V1.0

ESP STARTER PROJECT FOR LOW LAYER

This project is designed to be a starting point for students who want to use the Low Layer Library to complete their robot.

The project functions as so:-

- Sets up the oscillators to use 8 MHz external Crystal
- PLL's up the 8 MHz to a System Frequency of 84 MHz
- Sets up the flash memory latency
- Enables the SysTick Interrupt in NVIC
- Sets up the right and left timer peripheral PWM channels at a (1 KHz frequency) – MACRO's are included for changing the PWM frequency
- Sets up the Encoder channels on timer peripherals for right and left motor and starts the interrupt process so they can be read easily using functions
- Sets up USB UART so that data can be sent back to a host machine at 9600 BAUD

It is left to the team to implement ADC, GPIO, Control algorithms etc.

THINGS TO NOTE - NOT ALL TIMERS ARE CREATED EQUAL

From the STM32F401RE Datasheet

3.19.2 General-purpose timers (TIMx)

There are seven synchronizable general-purpose timers embedded in the STM32F401xD/xE (see *Table 4* for differences).

- **TIM2, TIM3, TIM4, TIM5**

  The STM32F401xD/xE devices are 4 full-featured general-purpose timers: TIM2, TIM5, TIM3, and TIM4.The TIM2 and TIM5 timers are based on a 32-bit auto-reload up/downcounter and a 16-bit prescaler. The TIM3 and TIM4 timers are based on a 16-bit auto-reload up/downcounter and a 16-bit prescaler. They all feature four independent channels for input capture/output compare, PWM or one-pulse mode output. This gives up to 15 input capture/output compare/PWMs.

  The TIM2, TIM3, TIM4, TIM5 general-purpose timers can work together, or with the other general-purpose timers and the advanced-control timers TIM1 and TIM8 via the Timer Link feature for synchronization or event chaining.

  Any of these general-purpose timers can be used to generate PWM outputs.

  TIM2, TIM3, TIM4, TIM5 all have independent DMA request generation. They are capable of handling quadrature (incremental) encoder signals and the digital outputs from 1 to 4 hall-effect sensors.

- **TIM9, TIM10 and TIM11**

  These timers are based on a 16-bit auto-reload upcounter and a 16-bit prescaler. TIM10 and TIM11 feature one independent channel, whereas TIM9 has two independent channels for input capture/output compare, PWM or one-pulse mode output. They can be synchronized with the TIM2, TIM3, TIM4, TIM5 full-featured general-purpose timers. They can also be used as simple time bases.

Table 4. Timer feature comparison

Timer type	Timer	Counter resolution	Counter type	Prescaler factor	DMA request generation	Capture/ compare channels	Complementary output	Max. interface clock (MHz)	Max. timer clock (MHz)
Advanced-control	TIM1	16-bit	Up, Down, Up/down	Any integer between 1 and 65536	Yes	4	Yes	84	84
General purpose	TIM2, TIM5	32-bit	Up, Down, Up/down	Any integer between 1 and 65536	Yes	4	No	42	84
	TIM3, TIM4	16-bit	Up, Down, Up/down	Any integer between 1 and 65536	Yes	4	No	42	84
	TIM9	16-bit	Up	Any integer between 1 and 65536	No	2	No	84	84
	TIM10, TIM11	16-bit	Up	Any integer between 1 and 65536	No	1	No	84	84

So, we can see that TIM2 and TIM5 are best for encoders as they can count signed 32-bit and thus will be less susceptible to rollover and no additional logic is needed for down counting making them ideal for encoders. TIM1 and TIM4. Unfortunately, these lines conflict with some of the features of the mbed shield and so trade offs must be decided by the group, it is for you to investigate which lines.

Included in this directory should be

- **A pre-configured Keil MDK Project designed for MDK5, NUCLEO-F401RE and ST LLL**
- **A library 'Motors_And_Encoders.c'**
- **A library 'System_Functions.c'**
- **A PDF diagram showing which pins are used for the project**
- **PDF documentation on the Low Layer Library**
- **PDF documentation on 'GPIO ALTERNATE FUNCTIONS'**
- **Guides to Keil, STM32CUBE, Debugging**
- **Other useful relevant information**