System Description

Motor Controller MCU Firmware

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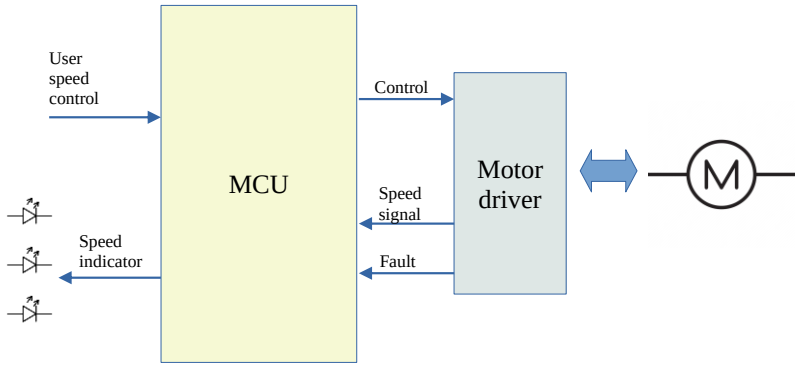
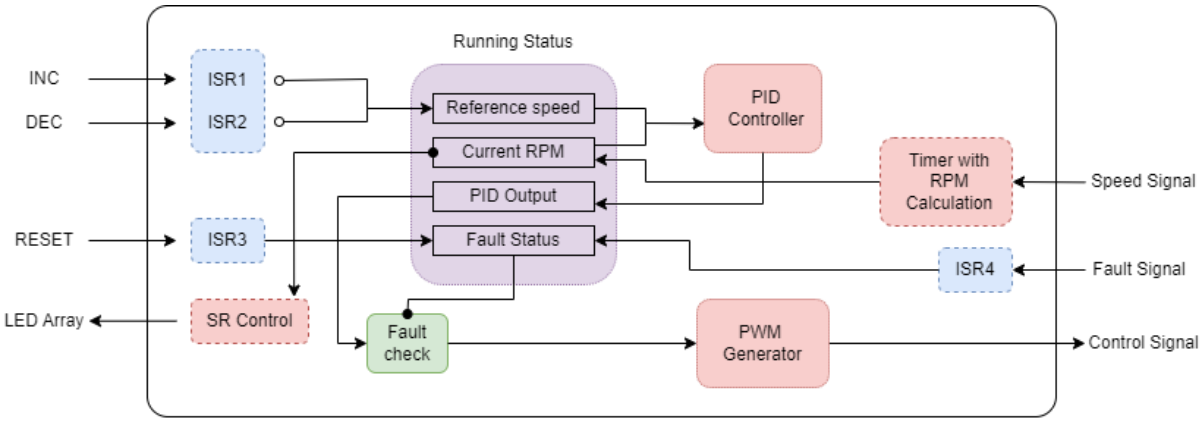


Microcontroller	STM32F103C8T6 (STM Blue pill)
Platform	STM32 Cube IDE 1.13.1
Programming Language	C
Link to source code	*https://github.com/AryansVj/motor-controller*

Firmware Architecture



Main components

***Running Status* struct:** A data structure defined to hold the real time parameters of the system providing a single point of access for write and read.

- **Reference Speed:** The speed required by the user – updated by user input (INC/DEC)
- **Current RPM:** The current rpm calculated by the Timer using motor controller feedback
- **PID Output:** The output generated by the closed loop PID controller output
- **Fault Status:** The True (1) / False (0) flag defined to indicate any fault conditions in the motor

Timer with RPM Calculator: A timer set to overflow at a sampling period of 600 ms (equivalent to 10 pulses at 100 RPM) with input capture configured to count the number of pulses that resets each

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time the timer interrupt is triggered. The count of pulses is used to calculate the current RPM and update in the *Running status* struct.

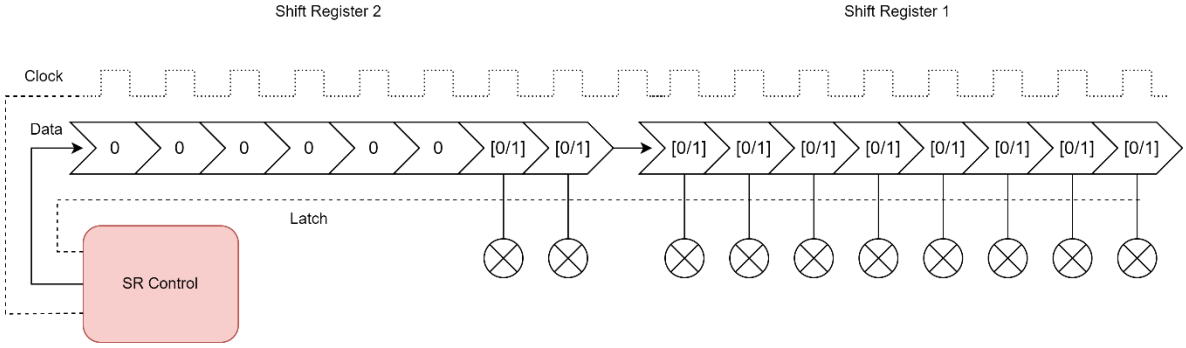
PID Controller: A closed loop PID controller that uses the reference speed, feedback motor speed and the tuned $K_p, K_i \; and \; K_d$ values to reduce the error.

$$error\;[i] = reference\;speed\;[i] - current\;RPM\;[i-1]$$

$$PID\;Output = [PID\;Controller\;gains] \leftarrow error$$

PWM Generator: Another timer is used to generate the PWM signal of 100 Hz frequency by varying the duty cycle according to the PID output. In case of a fault condition, the PID output is bypassed and the control signal is set to stop the motor.

SR Control: Shift Register control logic to control the LED Array. Two cascaded shift registers of 8 outputs each is configured to switch on required number of LEDs according to the current RPM out of the 10 LEDs by setting their register value High.

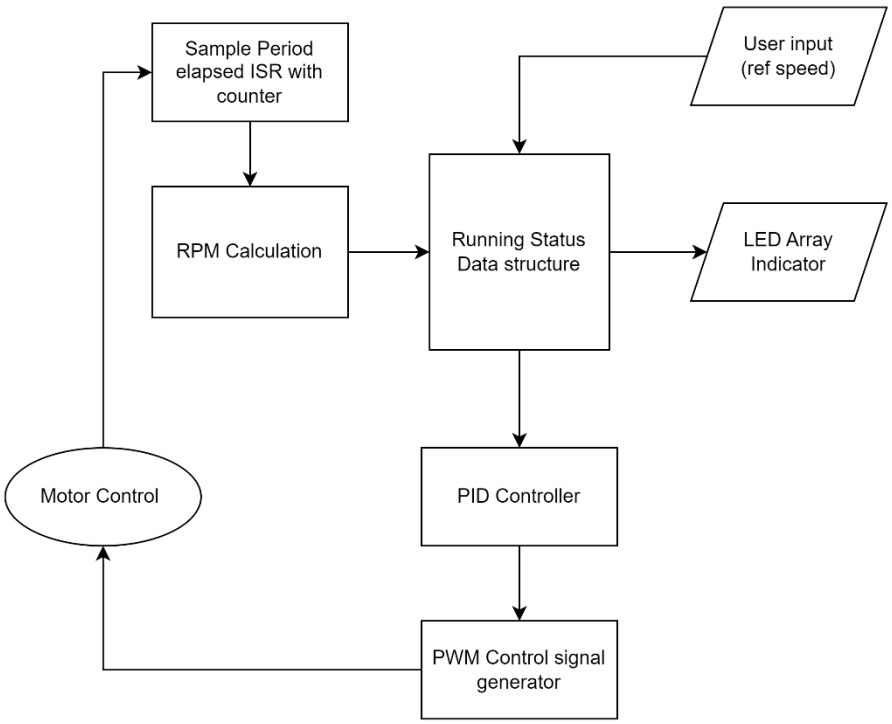


Ports and Signals

Name	Function	Operation description
INC	A button to increase the motor speed	Trigger the ISR 1 to increase the reference speed by 100 RPM via interrupts
DEC	A button to decrease the motor speed	Trigger the ISR 2 to reduce the reference speed by 100 RPM via interrupts
RESET	A reset button to reset the fault status	Trigger the ISR 3 to set the fault status of the system back to false (0)
Fault Signal	Indication of a motor fault	Triggers the ISR 4 setting the fault status to true (1)
Speed Signal	Feedback from the motor control with running speed	A pulse train that corresponds to the current motor speed
Control Signal	PWM signal to control the motor speed	PWM signal governed by the PID controller is sent with the required duty cycle to set the motor speed
LED Array	A linear indicator of the current motor speed	A shift register is driven using the 3 GPIO to switch on the required number of LEDs out of 10 LED array

Operation Logic

Following is the flow of the system.



Resource Allocation

Resource		Function
TIM2	General Purpose timer	Speed signal count capture and RPM calculation
PA0	GPIO (in)	
TIM3	General Purpose timer	PWM Signal generation
PA6	GPIO (out)	
PA1	GPIO_EXTI1	External interrupt for INC button
PA2	GPIO_EXTI2	External interrupt for DEC button
PA3	GPIO_EXTI3	External interrupt for RESET button
PA4	GPIO_EXTI4	External interrupt for FAULT CONDITION signal
PA10	GPIO (out)	LED Shift register data pin (DS)
PA11	GPIO (out)	LED Shift register clock pin (SHCP)
PA12	GPIO (out)	LED Shift register latch pin (STCP)
PC13	GPIO (out)	Built in LED for testing

References

1. PID Controller library for ARM Cortex M (STM32) by Majid Derhambakhsh (https://github.com/Majid-Derhambakhsh/PID-Library)
2. STM32F103C8 Datasheet (https://www.st.com/resource/en/datasheet/stm32f103c8.pdf)