c++ code to output PWM for acceleration and deceleration.

To generate a PWM signal for acceleration and deceleration in C++, we can use hardware-specific libraries that interface with hardware timers and GPIO (General Purpose Input/Output) pins. The specific implementation can vary depending on the platform (e.g., Arduino, Raspberry Pi). Below, I will show two examples:

1. **Arduino**: For microcontrollers like Arduino.
2. **Raspberry Pi**: Using the wiringPi library.

**Example 1: Arduino**

**Setup:**

1. Arduino IDE installed.
2. An Arduino board (e.g., Arduino Uno).

**Code:**

const int pwmPin = 9; // PWM output pin on Arduino

int pwmValue = 0; // Initial PWM value

void setup() {

pinMode(pwmPin, OUTPUT);

}

void loop() {

// Acceleration phase

for (pwmValue = 0; pwmValue <= 255; pwmValue++) {

analogWrite(pwmPin, pwmValue);

delay(10); // Adjust delay for acceleration rate

}

// Full speed

delay(1000); // Run at full speed for 1 second

// Deceleration phase

for (pwmValue = 255; pwmValue >= 0; pwmValue--) {

analogWrite(pwmPin, pwmValue);

delay(10); // Adjust delay for deceleration rate

}

// Stop

delay(1000); // Stop for 1 second

}

C++

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**Example 2: Raspberry Pi Using wiringPi Library**

**Setup:**

1. Raspberry Pi running Raspbian.
2. wiringPi library installed.

**Installation of wiringPi:**

sudo apt-get update

sudo apt-get install wiringpi

Shell

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**Code:**

#include <wiringPi.h>

const int pwmPin = 1; // GPIO18 (Physical pin 12) in PWM Mode

const int pwmRange = 1024; // Range for PWM

void setup() {

wiringPiSetup();

pinMode(pwmPin, PWM\_OUTPUT);

pwmSetMode(PWM\_MODE\_MS);

pwmSetRange(pwmRange);

pwmSetClock(384); // Adjust to set the PWM frequency

}

void loop() {

// Acceleration phase

for (int pwmValue = 0; pwmValue <= pwmRange; pwmValue++) {

pwmWrite(pwmPin, pwmValue);

delay(10); // Adjust delay for acceleration rate

}

// Full speed

delay(1000); // Run at full speed for 1 second

// Deceleration phase

for (int pwmValue = pwmRange; pwmValue >= 0; pwmValue--) {

pwmWrite(pwmPin, pwmValue);

delay(10); // Adjust delay for deceleration rate

}

// Stop

delay(1000); // Stop for 1 second

}

int main() {

setup();

while (1) {

loop();

}

return 0;

}

C++

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**Summary:**

* **Arduino**: Uses the analogWrite function to output PWM for the specified pin. The delay function is used to control the rate of acceleration and deceleration.
* **Raspberry Pi**: Uses the wiringPi library to control PWM output. This requires setting up the PWM mode, range, and clock to appropriately manage the PWM signal.

Let me know which platform you are working on, or if you have specific requirements so I can better tailor the solution to your needs!

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on stm32m103

To generate PWM signals for acceleration and deceleration on an STM32 microcontroller (such as the STM32F103), we typically use the HAL (Hardware Abstraction Layer) library provided by STMicroelectronics. The steps involve configuring the PWM output using a timer peripheral and then updating the PWM duty cycle in the code.

Here is an example using STM32CubeMX and HAL library in STM32CubeIDE.

**Step-by-Step Procedure**

**1. Configure PWM with STM32CubeMX**

1. **Open STM32CubeMX** and create a new project for the STM32F103 microcontroller.
2. **Configure the clock settings** as needed.
3. **Enable Timers** (e.g., TIM2) for PWM output:
   * Select TIM2 and configure one channel (e.g., Channel 1) in PWM mode.
   * Choose an appropriate pin for PWM output (e.g., PA0 for TIM2\_CH1).
4. **Set Timer Frequency** and **PWM properties**:
   * Configure the timer's prescaler and counter period to achieve the desired PWM frequency.
   * The counter period determines the PWM resolution.
5. **Generate the code** using STM32CubeMX.

**2. Write the Code in STM32CubeIDE**

The generated code will include the necessary initialization routines, and you'll need to add the logic for accelerating and decelerating the PWM signal.

Here's an example of how the code might look:

/\* Includes ------------------------------------------------------------------\*/

#include "main.h"

/\* Private variables ---------------------------------------------------------\*/

TIM\_HandleTypeDef htim2;

/\* Private function prototypes -----------------------------------------------\*/

void SystemClock\_Config(void);

static void MX\_GPIO\_Init(void);

static void MX\_TIM2\_Init(void);

/\* User Code \*/

void setPWM(uint16\_t pwmValue) {

\_\_HAL\_TIM\_SET\_COMPARE(&htim2, TIM\_CHANNEL\_1, pwmValue);

}

int main(void) {

/\* Reset of all peripherals, Initialize the Flash interface and the Systick. \*/

HAL\_Init();

/\* Configure the system clock \*/

SystemClock\_Config();

/\* Initialize all configured peripherals \*/

MX\_GPIO\_Init();

MX\_TIM2\_Init();

/\* Start PWM \*/

HAL\_TIM\_PWM\_Start(&htim2, TIM\_CHANNEL\_1);

uint16\_t pwmValue = 0;

uint16\_t maxPWMValue = \_\_HAL\_TIM\_GET\_AUTORELOAD(&htim2);

while (1) {

// Acceleration phase

for (pwmValue = 0; pwmValue <= maxPWMValue; pwmValue++) {

setPWM(pwmValue);

HAL\_Delay(10); // Adjust delay for acceleration rate

}

// Full speed

HAL\_Delay(1000); // Run at full speed for 1 second

// Deceleration phase

for (pwmValue = maxPWMValue; pwmValue > 0; pwmValue--) {

setPWM(pwmValue);

HAL\_Delay(10); // Adjust delay for deceleration rate

}

// Stop

HAL\_Delay(1000); // Stop for 1 second

}

}

static void MX\_TIM2\_Init(void)

{

TIM\_ClockConfigTypeDef sClockSourceConfig = {0};

TIM\_MasterConfigTypeDef sMasterConfig = {0};

TIM\_OC\_InitTypeDef sConfigOC = {0};

htim2.Instance = TIM2;

htim2.Init.Prescaler = 72 - 1; // Adjust prescaler as needed

htim2.Init.CounterMode = TIM\_COUNTERMODE\_UP;

htim2.Init.Period = 1000 - 1; // Adjust period for PWM resolution

htim2.Init.ClockDivision = TIM\_CLOCKDIVISION\_DIV1;

if (HAL\_TIM\_Base\_Init(&htim2) != HAL\_OK)

{

Error\_Handler();

}

sClockSourceConfig.ClockSource = TIM\_CLOCKSOURCE\_INTERNAL;

if (HAL\_TIM\_ConfigClockSource(&htim2, &sClockSourceConfig) != HAL\_OK)

{

Error\_Handler();

}

if (HAL\_TIM\_PWM\_Init(&htim2) != HAL\_OK)

{

Error\_Handler();

}

sMasterConfig.MasterOutputTrigger = TIM\_TRGO\_RESET;

sMasterConfig.MasterSlaveMode = TIM\_MASTERSLAVEMODE\_DISABLE;

if (HAL\_TIMEx\_MasterConfigSynchronization(&htim2, &sMasterConfig) != HAL\_OK)

{

Error\_Handler();

}

sConfigOC.OCMode = TIM\_OCMODE\_PWM1;

sConfigOC.Pulse = 0;

sConfigOC.OCPolarity = TIM\_OCPOLARITY\_HIGH;

sConfigOC.OCFastMode = TIM\_OCFAST\_DISABLE;

if (HAL\_TIM\_PWM\_ConfigChannel(&htim2, &sConfig

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continue

Certainly! Here is the continuation of the code within the MX\_TIM2\_Init function and the supporting functions for the STM32 microcontroller:

if (HAL\_TIM\_PWM\_ConfigChannel(&htim2, &sConfigOC, TIM\_CHANNEL\_1) != HAL\_OK)

{

Error\_Handler();

}

HAL\_TIM\_MspPostInit(&htim2);

}

static void MX\_GPIO\_Init(void)

{

\_\_HAL\_RCC\_GPIOA\_CLK\_ENABLE();

GPIO\_InitTypeDef GPIO\_InitStruct = {0};

/\*Configure GPIO pin : PA0 \*/

GPIO\_InitStruct.Pin = GPIO\_PIN\_0;

GPIO\_InitStruct.Mode = GPIO\_MODE\_AF\_PP;

GPIO\_InitStruct.Speed = GPIO\_SPEED\_FREQ\_LOW;

HAL\_GPIO\_Init(GPIOA, &GPIO\_InitStruct);

}

/\*\*

\* @brief System Clock Configuration

\* @retval None

\*/

void SystemClock\_Config(void)

{

RCC\_OscInitTypeDef RCC\_OscInitStruct = {0};

RCC\_ClkInitTypeDef RCC\_ClkInitStruct = {0};

/\*\* Initializes the RCC Oscillators according to the specified parameters

\* in the RCC\_OscInitTypeDef structure.

\*/

RCC\_OscInitStruct.OscillatorType = RCC\_OSCILLATORTYPE\_HSE;

RCC\_OscInitStruct.HSEState = RCC\_HSE\_ON;

RCC\_OscInitStruct.HSEPredivValue = RCC\_HSE\_PREDIV\_DIV1;

RCC\_OscInitStruct.PLL.PLLState = RCC\_PLL\_ON;

RCC\_OscInitStruct.PLL.PLLSource = RCC\_PLLSOURCE\_HSE;

RCC\_OscInitStruct.PLL.PLLMUL = RCC\_PLL\_MUL9;

if (HAL\_RCC\_OscConfig(&RCC\_OscInitStruct) != HAL\_OK)

{

Error\_Handler();

}

/\*\* Initializes the CPU, AHB and APB buses clocks

\*/

RCC\_ClkInitStruct.ClockType = RCC\_CLOCKTYPE\_HCLK|RCC\_CLOCKTYPE\_SYSCLK

|RCC\_CLOCKTYPE\_PCLK1|RCC\_CLOCKTYPE\_PCLK2;

RCC\_ClkInitStruct.SYSCLKSource = RCC\_SYSCLKSOURCE\_PLLCLK;

RCC\_ClkInitStruct.AHBCLKDivider = RCC\_SYSCLK\_DIV1;

RCC\_ClkInitStruct.APB1CLKDivider = RCC\_HCLK\_DIV2;

RCC\_ClkInitStruct.APB2CLKDivider = RCC\_HCLK\_DIV1;

if (HAL\_RCC\_ClockConfig(&RCC\_ClkInitStruct, FLASH\_LATENCY\_2) != HAL\_OK)

{

Error\_Handler();

}

}

/\*\*

\* @brief This function handles any errors that occur during initialization.

\* @retval None

\*/

void Error\_Handler(void)

{

while(1)

{

// Stay here to indicate an error (could also add custom error handling here)

}

}

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**Explanation & Final Notes**

* **TIM2 Configuration**:
  + **Prescaler**: Divides the timer's input clock to slow it down. Adjust this for your specific needs.
  + **Counter Period**: Defines the maximum count value. Adjust to set the PWM resolution.
  + **Clock Division**: Sets the clock division.
  + **Output Compare (OC) Mode**: Sets PWM mode (PWM1 in this case).
* **GPIO Initialization**:
  + Configures the GPIO pin for the Timer's PWM output.
* **System Clock Configuration**:
  + Sets up the system clock source and configuration for the microcontroller.
* **Error Handler**:
  + Infinite loop to indicate error state; customize as needed for your error handling.

**Usage**

* **Set PWM Duty Cycle**: The setPWM function is used to update the PWM value.
* **Control Loop**: In the main function, the PWM value is varied to produce acceleration and deceleration.

**Summary**

This code sets up a PWM signal on an STM32F103 and varies the duty cycle to emulate acceleration and deceleration. Make sure to adjust the TIM2 prescaler, counter period, and delay values to fit your specific requirements. If you need more detailed adjustments or have further specific questions, feel free to ask!

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c++ code to output PWM for acceleration and deceleration with X and Y intorpolation.

To generate PWM signals with acceleration and deceleration using X and Y interpolation (such as linear or smooth interpolation) on an STM32 microcontroller, we need to modify the previous example to include interpolation between the start and end values.

Below, I outline how to achieve this in C++. The example will show:

1. Linear interpolation between two points (X and Y) for PWM value changes.
2. Implementation for STM32 using the STM32CubeMX and STM32CubeIDE setup.

**Setup Using STM32CubeMX**

1. **Open STM32CubeMX** and create a new project for the STM32F103 microcontroller.
2. **Configure the clock settings** as needed.
3. **Enable Timers** (e.g., TIM2) for PWM output:
   * Select TIM2 and configure one channel (e.g., Channel 1) in PWM mode.
   * Choose an appropriate pin for PWM output (e.g., PA0 for TIM2\_CH1).
4. **Set Timer Frequency** and **PWM properties**:
   * Configure the timer's prescaler and counter period to achieve the desired PWM frequency.
   * The counter period determines the PWM resolution.
5. **Generate the code** using STM32CubeMX.

**Writing the Interpolation Code in STM32CubeIDE**

This example provides a linear interpolation function to vary the PWM value:

/\* Includes ------------------------------------------------------------------\*/

#include "main.h"

/\* Private variables ---------------------------------------------------------\*/

TIM\_HandleTypeDef htim2;

/\* Private function prototypes -----------------------------------------------\*/

void SystemClock\_Config(void);

static void MX\_GPIO\_Init(void);

static void MX\_TIM2\_Init(void);

float linearInterpolate(float x, float x0, float x1, float y0, float y1);

void setPWM(uint16\_t pwmValue);

/\* User Code \*/

float linearInterpolate(float x, float x0, float x1, float y0, float y1) {

return y0 + ( (x - x0) \* (y1 - y0) ) / (x1 - x0);

}

void setPWM(uint16\_t pwmValue) {

\_\_HAL\_TIM\_SET\_COMPARE(&htim2, TIM\_CHANNEL\_1, pwmValue);

}

int main(void) {

/\* Reset of all peripherals, Initialize the Flash interface and the Systick. \*/

HAL\_Init();

/\* Configure the system clock \*/

SystemClock\_Config();

/\* Initialize all configured peripherals \*/

MX\_GPIO\_Init();

MX\_TIM2\_Init();

/\* Start PWM \*/

HAL\_TIM\_PWM\_Start(&htim2, TIM\_CHANNEL\_1);

uint16\_t pwmValue = 0;

uint16\_t maxPWMValue = \_\_HAL\_TIM\_GET\_AUTORELOAD(&htim2);

float startTime = 0;

float endTime = 100.0; // Adjust the duration as necessary

while (1) {

// Acceleration phase

for (float currentTime = startTime; currentTime <= endTime; currentTime++) {

pwmValue = static\_cast<uint16\_t>(linearInterpolate(currentTime, startTime, endTime, 0, maxPWMValue));

setPWM(pwmValue);

HAL\_Delay(10); // Adjust delay for acceleration rate

}

// Full speed

HAL\_Delay(1000); // Run at full speed for 1 second

// Deceleration phase

for (float currentTime = startTime; currentTime <= endTime; currentTime++) {

pwmValue = static\_cast<uint16\_t>(linearInterpolate(currentTime, startTime, endTime, maxPWMValue, 0));

setPWM(pwmValue);

HAL\_Delay(10); // Adjust delay for deceleration rate

}

// Stop

HAL\_Delay(1000); // Stop for 1 second

}

}

static void MX\_TIM2\_Init(void)

{

TIM\_ClockConfigTypeDef sClockSourceConfig = {0};

TIM\_MasterConfigTypeDef sMasterConfig = {0};

TIM\_OC\_InitTypeDef sConfigOC = {0};

htim2.Instance = TIM2;

htim2.Init.Prescaler = 72 - 1; // Adjust prescaler as needed

htim2.Init.CounterMode = TIM\_COUNTERMODE\_UP;

htim2.Init.Period = 1000 - 1; // Adjust period for PWM resolution

htim2.Init.ClockDivision = TIM\_CLOCKDIVISION\_DIV1;

if (HAL\_TIM\_Base\_Init(&htim2) != HAL\_OK)

{

Error\_Handler();

}

sClockSourceConfig.ClockSource = TIM\_CLOCKSOURCE\_INTERNAL;

if (HAL\_TIM\_ConfigClockSource(&htim2, &sClockSourceConfig) != HAL\_OK)

{

Error\_Handler();

}

if (HAL\_TIM\_PWM\_Init

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continue

Certainly! Here’s the continuation and completion of the configuration and initialization code:

if (HAL\_TIM\_PWM\_Init(&htim2) != HAL\_OK)

{

Error\_Handler();

}

sMasterConfig.MasterOutputTrigger = TIM\_TRGO\_RESET;

sMasterConfig.MasterSlaveMode = TIM\_MASTERSLAVEMODE\_DISABLE;

if (HAL\_TIMEx\_MasterConfigSynchronization(&htim2, &sMasterConfig) != HAL\_OK)

{

Error\_Handler();

}

sConfigOC.OCMode = TIM\_OCMODE\_PWM1;

sConfigOC.Pulse = 0;

sConfigOC.OCPolarity = TIM\_OCPOLARITY\_HIGH;

sConfigOC.OCFastMode = TIM\_OCFAST\_DISABLE;

if (HAL\_TIM\_PWM\_ConfigChannel(&htim2, &sConfigOC, TIM\_CHANNEL\_1) != HAL\_OK)

{

Error\_Handler();

}

HAL\_TIM\_MspPostInit(&htim2);

}

static void MX\_GPIO\_Init(void)

{

\_\_HAL\_RCC\_GPIOA\_CLK\_ENABLE();

GPIO\_InitTypeDef GPIO\_InitStruct = {0};

GPIO\_InitStruct.Pin = GPIO\_PIN\_0;

GPIO\_InitStruct.Mode = GPIO\_MODE\_AF\_PP;

GPIO\_InitStruct.Speed = GPIO\_SPEED\_FREQ\_LOW;

HAL\_GPIO\_Init(GPIOA, &GPIO\_InitStruct);

}

void SystemClock\_Config(void)

{

RCC\_OscInitTypeDef RCC\_OscInitStruct = {0};

RCC\_ClkInitTypeDef RCC\_ClkInitStruct = {0};

RCC\_OscInitStruct.OscillatorType = RCC\_OSCILLATORTYPE\_HSE;

RCC\_OscInitStruct.HSEState = RCC\_HSE\_ON;

RCC\_OscInitStruct.HSEPredivValue = RCC\_HSE\_PREDIV\_DIV1;

RCC\_OscInitStruct.PLL.PLLState = RCC\_PLL\_ON;

RCC\_OscInitStruct.PLL.PLLSource = RCC\_PLLSOURCE\_HSE;

RCC\_OscInitStruct.PLL.PLLMUL = RCC\_PLL\_MUL9;

if (HAL\_RCC\_OscConfig(&RCC\_OscInitStruct) != HAL\_OK)

{

Error\_Handler();

}

RCC\_ClkInitStruct.ClockType = RCC\_CLOCKTYPE\_HCLK|RCC\_CLOCKTYPE\_SYSCLK

|RCC\_CLOCKTYPE\_PCLK1|RCC\_CLOCKTYPE\_PCLK2;

RCC\_ClkInitStruct.SYSCLKSource = RCC\_SYSCLKSOURCE\_PLLCLK;

RCC\_ClkInitStruct.AHBCLKDivider = RCC\_SYSCLK\_DIV1;

RCC\_ClkInitStruct.APB1CLKDivider = RCC\_HCLK\_DIV2;

RCC\_ClkInitStruct.APB2CLKDivider = RCC\_HCLK\_DIV1;

if (HAL\_RCC\_ClockConfig(&RCC\_ClkInitStruct, FLASH\_LATENCY\_2) != HAL\_OK)

{

Error\_Handler();

}

}

void Error\_Handler(void)

{

while(1)

{

// Stay here to indicate an error (could also add custom error handling here)

}

}

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**Final Notes**

This code configures the STM32 microcontroller to generate a PWM signal, using linear interpolation for the PWM duty cycle during acceleration and deceleration. Let’s break down a few points:

* **Initialization**: The peripherals and system clock are initialized using the generated code from STM32CubeMX.
* **Linear Interpolation**: The linearInterpolate function calculates the intermediate PWM values between the start (y0) and end (y1) values over a specified time period.
* **PWM Control**: The setPWM function sets the PWM duty cycle by modifying the compare register for the specified channel.
* **Main Loop**:
  + **Acceleration and Deceleration** phases adjust PWM linearly.
  + You can adjust startTime, endTime, and the delay within the loop to fine-tune the acceleration/deceleration.

Make sure you adjust the prescaler and counter period settings to match your specific timer requirements.

If you need further adjustments or additional features, let me know!

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c++ code to generate PWM signals with acceleration and deceleration using X and Y interpolation in 2 axes simultaneously

To generate PWM signals with acceleration and deceleration using X and Y interpolation for 2 axes simultaneously, we can expand on our existing approach. In this detailed example, we'll use two PWM channels (one for each axis) and linear interpolation to control the duty cycle for each axis independently.

For simplicity, I'll provide an example for an STM32 microcontroller. This involves:

* Configuring two PWM channels.
* Implementing linear interpolation for both axes.
* Creating a loop to adjust the PWM values for both axes simultaneously.

**Setup Using STM32CubeMX**

1. **Open STM32CubeMX** and create a new project for the STM32F103 microcontroller.
2. **Configure the clock settings** as needed.
3. **Enable Timers** (e.g., TIM2) for PWM output:
   * Select TIM2 and configure two channels (e.g., Channel 1 and Channel 2) in PWM mode.
   * Choose appropriate pins for PWM output (e.g., PA0 for TIM2\_CH1 and PA1 for TIM2\_CH2).
4. **Set Timer Frequency** and **PWM properties**:
   * Configure the timer's prescaler and counter period to achieve the desired PWM frequency.
   * The counter period determines the PWM resolution.
5. **Generate the code** using STM32CubeMX.

**Writing the Interpolation Code in STM32CubeIDE**

Below is a C++ example:

#include "main.h"

/\* Private variables ---------------------------------------------------------\*/

TIM\_HandleTypeDef htim2;

/\* Private function prototypes -----------------------------------------------\*/

void SystemClock\_Config(void);

static void MX\_GPIO\_Init(void);

static void MX\_TIM2\_Init(void);

float linearInterpolate(float x, float x0, float x1, float y0, float y1);

void setPWM(uint16\_t pwmValue, uint32\_t channel);

/\* User Code \*/

float linearInterpolate(float x, float x0, float x1, float y0, float y1) {

return y0 + ((x - x0) \* (y1 - y0)) / (x1 - x0);

}

void setPWM(uint16\_t pwmValue, uint32\_t channel) {

\_\_HAL\_TIM\_SET\_COMPARE(&htim2, channel, pwmValue);

}

int main(void) {

/\* Reset of all peripherals, Initialize the Flash interface and the Systick. \*/

HAL\_Init();

/\* Configure the system clock \*/

SystemClock\_Config();

/\* Initialize all configured peripherals \*/

MX\_GPIO\_Init();

MX\_TIM2\_Init();

/\* Start PWM \*/

HAL\_TIM\_PWM\_Start(&htim2, TIM\_CHANNEL\_1);

HAL\_TIM\_PWM\_Start(&htim2, TIM\_CHANNEL\_2);

uint16\_t pwmValueX = 0, pwmValueY = 0;

uint16\_t maxPWMValue = \_\_HAL\_TIM\_GET\_AUTORELOAD(&htim2);

float startTime = 0;

float endTime = 100.0; // Adjust the duration as necessary

while (1) {

// Acceleration phase for both axes

for (float currentTime = startTime; currentTime <= endTime; currentTime++) {

pwmValueX = static\_cast<uint16\_t>(linearInterpolate(currentTime, startTime, endTime, 0, maxPWMValue));

pwmValueY = static\_cast<uint16\_t>(linearInterpolate(currentTime, startTime, endTime, 0, maxPWMValue));

setPWM(pwmValueX, TIM\_CHANNEL\_1);

setPWM(pwmValueY, TIM\_CHANNEL\_2);

HAL\_Delay(10); // Adjust delay for acceleration rate

}

// Full speed for 1 second

HAL\_Delay(1000);

// Deceleration phase for both axes

for (float currentTime = startTime; currentTime <= endTime; currentTime++) {

pwmValueX = static\_cast<uint16\_t>(linearInterpolate(currentTime, startTime, endTime, maxPWMValue, 0));

pwmValueY = static\_cast<uint16\_t>(linearInterpolate(currentTime, startTime, endTime, maxPWMValue, 0));

setPWM(pwmValueX, TIM\_CHANNEL\_1);

setPWM(pwmValueY, TIM\_CHANNEL\_2);

HAL\_Delay(10); // Adjust delay for deceleration rate

}

// Stop for 1 second

HAL\_Delay(1000);

}

}

static void MX\_TIM2\_Init(void)

{

TIM\_ClockConfigTypeDef sClockSourceConfig = {0};

TIM\_MasterConfigTypeDef sMasterConfig = {0};

TIM\_OC\_InitTypeDef sConfigOC = {0};

htim2.Instance = TIM2;

htim2.Init.Prescaler = 72 - 1; //

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continue

Certainly! Here’s the continuation and completion of configuring and initializing the TIM2 for two PWM channels:

htim2.Init.Prescaler = 72 - 1; // Adjust prescaler as needed

htim2.Init.CounterMode = TIM\_COUNTERMODE\_UP;

htim2.Init.Period = 1000 - 1; // Adjust period for PWM resolution

htim2.Init.ClockDivision = TIM\_CLOCKDIVISION\_DIV1;

if (HAL\_TIM\_Base\_Init(&htim2) != HAL\_OK) {

Error\_Handler();

}

sClockSourceConfig.ClockSource = TIM\_CLOCKSOURCE\_INTERNAL;

if (HAL\_TIM\_ConfigClockSource(&htim2, &sClockSourceConfig) != HAL\_OK) {

Error\_Handler();

}

if (HAL\_TIM\_PWM\_Init(&htim2) != HAL\_OK) {

Error\_Handler();

}

sMasterConfig.MasterOutputTrigger = TIM\_TRGO\_RESET;

sMasterConfig.MasterSlaveMode = TIM\_MASTERSLAVEMODE\_DISABLE;

if (HAL\_TIMEx\_MasterConfigSynchronization(&htim2, &sMasterConfig) != HAL\_OK) {

Error\_Handler();

}

sConfigOC.OCMode = TIM\_OCMODE\_PWM1;

sConfigOC.Pulse = 0;

sConfigOC.OCPolarity = TIM\_OCPOLARITY\_HIGH;

sConfigOC.OCFastMode = TIM\_OCFAST\_DISABLE;

if (HAL\_TIM\_PWM\_ConfigChannel(&htim2, &sConfigOC, TIM\_CHANNEL\_1) != HAL\_OK) {

Error\_Handler();

}

if (HAL\_TIM\_PWM\_ConfigChannel(&htim2, &sConfigOC, TIM\_CHANNEL\_2) != HAL\_OK) {

Error\_Handler();

}

HAL\_TIM\_MspPostInit(&htim2);

}

static void MX\_GPIO\_Init(void)

{

\_\_HAL\_RCC\_GPIOA\_CLK\_ENABLE();

GPIO\_InitTypeDef GPIO\_InitStruct = {0};

GPIO\_InitStruct.Pin = GPIO\_PIN\_0 | GPIO\_PIN\_1; // PA0 for TIM2\_CH1, PA1 for TIM2\_CH2

GPIO\_InitStruct.Mode = GPIO\_MODE\_AF\_PP;

GPIO\_InitStruct.Speed = GPIO\_SPEED\_FREQ\_LOW;

HAL\_GPIO\_Init(GPIOA, &GPIO\_InitStruct);

}

void SystemClock\_Config(void)

{

RCC\_OscInitTypeDef RCC\_OscInitStruct = {0};

RCC\_ClkInitTypeDef RCC\_ClkInitStruct = {0};

RCC\_OscInitStruct.OscillatorType = RCC\_OSCILLATORTYPE\_HSE;

RCC\_OscInitStruct.HSEState = RCC\_HSE\_ON;

RCC\_OscInitStruct.HSEPredivValue = RCC\_HSE\_PREDIV\_DIV1;

RCC\_OscInitStruct.PLL.PLLState = RCC\_PLL\_ON;

RCC\_OscInitStruct.PLL.PLLSource = RCC\_PLLSOURCE\_HSE;

RCC\_OscInitStruct.PLL.PLLMUL = RCC\_PLL\_MUL9;

if (HAL\_RCC\_OscConfig(&RCC\_OscInitStruct) != HAL\_OK) {

Error\_Handler();

}

RCC\_ClkInitStruct.ClockType = RCC\_CLOCKTYPE\_HCLK|RCC\_CLOCKTYPE\_SYSCLK|RCC\_CLOCKTYPE\_PCLK1|RCC\_CLOCKTYPE\_PCLK2;

RCC\_ClkInitStruct.SYSCLKSource = RCC\_SYSCLKSOURCE\_PLLCLK;

RCC\_ClkInitStruct.AHBCLKDivider = RCC\_SYSCLK\_DIV1;

RCC\_ClkInitStruct.APB1CLKDivider = RCC\_HCLK\_DIV2;

RCC\_ClkInitStruct.APB2CLKDivider = RCC\_HCLK\_DIV1;

if (HAL\_RCC\_ClockConfig(&RCC\_ClkInitStruct, FLASH\_LATENCY\_2) != HAL\_OK) {

Error\_Handler();

}

}

void Error\_Handler(void)

{

while(1) {

// Stay here to indicate an error (could also add custom error handling here)

}

}

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**Final Notes**

This code configures the STM32 microcontroller to generate PWM signals for two axes (channels) using linear interpolation for acceleration and deceleration. Breaking down a few important points:

* **Initialization**: The MX\_TIM2\_Init function configures two channels for PWM output.
* **Linear Interpolation**: The linearInterpolate function calculates intermediate PWM values between the start (y0) and end (y1) values over a specified time period.
* **PWM Control**: The setPWM function sets the PWM duty cycle by modifying the compare register for the specified channel.
* **Main Loop**:
  + **Acceleration phase**: Adjusts PWM for both channels linearly.
  + **Full speed**: Maintains maximum PWM for a specified duration.
  + \*\*Deceleration phase

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Certainly! Continuing from where we left off:

**Finalizing the Main Loop**

The main loop handles the PWM duty cycle adjustment using linear interpolation for both the acceleration and deceleration phases. Here, we maintain PWM duty cycles at maximum value for a set duration after acceleration and deceleration.

Here's the full, combined example for the main loop:

#include "main.h"

/\* Private variables ---------------------------------------------------------\*/

TIM\_HandleTypeDef htim2;

/\* Private function prototypes -----------------------------------------------\*/

void SystemClock\_Config(void);

static void MX\_GPIO\_Init(void);

static void MX\_TIM2\_Init(void);

float linearInterpolate(float x, float x0, float x1, float y0, float y1);

void setPWM(uint16\_t pwmValue, uint32\_t channel);

/\* User Code \*/

float linearInterpolate(float x, float x0, float x1, float y0, float y1) {

return y0 + ((x - x0) \* (y1 - y0)) / (x1 - x0);

}

void setPWM(uint16\_t pwmValue, uint32\_t channel) {

\_\_HAL\_TIM\_SET\_COMPARE(&htim2, channel, pwmValue);

}

int main(void) {

/\* Reset of all peripherals, Initialize the Flash interface and the Systick. \*/

HAL\_Init();

/\* Configure the system clock \*/

SystemClock\_Config();

/\* Initialize all configured peripherals \*/

MX\_GPIO\_Init();

MX\_TIM2\_Init();

/\* Start PWM \*/

HAL\_TIM\_PWM\_Start(&htim2, TIM\_CHANNEL\_1);

HAL\_TIM\_PWM\_Start(&htim2, TIM\_CHANNEL\_2);

uint16\_t pwmValueX = 0, pwmValueY = 0;

uint16\_t maxPWMValue = \_\_HAL\_TIM\_GET\_AUTORELOAD(&htim2);

float startTime = 0;

float endTime = 100.0; // Adjust the duration as necessary

while (1) {

// Acceleration phase for both axes

for (float currentTime = startTime; currentTime <= endTime; currentTime++) {

pwmValueX = static\_cast<uint16\_t>(linearInterpolate(currentTime, startTime, endTime, 0, maxPWMValue));

pwmValueY = static\_cast<uint16\_t>(linearInterpolate(currentTime, startTime, endTime, 0, maxPWMValue));

setPWM(pwmValueX, TIM\_CHANNEL\_1);

setPWM(pwmValueY, TIM\_CHANNEL\_2);

HAL\_Delay(10); // Adjust delay for acceleration rate

}

// Full speed for 1 second

HAL\_Delay(1000);

// Deceleration phase for both axes

for (float currentTime = startTime; currentTime <= endTime; currentTime++) {

pwmValueX = static\_cast<uint16\_t>(linearInterpolate(currentTime, startTime, endTime, maxPWMValue, 0));

pwmValueY = static\_cast<uint16\_t>(linearInterpolate(currentTime, startTime, endTime, maxPWMValue, 0));

setPWM(pwmValueX, TIM\_CHANNEL\_1);

setPWM(pwmValueY, TIM\_CHANNEL\_2);

HAL\_Delay(10); // Adjust delay for deceleration rate

}

// Stop for 1 second

HAL\_Delay(1000);

}

}

static void MX\_TIM2\_Init(void) {

TIM\_ClockConfigTypeDef sClockSourceConfig = {0};

TIM\_MasterConfigTypeDef sMasterConfig = {0};

TIM\_OC\_InitTypeDef sConfigOC = {0};

htim2.Instance = TIM2;

htim2.Init.Prescaler = 72 - 1;

htim2.Init.CounterMode = TIM\_COUNTERMODE\_UP;

htim2.Init.Period = 1000 - 1;

htim2.Init.ClockDivision = TIM\_CLOCKDIVISION\_DIV1;

if (HAL\_TIM\_Base\_Init(&htim2) != HAL\_OK) {

Error\_Handler();

}

sClockSourceConfig.ClockSource = TIM\_CLOCKSOURCE\_INTERNAL;

if (HAL\_TIM\_ConfigClockSource(&htim2, &sClockSourceConfig) != HAL\_OK) {

Error\_Handler();

}

if (HAL\_TIM\_PWM\_Init(&htim2) != HAL\_OK) {

Error\_Handler();

}

sMasterConfig.MasterOutputTrigger = TIM\_TRGO\_RESET;

sMasterConfig.MasterSlaveMode = TIM\_MASTERSLAVEMODE\_DISABLE;

if (HAL\_TIMEx\_MasterConfigSynchronization(&htim2, &sMasterConfig) != HAL\_OK) {

Error\_Handler();

}

sConfigOC.OCMode = TIM\_OCMODE\_PWM1;

sConfigOC.Pulse = 0;

s

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continue

Sure, let's continue with the configuration for the PWM initialization and complete the MX\_TIM2\_Init function.

**Completing MX\_TIM2\_Init Function**

Here is the continuation of the MX\_TIM2\_Init function:

sConfigOC.OCMode = TIM\_OCMODE\_PWM1;

sConfigOC.Pulse = 0;

sConfigOC.OCPolarity = TIM\_OCPOLARITY\_HIGH;

sConfigOC.OCFastMode = TIM\_OCFAST\_DISABLE;

// Configuring Channel 1

if (HAL\_TIM\_PWM\_ConfigChannel(&htim2, &sConfigOC, TIM\_CHANNEL\_1) != HAL\_OK) {

Error\_Handler();

}

// Configuring Channel 2

if (HAL\_TIM\_PWM\_ConfigChannel(&htim2, &sConfigOC, TIM\_CHANNEL\_2) != HAL\_OK) {

Error\_Handler();

}

HAL\_TIM\_MspPostInit(&htim2);

}

static void MX\_GPIO\_Init(void) {

\_\_HAL\_RCC\_GPIOA\_CLK\_ENABLE();

GPIO\_InitTypeDef GPIO\_InitStruct = {0};

GPIO\_InitStruct.Pin = GPIO\_PIN\_0 | GPIO\_PIN\_1; // PA0 for TIM2\_CH1, PA1 for TIM2\_CH2

GPIO\_InitStruct.Mode = GPIO\_MODE\_AF\_PP;

GPIO\_InitStruct.Speed = GPIO\_SPEED\_FREQ\_LOW;

HAL\_GPIO\_Init(GPIOA, &GPIO\_InitStruct);

}

void SystemClock\_Config(void) {

RCC\_OscInitTypeDef RCC\_OscInitStruct = {0};

RCC\_ClkInitTypeDef RCC\_ClkInitStruct = {0};

RCC\_OscInitStruct.OscillatorType = RCC\_OSCILLATORTYPE\_HSE;

RCC\_OscInitStruct.HSEState = RCC\_HSE\_ON;

RCC\_OscInitStruct.HSEPredivValue = RCC\_HSE\_PREDIV\_DIV1;

RCC\_OscInitStruct.PLL.PLLState = RCC\_PLL\_ON;

RCC\_OscInitStruct.PLL.PLLSource = RCC\_PLLSOURCE\_HSE;

RCC\_OscInitStruct.PLL.PLLMUL = RCC\_PLL\_MUL9;

if (HAL\_RCC\_OscConfig(&RCC\_OscInitStruct) != HAL\_OK) {

Error\_Handler();

}

RCC\_ClkInitStruct.ClockType = RCC\_CLOCKTYPE\_HCLK|RCC\_CLOCKTYPE\_SYSCLK|RCC\_CLOCKTYPE\_PCLK1|RCC\_CLOCKTYPE\_PCLK2;

RCC\_ClkInitStruct.SYSCLKSource = RCC\_SYSCLKSOURCE\_PLLCLK;

RCC\_ClkInitStruct.AHBCLKDivider = RCC\_SYSCLK\_DIV1;

RCC\_ClkInitStruct.APB1CLKDivider = RCC\_HCLK\_DIV2;

RCC\_ClkInitStruct.APB2CLKDivider = RCC\_HCLK\_DIV1;

if (HAL\_RCC\_ClockConfig(&RCC\_ClkInitStruct, FLASH\_LATENCY\_2) != HAL\_OK) {

Error\_Handler();

}

}

void Error\_Handler(void) {

while(1) {

// Stay here to indicate an error (could also add custom error handling here)

}

}

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**Final Notes**

This complete program configures the STM32 microcontroller to generate PWM signals for two axes using Timers in PWM mode. The relevant setup details include:

* **System Clock Configuration**: Setting the system clock to ensure that the microcontroller operates at the intended frequency.
* **GPIO Initialization**: Configuring pins PA0 and PA1 for PWM output.
* **PWM Initialization**: Setting up TIM2 with two channels configured for PWM output.

**Key Concepts Explained:**

* **Linear Interpolation Function (linearInterpolate)**: Calculates intermediate values for smooth transition between start and end points.
* **PWM Duty Cycle Adjustment**: The setPWM function sets the duty cycle by configuring the appropriate timer compare register.
* **Acceleration/Deceleration Implementation**: Adjusts PWM values gradually using linear interpolation over a specified duration.

If you need further clarification or additional features implemented, feel free to ask!

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c++ code to generate PWM signals with acceleration and deceleration using X,Y and Z interpolation in 3 axes simultaneously

To generate PWM signals for three axes simultaneously (X, Y, and Z) with acceleration and deceleration using interpolation, we need to expand our approach to handle three PWM channels. Here is an example using an STM32 microcontroller's hardware timers configured for PWM output.

**Setup Using STM32CubeMX**

1. **Open STM32CubeMX** and create a new project for the STM32F103 microcontroller.
2. **Configure the clock settings** as needed.
3. **Enable Timers** (e.g., TIM2) for PWM output, selecting three channels (e.g., Channel 1, Channel 2, and Channel 3).
4. **Set Timer Frequency** and **PWM properties**:
   * Configure the timer's prescaler and counter period to achieve the desired PWM frequency.
   * The counter period determines the PWM resolution.
5. **Generate the code** using STM32CubeMX.

**Writing the Interpolation Code in STM32CubeIDE**

In this example, we will:

* Configure three PWM channels.
* Use linear interpolation for acceleration and deceleration.
* Adjust PWM values for all three channels simultaneously.

Here's the complete C++ code:

#include "main.h"

/\* Private variables ---------------------------------------------------------\*/

TIM\_HandleTypeDef htim2;

/\* Private function prototypes -----------------------------------------------\*/

void SystemClock\_Config(void);

static void MX\_GPIO\_Init(void);

static void MX\_TIM2\_Init(void);

float linearInterpolate(float x, float x0, float x1, float y0, float y1);

void setPWM(uint16\_t pwmValue, uint32\_t channel);

/\* User Code \*/

float linearInterpolate(float x, float x0, float x1, float y0, float y1) {

return y0 + ((x - x0) \* (y1 - y0)) / (x1 - x0);

}

void setPWM(uint16\_t pwmValue, uint32\_t channel) {

\_\_HAL\_TIM\_SET\_COMPARE(&htim2, channel, pwmValue);

}

int main(void) {

/\* Reset of all peripherals, Initialize the Flash interface and the Systick. \*/

HAL\_Init();

/\* Configure the system clock \*/

SystemClock\_Config();

/\* Initialize all configured peripherals \*/

MX\_GPIO\_Init();

MX\_TIM2\_Init();

/\* Start PWM \*/

HAL\_TIM\_PWM\_Start(&htim2, TIM\_CHANNEL\_1);

HAL\_TIM\_PWM\_Start(&htim2, TIM\_CHANNEL\_2);

HAL\_TIM\_PWM\_Start(&htim2, TIM\_CHANNEL\_3);

uint16\_t pwmValueX = 0, pwmValueY = 0, pwmValueZ = 0;

uint16\_t maxPWMValue = \_\_HAL\_TIM\_GET\_AUTORELOAD(&htim2);

float startTime = 0;

float endTime = 100.0; // Adjust the duration as necessary

while (1) {

// Acceleration phase for all three axes

for (float currentTime = startTime; currentTime <= endTime; currentTime++) {

pwmValueX = static\_cast<uint16\_t>(linearInterpolate(currentTime, startTime, endTime, 0, maxPWMValue));

pwmValueY = static\_cast<uint16\_t>(linearInterpolate(currentTime, startTime, endTime, 0, maxPWMValue));

pwmValueZ = static\_cast<uint16\_t>(linearInterpolate(currentTime, startTime, endTime, 0, maxPWMValue));

setPWM(pwmValueX, TIM\_CHANNEL\_1);

setPWM(pwmValueY, TIM\_CHANNEL\_2);

setPWM(pwmValueZ, TIM\_CHANNEL\_3);

HAL\_Delay(10); // Adjust delay for acceleration rate

}

// Full speed for 1 second

HAL\_Delay(1000);

// Deceleration phase for all three axes

for (float currentTime = startTime; currentTime <= endTime; currentTime++) {

pwmValueX = static\_cast<uint16\_t>(linearInterpolate(currentTime, startTime, endTime, maxPWMValue, 0));

pwmValueY = static\_cast<uint16\_t>(linearInterpolate(currentTime, startTime, endTime, maxPWMValue, 0));

pwmValueZ = static\_cast<uint16\_t>(linearInterpolate(currentTime, startTime, endTime, maxPWMValue, 0));

setPWM(pwmValueX, TIM\_CHANNEL\_1);

setPWM(pwmValueY, TIM\_CHANNEL\_2);

setPWM(pwmValueZ, TIM\_CHANNEL\_3);

HAL\_Delay(10); // Adjust delay for deceleration rate

}

// Stop for 1 second

HAL\_Delay(1000);

}

}

static void MX\_TIM2\_Init(void) {

TIM\_Clock

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continue

Certainly, let's continue the MX\_TIM2\_Init function and ensure we finish the setup for the three PWM channels. Here is the full code:

**Completing MX\_TIM2\_Init Function**

Here is the continuation of the MX\_TIM2\_Init function:

static void MX\_TIM2\_Init(void) {

TIM\_ClockConfigTypeDef sClockSourceConfig = {0};

TIM\_MasterConfigTypeDef sMasterConfig = {0};

TIM\_OC\_InitTypeDef sConfigOC = {0};

htim2.Instance = TIM2;

htim2.Init.Prescaler = 72 - 1; // Adjust as necessary for the desired frequency

htim2.Init.CounterMode = TIM\_COUNTERMODE\_UP;

htim2.Init.Period = 1000 - 1; // Adjust for desired PWM resolution

htim2.Init.ClockDivision = TIM\_CLOCKDIVISION\_DIV1;

if (HAL\_TIM\_Base\_Init(&htim2) != HAL\_OK) {

Error\_Handler();

}

sClockSourceConfig.ClockSource = TIM\_CLOCKSOURCE\_INTERNAL;

if (HAL\_TIM\_ConfigClockSource(&htim2, &sClockSourceConfig) != HAL\_OK) {

Error\_Handler();

}

if (HAL\_TIM\_PWM\_Init(&htim2) != HAL\_OK) {

Error\_Handler();

}

sMasterConfig.MasterOutputTrigger = TIM\_TRGO\_RESET;

sMasterConfig.MasterSlaveMode = TIM\_MASTERSLAVEMODE\_DISABLE;

if (HAL\_TIMEx\_MasterConfigSynchronization(&htim2, &sMasterConfig) != HAL\_OK) {

Error\_Handler();

}

sConfigOC.OCMode = TIM\_OCMODE\_PWM1;

sConfigOC.Pulse = 0;

sConfigOC.OCPolarity = TIM\_OCPOLARITY\_HIGH;

sConfigOC.OCFastMode = TIM\_OCFAST\_DISABLE;

// Configuring Channel 1

if (HAL\_TIM\_PWM\_ConfigChannel(&htim2, &sConfigOC, TIM\_CHANNEL\_1) != HAL\_OK) {

Error\_Handler();

}

// Configuring Channel 2

if (HAL\_TIM\_PWM\_ConfigChannel(&htim2, &sConfigOC, TIM\_CHANNEL\_2) != HAL\_OK) {

Error\_handler();

}

// Configuring Channel 3

if (HAL\_TIM\_PWM\_ConfigChannel(&htim2, &sConfigOC, TIM\_CHANNEL\_3) != HAL\_OK) {

Error\_Handler();

}

HAL\_TIM\_MspPostInit(&htim2);

}

static void MX\_GPIO\_Init(void) {

\_\_HAL\_RCC\_GPIOA\_CLK\_ENABLE();

GPIO\_InitTypeDef GPIO\_InitStruct = {0};

GPIO\_InitStruct.Pin = GPIO\_PIN\_0 | GPIO\_PIN\_1 | GPIO\_PIN\_2; // PA0 for TIM2\_CH1, PA1 for TIM2\_CH2, PA2 for TIM2\_CH3

GPIO\_InitStruct.Mode = GPIO\_MODE\_AF\_PP;

GPIO\_InitStruct.Speed = GPIO\_SPEED\_FREQ\_LOW;

HAL\_GPIO\_Init(GPIOA, &GPIO\_InitStruct);

}

void SystemClock\_Config(void) {

RCC\_OscInitTypeDef RCC\_OscInitStruct = {0};

RCC\_ClkInitTypeDef RCC\_ClkInitStruct = {0};

RCC\_OscInitStruct.OscillatorType = RCC\_OSCILLATORTYPE\_HSE;

RCC\_OscInitStruct.HSEState = RCC\_HSE\_ON;

RCC\_OscInitStruct.HSEPredivValue = RCC\_HSE\_PREDIV\_DIV1;

RCC\_OscInitStruct.PLL.PLLState = RCC\_PLL\_ON;

RCC\_OscInitStruct.PLL.PLLSource = RCC\_PLLSOURCE\_HSE;

RCC\_OscInitStruct.PLL.PLLMUL = RCC\_PLL\_MUL9;

if (HAL\_RCC\_OscConfig(&RCC\_OscInitStruct) != HAL\_OK) {

Error\_Handler();

}

RCC\_ClkInitStruct.ClockType = RCC\_CLOCKTYPE\_HCLK|RCC\_CLOCKTYPE\_SYSCLK|RCC\_CLOCKTYPE\_PCLK1|RCC\_CLOCKTYPE\_PCLK2;

RCC\_ClkInitStruct.SYSCLKSource = RCC\_SYSCLKSOURCE\_PLLCLK;

RCC\_ClkInitStruct.AHBCLKDivider = RCC\_SYSCLK\_DIV1;

RCC\_ClkInitStruct.APB1CLKDivider = RCC\_HCLK\_DIV2;

RCC\_ClkInitStruct.APB2CLKDivider = RCC\_HCLK\_DIV1;

if (HAL\_RCC\_ClockConfig(&RCC\_ClkInitStruct, FLASH\_LATENCY\_2) != HAL\_OK) {

Error\_Handler();

}

}

void Error\_Handler(void) {

while(1) {

// Stay here to indicate an error (could also add custom error handling here)

}

}

#ifdef USE\_FULL\_ASSERT

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continue

Certainly, here is the continuation and completion of the setup and necessary configuration:

**Completing the Error Handler and Assert**

The remaining part ensures robust error handling and assertion support when using USE\_FULL\_ASSERT.

#ifdef USE\_FULL\_ASSERT

void assert\_failed(uint8\_t \*file, uint32\_t line) {

/\* User can add his own implementation to report the HAL assert error return state \*/

sprintf((char\*)aTxBuffer, "Wrong parameters value: file %s on line %lu\r\n", file, line);

HAL\_UART\_Transmit(&huart2, (uint8\_t\*)aTxBuffer, strlen((char\*)aTxBuffer), 0xFFFF);

// Possibly blink an LED or send a debug message

}

#endif /\* USE\_FULL\_ASSERT \*/

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**Full Code Summary**

Here is the full example summarized, combining all the individual pieces:

#include "main.h"

/\* Private variables ---------------------------------------------------------\*/

TIM\_HandleTypeDef htim2;

/\* Private function prototypes -----------------------------------------------\*/

void SystemClock\_Config(void);

static void MX\_GPIO\_Init(void);

static void MX\_TIM2\_Init(void);

float linearInterpolate(float x, float x0, float x1, float y0, float y1);

void setPWM(uint16\_t pwmValue, uint32\_t channel);

/\* User Code \*/

float linearInterpolate(float x, float x0, float x1, float y0, float y1) {

return y0 + ((x - x0) \* (y1 - y0)) / (x1 - x0);

}

void setPWM(uint16\_t pwmValue, uint32\_t channel) {

\_\_HAL\_TIM\_SET\_COMPARE(&htim2, channel, pwmValue);

}

int main(void) {

/\* Reset of all peripherals, Initialize the Flash interface and the Systick. \*/

HAL\_Init();

/\* Configure the system clock \*/

SystemClock\_Config();

/\* Initialize all configured peripherals \*/

MX\_GPIO\_Init();

MX\_TIM2\_Init();

/\* Start PWM \*/

HAL\_TIM\_PWM\_Start(&htim2, TIM\_CHANNEL\_1);

HAL\_TIM\_PWM\_Start(&htim2, TIM\_CHANNEL\_2);

HAL\_TIM\_PWM\_Start(&htim2, TIM\_CHANNEL\_3);

uint16\_t pwmValueX = 0, pwmValueY = 0, pwmValueZ = 0;

uint16\_t maxPWMValue = \_\_HAL\_TIM\_GET\_AUTORELOAD(&htim2);

float startTime = 0;

float endTime = 100.0; // Adjust the duration as necessary

while (1) {

// Acceleration phase for all three axes

for (float currentTime = startTime; currentTime <= endTime; currentTime++) {

pwmValueX = static\_cast<uint16\_t>(linearInterpolate(currentTime, startTime, endTime, 0, maxPWMValue));

pwmValueY = static\_cast<uint16\_t>(linearInterpolate(currentTime, startTime, endTime, 0, maxPWMValue));

pwmValueZ = static\_cast<uint16\_t>(linearInterpolate(currentTime, startTime, endTime, 0, maxPWMValue));

setPWM(pwmValueX, TIM\_CHANNEL\_1);

setPWM(pwmValueY, TIM\_CHANNEL\_2);

setPWM(pwmValueZ, TIM\_CHANNEL\_3);

HAL\_Delay(10); // Adjust delay for acceleration rate

}

// Full speed for 1 second

HAL\_Delay(1000);

// Deceleration phase for all three axes

for (float currentTime = startTime; currentTime <= endTime; currentTime++) {

pwmValueX = static\_cast<uint16\_t>(linearInterpolate(currentTime, startTime, endTime, maxPWMValue, 0));

pwmValueY = static\_cast<uint16\_t>(linearInterpolate(currentTime, startTime, endTime, maxPWMValue, 0));

pwmValueZ = static\_cast<uint16\_t>(linearInterpolate(currentTime, startTime, endTime, maxPWMValue, 0));

setPWM(pwmValueX, TIM\_CHANNEL\_1);

setPWM(pwmValueY, TIM\_CHANNEL\_2);

setPWM(pwmValueZ, TIM\_CHANNEL\_3);

HAL\_Delay(10); // Adjust delay for deceleration rate

}

// Stop for 1 second

HAL\_Delay(1000);

}

}

static void MX\_TIM2\_Init(void) {

TIM\_ClockConfigTypeDef sClockSourceConfig = {0};

TIM\_MasterConfigTypeDef sMasterConfig = {0};

TIM\_OC\_InitTypeDef sConfigOC = {0};

htim2.Instance = TIM2;

htim2.Init.Prescaler = 72 -

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continue

Certainly, let's continue and complete the MX\_TIM2\_Init function and ensure the code summary is complete.

**Full Code Summary (Continued)**

void MX\_TIM2\_Init(void) {

TIM\_ClockConfigTypeDef sClockSourceConfig = {0};

TIM\_MasterConfigTypeDef sMasterConfig = {0};

TIM\_OC\_InitTypeDef sConfigOC = {0};

htim2.Instance = TIM2;

htim2.Init.Prescaler = 72 - 1; // Adjust prescaler to get desired frequency

htim2.Init.CounterMode = TIM\_COUNTERMODE\_UP;

htim2.Init.Period = 1000 - 1; // Adjust Period to get desired PWM resolution

htim2.Init.ClockDivision = TIM\_CLOCKDIVISION\_DIV1;

if (HAL\_TIM\_Base\_Init(&htim2) != HAL\_OK) {

Error\_Handler();

}

sClockSourceConfig.ClockSource = TIM\_CLOCKSOURCE\_INTERNAL;

if (HAL\_TIM\_ConfigClockSource(&htim2, &sClockSourceConfig) != HAL\_OK) {

Error\_Handler();

}

if (HAL\_TIM\_PWM\_Init(&htim2) != HAL\_OK) {

Error\_Handler();

}

sMasterConfig.MasterOutputTrigger = TIM\_TRGO\_RESET;

sMasterConfig.MasterSlaveMode = TIM\_MASTERSLAVEMODE\_DISABLE;

if (HAL\_TIMEx\_MasterConfigSynchronization(&htim2, &sMasterConfig) != HAL\_OK) {

Error\_Handler();

}

sConfigOC.OCMode = TIM\_OCMODE\_PWM1;

sConfigOC.Pulse = 0;

sConfigOC.OCPolarity = TIM\_OCPOLARITY\_HIGH;

sConfigOC.OCFastMode = TIM\_OCFAST\_DISABLE;

// Configure Channel 1

if (HAL\_TIM\_PWM\_ConfigChannel(&htim2, &sConfigOC, TIM\_CHANNEL\_1) != HAL\_OK) {

Error\_Handler();

}

// Configure Channel 2

if (HAL\_TIM\_PWM\_ConfigChannel(&htim2, &sConfigOC, TIM\_CHANNEL\_2) != HAL\_OK) {

Error\_Handler();

}

// Configure Channel 3

if (HAL\_TIM\_PWM\_ConfigChannel(&htim2, &sConfigOC, TIM\_CHANNEL\_3) != HAL\_OK) {

Error\_Handler();

}

HAL\_TIM\_MspPostInit(&htim2);

}

static void MX\_GPIO\_Init(void) {

\_\_HAL\_RCC\_GPIOA\_CLK\_ENABLE();

GPIO\_InitTypeDef GPIO\_InitStruct = {0};

GPIO\_InitStruct.Pin = GPIO\_PIN\_0 | GPIO\_PIN\_1 | GPIO\_PIN\_2; // PA0 for TIM2\_CH1, PA1 for TIM2\_CH2, PA2 for TIM2\_CH3

GPIO\_InitStruct.Mode = GPIO\_MODE\_AF\_PP;

GPIO\_InitStruct.Speed = GPIO\_SPEED\_FREQ\_LOW;

HAL\_GPIO\_Init(GPIOA, &GPIO\_InitStruct);

}

void SystemClock\_Config(void) {

RCC\_OscInitTypeDef RCC\_OscInitStruct = {0};

RCC\_ClkInitTypeDef RCC\_ClkInitStruct = {0};

RCC\_OscInitStruct.OscillatorType = RCC\_OSCILLATORTYPE\_HSE;

RCC\_OscInitStruct.HSEState = RCC\_HSE\_ON;

RCC\_OscInitStruct.HSEPredivValue = RCC\_HSE\_PREDIV\_DIV1;

RCC\_OscInitStruct.PLL.PLLState = RCC\_PLL\_ON;

RCC\_OscInitStruct.PLL.PLLSource = RCC\_PLLSOURCE\_HSE;

RCC\_OscInitStruct.PLL.PLLMUL = RCC\_PLL\_MUL9;

if (HAL\_RCC\_OscConfig(&RCC\_OscInitStruct) != HAL\_OK) {

Error\_Handler();

}

RCC\_ClkInitStruct.ClockType = RCC\_CLOCKTYPE\_HCLK|RCC\_CLOCKTYPE\_SYSCLK|RCC\_CLOCKTYPE\_PCLK1|RCC\_CLOCKTYPE\_PCLK2;

RCC\_ClkInitStruct.SYSCLKSource = RCC\_SYSCLKSOURCE\_PLLCLK;

RCC\_ClkInitStruct.AHBCLKDivider = RCC\_SYSCLK\_DIV1;

RCC\_ClkInitStruct.APB1CLKDivider = RCC\_HCLK\_DIV2;

RCC\_ClkInitStruct.APB2CLKDivider = RCC\_HCLK\_DIV1;

if (HAL\_RCC\_ClockConfig(&RCC\_ClkInitStruct, FLASH\_LATENCY\_2) != HAL\_OK) {

Error\_Handler();

}

}

void Error\_Handler(void) {

while(1) {

// Stay here to indicate an error (could also add custom error handling here)

}

}

#ifdef USE\_FULL\_ASSERT

void assert\_failed(uint8\_t \*file, uint32\_t line) {

/\* User can add his own implementation

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continue

Certainly! Here is the continuation and completion of the assert\_failed function as well as a final cohesive wrap-up of the entire code structure.

**Full Code Summary (Continued)**

void assert\_failed(uint8\_t \*file, uint32\_t line) {

/\* User can add their own implementation to report the file name and line number,

tex: printf("Wrong parameters value: file %s on line %d\r\n", file, line) \*/

printf("Assertion failed: file %s on line %lu\r\n", file, line);

// Optionally, add LED indication or logging

}

#endif /\* USE\_FULL\_ASSERT \*/

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**Header Includes and Definitions**

Make sure the necessary includes and definitions are at the top of the file:

#include "main.h"

#include <stdlib.h>

#include <stdio.h>

#include <string.h>

/\* Private variables ---------------------------------------------------------\*/

TIM\_HandleTypeDef htim2;

/\* Private function prototypes -----------------------------------------------\*/

void SystemClock\_Config(void);

static void MX\_GPIO\_Init(void);

static void MX\_TIM2\_Init(void);

float linearInterpolate(float x, float x0, float x1, float y0, float y1);

void setPWM(uint16\_t pwmValue, uint32\_t channel);

void Error\_Handler(void);

#ifdef USE\_FULL\_ASSERT

void assert\_failed(uint8\_t \*file, uint32\_t line);

#endif

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**Full Main Program Structured for STM32**

Here is the final, consolidated main program for the STM32 using CubeMX and HAL drivers:

#include "main.h"

#include <stdlib.h>

#include <stdio.h>

#include <string.h>

/\* Private variables ---------------------------------------------------------\*/

TIM\_HandleTypeDef htim2;

/\* Private function prototypes -----------------------------------------------\*/

void SystemClock\_Config(void);

static void MX\_GPIO\_Init(void);

static void MX\_TIM2\_Init(void);

float linearInterpolate(float x, float x0, float x1, float y0, float y1);

void setPWM(uint16\_t pwmValue, uint32\_t channel);

void Error\_Handler(void);

#ifdef USE\_FULL\_ASSERT

void assert\_failed(uint8\_t \*file, uint32\_t line);

#endif

/\* Main Code \*/

float linearInterpolate(float x, float x0, float x1, float y0, float y1) {

return y0 + ((x - x0) \* (y1 - y0)) / (x1 - x0);

}

void setPWM(uint16\_t pwmValue, uint32\_t channel) {

\_\_HAL\_TIM\_SET\_COMPARE(&htim2, channel, pwmValue);

}

int main(void) {

/\* Reset of all peripherals, Initialize Flash interface and SysTick \*/

HAL\_Init();

/\* Configure the system clock \*/

SystemClock\_Config();

/\* Initialize all configured peripherals \*/

MX\_GPIO\_Init();

MX\_TIM2\_Init();

/\* Start PWM for all channels \*/

HAL\_TIM\_PWM\_Start(&htim2, TIM\_CHANNEL\_1);

HAL\_TIM\_PWM\_Start(&htim2, TIM\_CHANNEL\_2);

HAL\_TIM\_PWM\_Start(&htim2, TIM\_CHANNEL\_3);

uint16\_t pwmValueX = 0, pwmValueY = 0, pwmValueZ = 0;

uint16\_t maxPWMValue = \_\_HAL\_TIM\_GET\_AUTORELOAD(&htim2);

float startTime = 0;

float endTime = 100.0; // 100 time intervals, adjust as necessary

while (1) {

// Acceleration phase for all three axes

for (float currentTime = startTime; currentTime <= endTime; currentTime++) {

pwmValueX = static\_cast<uint16\_t>(linearInterpolate(currentTime, startTime, endTime, 0, maxPWMValue));

pwmValueY = static\_cast<uint16\_t>(linearInterpolate(currentTime, startTime, endTime, 0, maxPWMValue));

pwmValueZ = static\_cast<uint16\_t>(linearInterpolate(currentTime, startTime, endTime, 0, maxPWMValue));

setPWM(pwmValueX, TIM\_CHANNEL\_1);

setPWM(pwmValueY, TIM\_CHANNEL\_2);

setPWM(pwmValueZ, TIM\_CHANNEL\_3);

HAL\_Delay(10); // Adjust delay for acceleration rate

}

// Full speed for 1 second

HAL\_Delay(1000);

// Deceleration phase for all three axes

for (float currentTime = startTime; currentTime <= endTime; currentTime++) {

pwmValueX = static\_cast<uint16\_t>(linearInterpolate(currentTime, startTime, endTime, maxPWMValue, 0));

pwmValueY = static\_cast<uint16\_t>(linearInterpolate(currentTime, startTime, endTime, maxPWMValue, 0));

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continue

Certainly! Let's complete the deceleration phase loop, and a summary of the rest of the code:

**Full Code Summary (Completion of Main Loop)**

pwmValueZ = static\_cast<uint16\_t>(linearInterpolate(currentTime, startTime, endTime, maxPWMValue, 0));

setPWM(pwmValueX, TIM\_CHANNEL\_1);

setPWM(pwmValueY, TIM\_CHANNEL\_2);

setPWM(pwmValueZ, TIM\_CHANNEL\_3);

HAL\_Delay(10); // Adjust delay for deceleration rate

}

// Stop for 1 second

HAL\_Delay(1000);

}

}

static void MX\_TIM2\_Init(void) {

TIM\_ClockConfigTypeDef sClockSourceConfig = {0};

TIM\_MasterConfigTypeDef sMasterConfig = {0};

TIM\_OC\_InitTypeDef sConfigOC = {0};

htim2.Instance = TIM2;

htim2.Init.Prescaler = 72 - 1; // Adjust prescaler to get desired frequency

htim2.Init.CounterMode = TIM\_COUNTERMODE\_UP;

htim2.Init.Period = 1000 - 1; // Adjust Period to get desired PWM resolution

htim2.Init.ClockDivision = TIM\_CLOCKDIVISION\_DIV1;

if (HAL\_TIM\_Base\_Init(&htim2) != HAL\_OK) {

Error\_Handler();

}

sClockSourceConfig.ClockSource = TIM\_CLOCKSOURCE\_INTERNAL;

if (HAL\_TIM\_ConfigClockSource(&htim2, &sClockSourceConfig) != HAL\_OK) {

Error\_Handler();

}

if (HAL\_TIM\_PWM\_Init(&htim2) != HAL\_OK) {

Error\_Handler();

}

sMasterConfig.MasterOutputTrigger = TIM\_TRGO\_RESET;

sMasterConfig.MasterSlaveMode = TIM\_MASTERSLAVEMODE\_DISABLE;

if (HAL\_TIMEx\_MasterConfigSynchronization(&htim2, &sMasterConfig) != HAL\_OK) {

Error\_Handler();

}

sConfigOC.OCMode = TIM\_OCMODE\_PWM1;

sConfigOC.Pulse = 0;

sConfigOC.OCPolarity = TIM\_OCPOLARITY\_HIGH;

sConfigOC.OCFastMode = TIM\_OCFAST\_DISABLE;

// Configure Channel 1

if (HAL\_TIM\_PWM\_ConfigChannel(&htim2, &sConfigOC, TIM\_CHANNEL\_1) != HAL\_OK) {

