value)
223                  {
224                  case 0:
225                      GPIO_PORTF_DATA_R ^= 0x02;
226                      break;
227                  case 1:
228                      GPIO_PORTF_DATA_R ^= 0x04;
229                      break;
230                  case 2:
231                      GPIO_PORTF_DATA_R ^= 0x08;
232                      break;
233                  }
234                  INT16U adc_value = get_adc();
235                  INT16U delay_ms = MAX_DELAY_MS - ((adc_value * (MAX_DELAY_MS - MIN_DELAY_MS)) / MAX_ADC_VALUE);
236                  vTaskDelay(delay_ms / portTICK_RATE_MS);
237              }
238          }
```

delay_ms determines the frequency for which the LEDs flicker. The ADC gives a value from 0-4095. The max. delay is 1000 ms resulting in 1 Hz. The min. delay is 100 ms resulting in 10 Hz. However, in practice this seems to be incorrect. It is suspected that various tasks running in the background may increase the delay in an unpredictable way.

Choosing amount to withdraw



Choosing the amount to withdraw is done using the two buttons. Button 1 cycles left and button 2 cycles right. They update a value that is used to index into an array of the different withdraw amounts allowed. A double press on button 2 confirms the chosen amount.

Full demonstration video link: