

Motor PID Control

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This tutorial demonstrates: using **timer** to control 2 TT encoded motors and print encoder values via serial port, where KEY buttons can control the motor rotation mode.

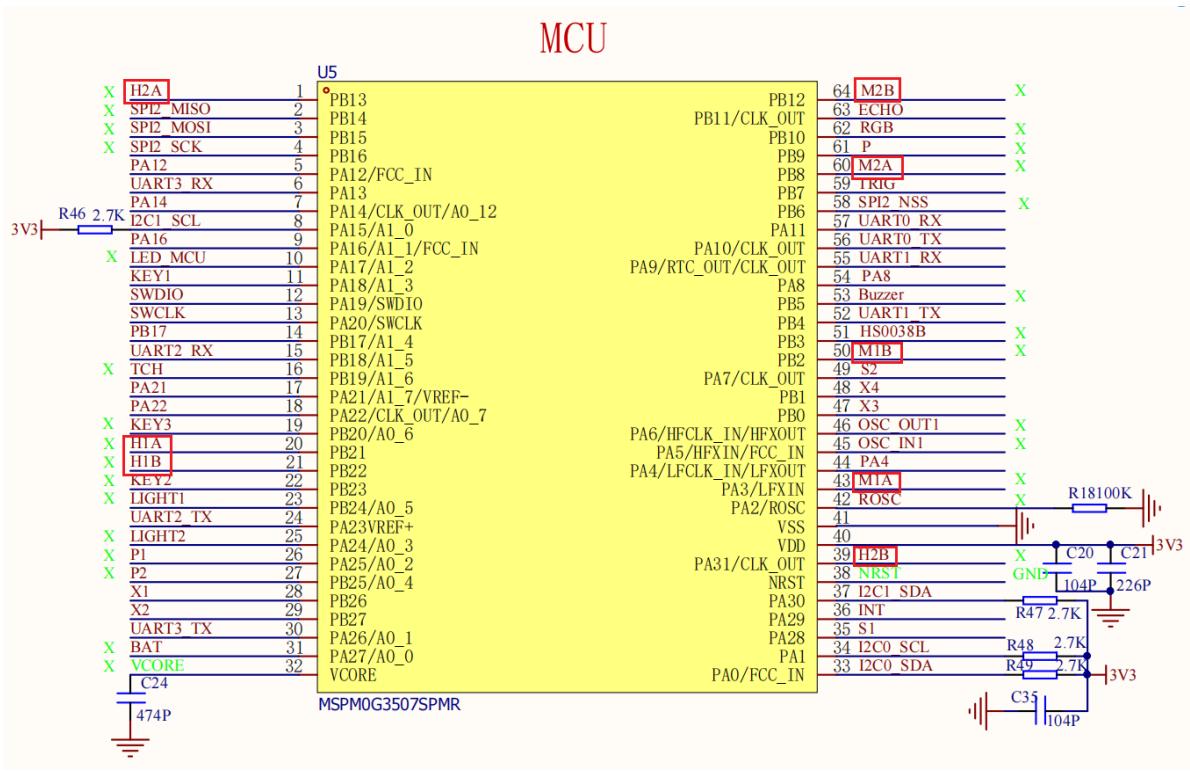
1. Software and Hardware

- **KEIL5**
- **MSPM0G3507 Robot Development Board**
- **TT Encoded Motor * 2**
- **Type-C data cable or DAP-Link**

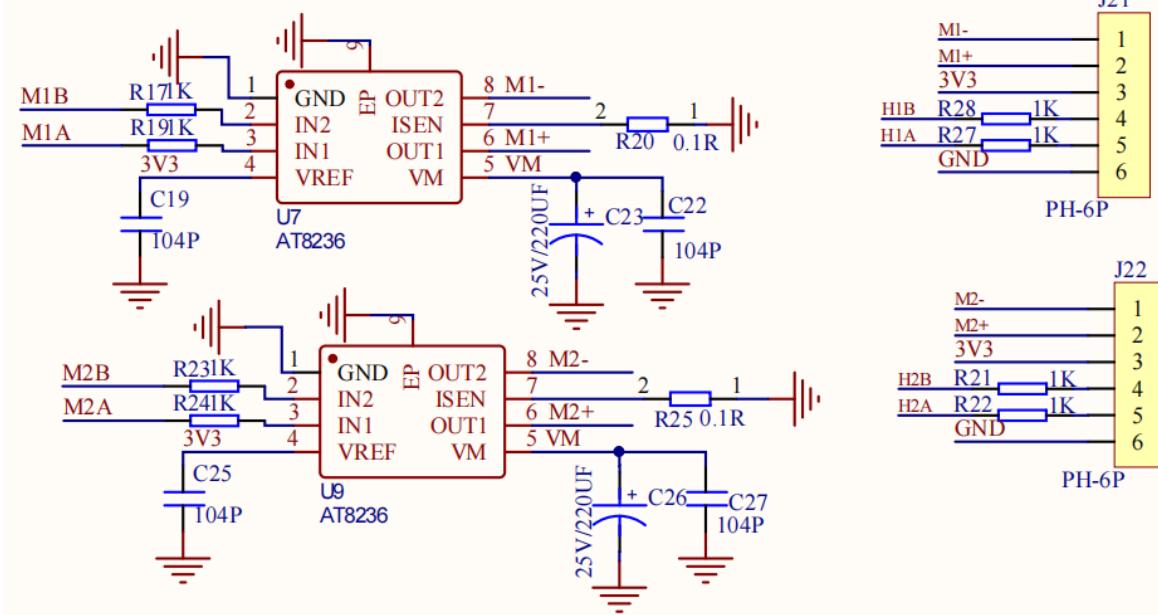
For programming download or simulation to the development board

2. Basic Principles

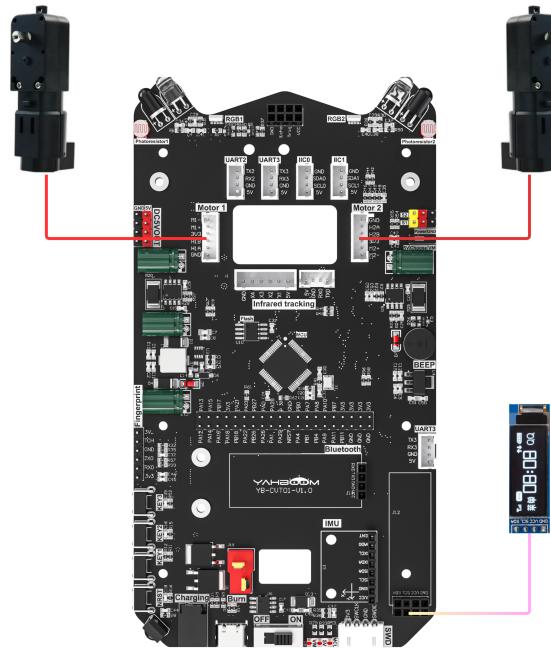
2.1 Hardware Schematic



Motor Drive



2.2 Physical Connection Diagram



2.3 Control Principle

Motor speed and direction control: configure timer PWM output mode and change the duty cycle of PWM signal;

Motor encoder reading: configure timer to count motor encoder signals.

- **TT Encoded Motor**

Motor Model	TT Encoded Motor
Motor Rated Voltage	6V
Encoder Supply Voltage	3.3-5V
Gearbox Reduction Ratio	1:45
Magnetic Ring Line Count	13 lines
Encoder Type	AB Phase Hall Encoder

Count Value

Maximum count value reduction ratio encoder line count

4: Represents encoder frequency multiplication
Based on the count value of one rotation, the car's speed can be calculated. This tutorial does not involve speed conversion

- **Motor Driver**

MSPMOG3507 integrates 2 AT8236 single-channel brush DC motor driver chips.

Input pins IN1 and IN2 control the output state of the H-bridge. The following table shows the logical relationship between input and output:

IN1	IN2	OUT1	OUT2	Function
0	0	Z	Z	Coast, Sleep
1	0	H	L	Forward
0	1	L	H	Reverse
1	1	L	L	Brake

When using PWM control to achieve speed adjustment function, the H-bridge can operate in two different states: fast decay or slow decay.

IN1	IN2	Function
PWM	0	Forward PWM, Fast Decay
1	PWM	Forward PWM, Slow Decay
0	PWM	Reverse PWM, Fast Decay
PWM	1	Reverse PWM, Slow Decay

PWM Period: T = 50us → f = 20KHz

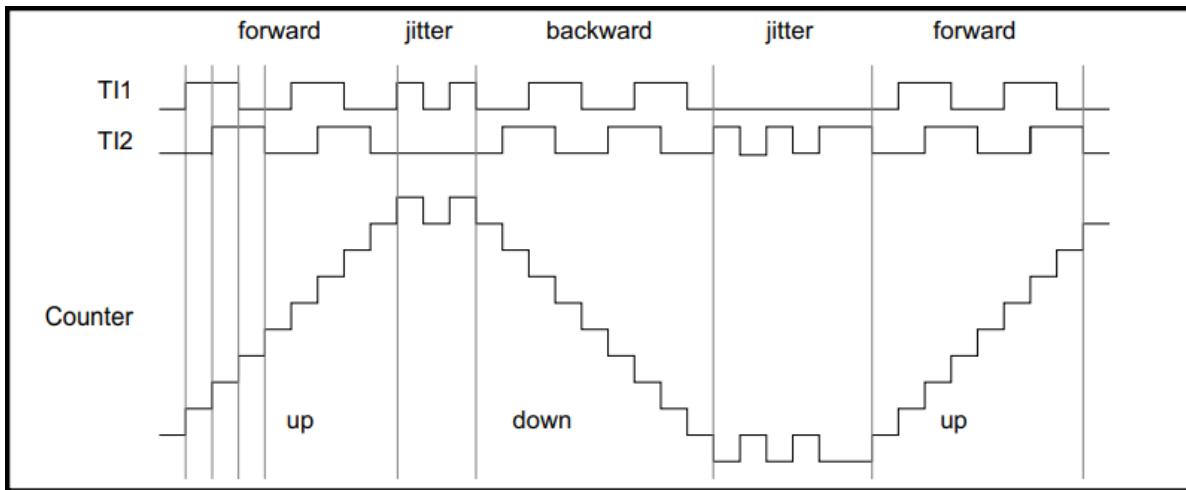
- **Encoder Reading**

Obtain count value by directly reading timer CNT register value.

Table 81. Counting direction versus encoder signals

Active edge	Level on opposite signal (TI1FP1 for TI2, TI2FP2 for TI1)	TI1FP1 signal		TI2FP2 signal	
		Rising	Falling	Rising	Falling
Counting on TI1 only	High	Down	Up	No Count	No Count
	Low	Up	Down	No Count	No Count
Counting on TI2 only	High	No Count	No Count	Up	Down
	Low	No Count	No Count	Down	Up
Counting on TI1 and TI2	High	Down	Up	Up	Down
	Low	Up	Down	Down	Up

The tutorial is set to **count on TI1 and TI2**, input signals not inverted;



whether the counter counts up or down depends on the AB phase signals

3. Project Configuration

3.1 Description

You can refer to the basic tutorial to complete the development environment setup.

The non-omitted project configuration part is the key point that needs to be configured in this tutorial.

3.2 Pin Configuration

- **GPIO**

Type Filter Text... X ← → Software > GPIO

PROJECT CONFIGURATION Project Config... 1/1 ✓ +

MSP400 DRIVER LIBRARY SYSTEM (9)

- Board 1/1 ✓ +
- Configuration NVM +
- DMA +
- GPIO** 5 ✓ +
- MATHACL +
- RTC +
- SYSTICK 1/1 ✓ +
- WWDT +

ANALOG (6)

- ADC12 +
- COMP +
- DAC12 +
- GPAMP +
- OPA +
- VREF +

COMMUNICATIONS (6)

- I2C +
- I2C - SMBUS +
- MCAN +
- SPI +
- UART** 1/4 ✓ +
- UART - LIN +

TIMERS (6)

- TIMER 1/7 ✓ +
- TIMER - CAPTURE +
- TIMER - COMPARE +
- TIMER - PWM 1/7 ✓ +
- TIMER - QEI +
- Timer Fault +

GPIO (5 Added) ⓘ

- ✓ LED
- ✓ KEY
- ✓ GPIO_ENCODER_L
- ✓ GPIO_ENCODER_R
- ✓ OLED

+ ADD REMOVE ALL

Name: GPIO_ENCODER_LL
Port: PORTB
Port Segment: Any

Group Pins

2 added

- ✓ H1A
- ✓ H1B

+ ADD REMOVE ALL

Name: H1A
Direction: Input
IO Structure: Any

Digital IOMUX Features

Assigned Port: PORTB
Assigned Port Segment: Any
Assigned Pin: 21

Interrupts/Events

LaunchPad-Specific Pin: No Shortcut Used

FILE ABOUT

Type Filter Text... X ← → Software > GPIO

PROJECT CONFIGURATION... Project Config... 1/1 ✓ +

MSPM0 DRIVER LIBRARY ...

- SYSTEM (9)**
 - Board 1/1 ✓ +
 - Configuration NVM +
 - DMA +
 - GPIO 5** ✓ +
 - MATHACL +
 - RTC +
 - SYSTCL 1/1 ✓ +
 - SYSTICK 1/1 ✓ +
 - WWDT +
- ANALOG (6)**
 - ADC12 +
 - COMP +
 - DAC12 +
 - GPAMP +
 - OPA +
 - VREF +
- COMMUNICATIONS (6)**
 - I2C +
 - I2C - SMBUS +
 - MCAN +
 - SPI +
 - UART 1/4** ✓ +
 - UART - LIN +
- TIMERS (6)**
 - TIMER 1/7 ✓ +
 - TIMER - CAPTURE +
 - TIMER - COMPARE +
 - TIMER - PWM 1/7** ✓ +
 - TIMER - QEI +
 - Timer Fault +

GPIO_ENCODER_L

GPIO_ENCODER_R

OLED

Name: GPIO_ENCODER_R
Port: Any
Port Segment: Any

Group Pins
2 added

+ ADD REMOVE ALL

H2A
H2B

Name: H2A
Direction: Input
IO Structure: Any

Digital IOMUX Features

Assigned Port: PORTB
Assigned Port Segment: Any
Assigned Pin: 13

Interrupts/Events
LaunchPad-Specific Pin: No Shortcut Used

PinMux Peripheral and Pin Configuration

Other Dependencies

FILE ABOUT

Type Filter Text... X ← → Software > GPIO

PROJECT CONFIGURATION... Project Config... 1/1 ✓ +

MSPM0 DRIVER LIBRARY ...

SYSTEM (9)

- Board 1/1 ✓ +
- Configuration NVM +
- DMA +
- GPIO 5** ✓ +
- MATHACL +
- RTC +
- SYSTCL 1/1 ✓ +
- SYSTICK 1/1 ✓ +
- WWDT +

ANALOG (6)

- ADC12 +
- COMP +
- DAC12 +
- GPAMP +
- OPA +
- VREF +

COMMUNICATIONS (6)

- I2C +
- I2C - SMBUS +
- MCAN +
- SPI +
- UART 1/4** ✓ +
- UART - LIN +

TIMERS (6)

- TIMER 1/7 ✓ +
- TIMER - CAPTURE +
- TIMER - COMPARE +
- TIMER - PWM 1/7** ✓ +
- TIMER - QEI +
- Timer Fault +

GPIO_ENCODER_L

GPIO_ENCODER_R

OLED

Name: GPIO_ENCODER_L
Port: PORTB
Port Segment: Any

Group Pins
2 added

+ ADD REMOVE ALL

H1A
H1B

Name: H1B
Direction: Input
IO Structure: Any

Digital IOMUX Features

Assigned Port: PORTB
Assigned Port Segment: Any
Assigned Pin: 22

Interrupts/Events
LaunchPad-Specific Pin: No Shortcut Used

PinMux Peripheral and Pin Configuration

Other Dependencies

Problems

ERRORS 0 **WARNINGS 0** **SUPPRESSED 0**

Location ↑ **Details**

Generated Files

Filter: all

File name	Category	Incl.
ti_msp_dl_config.c	MSPM0 Driver Library	
ti_msp_dl_config.h	MSPM0 Driver Library	
Event.dot	MSPM0 Driver Library	
empty.syscfg	Configuration Script	

4 Total Files

MSPM0G3507 (Device)
LQFP-64(PM) (Package)

Type Filter Text... X ← → Software > GPIO

PROJECT CONFIGURATION Project Config... 1/1 ✓ +

MSP400 DRIVER LIBRARY SYSTEM (9)

- Board 1/1 ✓ +
- Configuration NVM +
- DMA +
- GPIO** 5 ✓ +
- MATHACL +
- RTC +
- SYSTICK 1/1 ✓ +
- WWDT +

ANALOG (6)

- ADC12 +
- COMP +
- DAC12 +
- GPAMP +
- OPA +
- VREF +

COMMUNICATIONS (6)

- I2C +
- I2C - SMBUS +
- MCAN +
- SPI +
- UART** 1/4 ✓ +
- UART - LIN +

TIMERS (6)

- TIMER 1/7 ✓ +
- TIMER - CAPTURE +
- TIMER - COMPARE +
- TIMER - PWM 1/7 ✓ +
- TIMER - QEI +
- Timer Fault +

GPIO (5 Added) ⓘ

- ✓ LED
- ✓ KEY
- ✓ GPIO_ENCODER_L
- ✓ GPIO_ENCODER_R
- ✓ OLED

+ ADD REMOVE ALL

Name: GPIO_ENCODER_LL
Port: PORTB
Port Segment: Any

Group Pins

2 added

- ✓ H1A
- ✓ H1B

+ ADD REMOVE ALL

Name: H1A
Direction: Input
IO Structure: Any

Digital IOMUX Features

Assigned Port: PORTB
Assigned Port Segment: Any
Assigned Pin: 21

Interrupts/Events

LaunchPad-Specific Pin: No Shortcut Used

Type Filter Text... X ← → Software > GPIO

PROJECT CONFIGURATION Project Config... 1/1

MSPM0 DRIVER LIBRARY ...

SYSTEM (9)

- Board 1/1
- Configuration NVM
- DMA
- GPIO** 5
- MATHACL
- RTC
- SYSCTL 1/1
- SYSTICK 1/1
- WWDT

ANALOG (6)

- ADC12
- COMP
- DAC12
- GPAMP
- OPA
- VREF

COMMUNICATIONS (6)

- I2C
- I2C - SMBUS
- MCAN
- SPI
- UART 1/4
- UART - LIN

TIMERS (6)

- TIMER 1/7
- TIMER - CAPTURE
- TIMER - COMPARE
- TIMER - PWM 1/7
- TIMER - QEI
- Timer Fault

GPIO (5 Added)

Name	Port	Port Segment
KEY	Any	Any
GPIO_ENCODER_L		
GPIO_ENCODER_R		
OLED		

Group Pins

3 added

Name
button1
button2
button3

Digital IOMUX Features

Assigned Port	Assigned Port Segment	Assigned Pin
Any	Any	18

Interrupts/Events

- **USART**

UART (1 of 4 Added)  ADD REMOVE ALL UART_0

Name

UART_0

Selected Peripheral

UART0

Quick Profiles

UART Profiles

Custom

Basic Configuration

UART Initialization Configuration

Clock Source

MFCLK

Clock Divider

Divide by 1

Calculated Clock Source

4.00 MHz

Target Baud Rate

115200

Calculated Baud Rate

115107.91

Calculated Error (%)

0.0799

Word Length

8 bits

Parity

None

Stop Bits

One

HW Flow Control

Disable HW flow control

Advanced Configuration

Extend Configuration

- **Timer Configuration:** Here demonstrates TIMA1 configuration

← → Software > TIMER

TIMER (1 of 7 Added)

ADD **REMOVE ALL**

TIMER_1ms

Peripheral does not retain register contents in STOP or STANDBY modes. User should take care to save and restore register configuration in application. See Retention Configuration section for more details.

Name: **TIMER_1ms**

Selected Peripheral: **TIMA1**

Quick Profiles

Timer Profiles: **Custom**

Basic Configuration

Clock Configuration

Timer Clock Source: **MFCLK**

Timer Clock Divider: **Divided by 5**

Calculated Timer Clock Source: **800000**

Timer Clock Prescaler: **1**

Calculated Timer Clock Values

Timer Clock Frequency: **800.00 kHz**

Timer Period Range And Resolution: **1.25 µs to 81.92 ms w/ resolution c**

Timer Mode: **Periodic Up Counting**

Desired Timer Period: **1 ms**

Actual Timer Period: **1.00 ms**

Start Timer:

- **PWM Configuration:** Here demonstrates motor PWM configuration

TIMER - PWM (1 of 7 Added) ⓘ

ADD

REMOVE ALL

motor_PWM



Peripheral does not retain register contents in STOP or STANDBY modes. User should take care to save and restore register configuration in application. See Retention Configuration section for more details.

Name ⓘ

motor_PWM

Selected Peripheral

TIMA0

Quick Profiles

PWM Profiles

Custom

Basic Configuration**Clock Configuration**

Timer Clock Source

BUSCLK

Timer Clock Divider

Divided by 2

Calculated Timer Clock Source

40000000

Timer Clock Prescale

1

Calculated Timer Clock Values

Calculated Clock Frequency (Hz)... 40000000

Timer Clock Information 610.35 Hz to 20.00 MHz w/ resolut

PWM Period Count

1000

Calculated PWM Frequency (Hz)

40000

Start Timer

**PWM Configuration**

4. Main Functions

For detailed code, you can open the project files we provide and view the source code in the Bsp folder.

4.1 Main Functions

Function	Corresponding Tutorial
Button	Development Board Basic Tutorial: Button Control
Serial Port	Development Board Basic Tutorial: Serial Communication

4.2 User Functions

Function: PID_Location_Calc

Function Prototype	float PID_Location_Calc**(PID_t *pid, float actual_val)
Function Description	Positional PID algorithm
Input Parameter 1	PID_t *pid: structure
Input Parameter 2	actual_val : PID target value
Return Value	PID output value

Function: PID_Calc_One_Motor

Function Prototype	float PID_Calc_One_Motor(uint8_t motor_id, float now_speed)
Function Description	Separately calculate one channel PID
Input Parameter 1	motor_id : motor id. Use 0 and 1 to represent left and right motors respectively
Input Parameter 2	now_speed : set PID target value
Return Value	Positional PID calculated output value

Function: encoder_update

Function Prototype	void encoder_update(void)
Function Description	Encoder data update
Input Parameters	None
Return Value	None

Function: Scheduler_Run

Function Prototype	void Scheduler_Run(void)
Function Description	Configure task scheduler for task scheduling
Input Parameters	None
Return Value	

5. Experimental Phenomenon

After successfully downloading the program, press the RESET button on the development board and open the serial port debugging assistant to observe the phenomenon!

For program download, refer to **【3. Development Environment Setup and Usage: 3. uniflash burning】**

Phenomenon:

Press KEY1: can select mode;

Press and hold KEY1 then press KEY2: confirm the selected mode;

mode1: Display encoder values on OLED and send via serial port, then receive encoder values through serial port assistant;

mode2: Motor rotates forward and can display encoder values on OLED and send via serial port, then receive encoder values through serial port assistant;

mode3: Motor rotates in reverse and can display encoder values on OLED and send via serial port, then receive encoder values through serial port assistant;