Error\_Handler();

}

// Configure Channel 2

if (HAL\_TIM\_PWM\_ConfigChannel(&htim2, &sConfigOC, TIM\_CHANNEL\_2) != HAL\_OK) {

Error\_Handler();

}

// Configure Channel 3

if (HAL\_TIM\_PWM\_ConfigChannel(&htim2, &sConfigOC, TIM\_CHANNEL\_3) != HAL\_OK) {

Error\_Handler();

}

HAL\_TIM\_MspPostInit(&htim2);

}

static void MX\_GPIO\_Init(void) {

\_\_HAL\_RCC\_GPIOA\_CLK\_ENABLE();

GPIO\_InitTypeDef GPIO\_InitStruct = {0};

GPIO\_InitStruct.Pin = GPIO\_PIN\_0 | GPIO\_PIN\_1 | GPIO\_PIN\_2; // PA0 for TIM2\_CH1, PA1 for TIM2\_CH2, PA2 for TIM2\_CH3

GPIO\_InitStruct.Mode = GPIO\_MODE\_AF\_PP;

GPIO\_InitStruct.Speed = GPIO\_SPEED\_FREQ\_LOW;

HAL\_GPIO\_Init(GPIOA, &GPIO\_InitStruct);

}

void SystemClock\_Config(void) {

RCC\_OscInitTypeDef RCC\_OscInitStruct = {0};

RCC\_ClkInitTypeDef RCC\_ClkInitStruct = {0};

RCC\_OscInitStruct.OscillatorType = RCC\_OSCILLATORTYPE\_HSE;

RCC\_OscInitStruct.HSEState = RCC\_HSE\_ON;

RCC\_OscInitStruct.HSEPredivValue = RCC\_HSE\_PREDIV\_DIV1;

RCC\_OscInitStruct.PLL.PLLState = RCC\_PLL\_ON;

RCC\_OscInitStruct.PLL.PLLSource = RCC\_PLLSOURCE\_HSE;

RCC\_OscInitStruct.PLL.PLLMUL = RCC\_PLL\_MUL9;

if (HAL\_RCC\_OscConfig(&RCC\_OscInitStruct) != HAL\_OK) {

Error\_Handler();

}

RCC\_ClkInitStruct.ClockType = RCC\_CLOCKTYPE\_HCLK|RCC\_CLOCKTYPE\_SYSCLK|RCC\_CLOCKTYPE\_PCLK1|RCC\_CLOCKTYPE\_PCLK2;

RCC\_ClkInitStruct.SYSCLKSource = RCC\_SYSCLKSOURCE\_PLLCLK;

RCC\_ClkInitStruct.AHBCLKDivider = RCC\_SYSCLK\_DIV1;

RCC\_ClkInitStruct.APB1CLKDivider = RCC\_HCLK\_DIV2;

RCC\_ClkInitStruct.AP

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continue

Certainly! Let's finish configuring the system clock and complete the full program structure.

**Full Code Summary (Completion of System Clock Configuration)**

RCC\_ClkInitStruct.APB1CLKDivider = RCC\_HCLK\_DIV2;

RCC\_ClkInitStruct.APB2CLKDivider = RCC\_HCLK\_DIV1;

if (HAL\_RCC\_ClockConfig(&RCC\_ClkInitStruct, FLASH\_LATENCY\_2) != HAL\_OK) {

Error\_Handler();

}

}

void Error\_Handler(void) {

while(1) {

// Stay here to indicate an error (could also add custom error handling here)

}

}

#ifdef USE\_FULL\_ASSERT

void assert\_failed(uint8\_t \*file, uint32\_t line) {

// Report the file name and line number where assert failure occured

printf("Assertion failed: file %s on line %lu\r\n", file, line);

// Optionally, add LED indication or logging

}

#endif /\* USE\_FULL\_ASSERT \*/

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**Full Main Program Structured for STM32**

Here is the consolidated main program for the STM32 using CubeMX and HAL drivers:

#include "main.h"

#include <stdlib.h>

#include <stdio.h>

#include <string.h>

/\* Private variables ---------------------------------------------------------\*/

TIM\_HandleTypeDef htim2;

/\* Private function prototypes -----------------------------------------------\*/

void SystemClock\_Config(void);

static void MX\_GPIO\_Init(void);

static void MX\_TIM2\_Init(void);

float linearInterpolate(float x, float x0, float x1, float y0, float y1);

void setPWM(uint16\_t pwmValue, uint32\_t channel);

void Error\_Handler(void);

#ifdef USE\_FULL\_ASSERT

void assert\_failed(uint8\_t \*file, uint32\_t line);

#endif

/\* Main Code \*/

float linearInterpolate(float x, float x0, float x1, float y0, float y1) {

return y0 + ((x - x0) \* (y1 - y0)) / (x1 - x0);

}

void setPWM(uint16\_t pwmValue, uint32\_t channel) {

\_\_HAL\_TIM\_SET\_COMPARE(&htim2, channel, pwmValue);

}

int main(void) {

/\* Reset of all peripherals, Initialize Flash interface and SysTick \*/

HAL\_Init();

/\* Configure the system clock \*/

SystemClock\_Config();

/\* Initialize all configured peripherals \*/

MX\_GPIO\_Init();

MX\_TIM2\_Init();

/\* Start PWM for all channels \*/

HAL\_TIM\_PWM\_Start(&htim2, TIM\_CHANNEL\_1);

HAL\_TIM\_PWM\_Start(&htim2, TIM\_CHANNEL\_2);

HAL\_TIM\_PWM\_Start(&htim2, TIM\_CHANNEL\_3);

uint16\_t pwmValueX = 0, pwmValueY = 0, pwmValueZ = 0;

uint16\_t maxPWMValue = \_\_HAL\_TIM\_GET\_AUTORELOAD(&htim2);

float startTime = 0;

float endTime = 100.0; // 100 time intervals, adjust as necessary

while (1) {

// Acceleration phase for all three axes

for (float currentTime = startTime; currentTime <= endTime; currentTime++) {

pwmValueX = static\_cast<uint16\_t>(linearInterpolate(currentTime, startTime, endTime, 0, maxPWMValue));

pwmValueY = static\_cast<uint16\_t>(linearInterpolate(currentTime, startTime, endTime, 0, maxPWMValue));

pwmValueZ = static\_cast<uint16\_t>(linearInterpolate(currentTime, startTime, endTime, 0, maxPWMValue));

setPWM(pwmValueX, TIM\_CHANNEL\_1);

setPWM(pwmValueY, TIM\_CHANNEL\_2);

setPWM(pwmValueZ, TIM\_CHANNEL\_3);

HAL\_Delay(10); // Adjust delay for acceleration rate

}

// Full speed for 1 second

HAL\_Delay(1000);

// Deceleration phase for all three axes

for (float currentTime = startTime; currentTime <= endTime; currentTime++) {

pwmValueX = static\_cast<uint16\_t>(linearInterpolate(currentTime, startTime, endTime, maxPWMValue, 0));

pwmValueY = static\_cast<uint16\_t>(linearInterpolate(currentTime, startTime, endTime, maxPWMValue, 0));

pwmValueZ = static\_cast<uint16\_t>(linearInterpolate(currentTime, startTime, endTime, maxPWMValue, 0));

setPWM(pwmValueX, TIM\_CHANNEL\_1);

setPWM(pwmValueY, TIM\_CHANNEL\_2);

setPWM(pwmValueZ, TIM\_CHANNEL\_3);

HAL\_Delay(10); // Adjust delay for deceleration rate

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continue

Sure thing! Let’s complete the deceleration phase loop and finalize the implementation:

**Full Code Summary (Completion of Deceleration Loop and Main Program)**

HAL\_Delay(10); // Adjust delay for deceleration rate

}

// Stop for 1 second

HAL\_Delay(1000);

}

}

static void MX\_TIM2\_Init(void) {

TIM\_ClockConfigTypeDef sClockSourceConfig = {0};

TIM\_MasterConfigTypeDef sMasterConfig = {0};

TIM\_OC\_InitTypeDef sConfigOC = {0};

htim2.Instance = TIM2;

htim2.Init.Prescaler = 72 - 1; // Adjust prescaler for desired frequency (assuming 72 MHz clock)

htim2.Init.CounterMode = TIM\_COUNTERMODE\_UP;

htim2.Init.Period = 1000 - 1; // Adjust period for desired PWM resolution

htim2.Init.ClockDivision = TIM\_CLOCKDIVISION\_DIV1;

if (HAL\_TIM\_Base\_Init(&htim2) != HAL\_OK) {

Error\_Handler();

}

sClockSourceConfig.ClockSource = TIM\_CLOCKSOURCE\_INTERNAL;

if (HAL\_TIM\_ConfigClockSource(&htim2, &sClockSourceConfig) != HAL\_OK) {

Error\_Handler();

}

if (HAL\_TIM\_PWM\_Init(&htim2) != HAL\_OK) {

Error\_Handler();

}

sMasterConfig.MasterOutputTrigger = TIM\_TRGO\_RESET;

sMasterConfig.MasterSlaveMode = TIM\_MASTERSLAVEMODE\_DISABLE;

if (HAL\_TIMEx\_MasterConfigSynchronization(&htim2, &sMasterConfig) != HAL\_OK) {

Error\_Handler();

}

sConfigOC.OCMode = TIM\_OCMODE\_PWM1;

sConfigOC.Pulse = 0;

sConfigOC.OCPolarity = TIM\_OCPOLARITY\_HIGH;

sConfigOC.OCFastMode = TIM\_OCFAST\_DISABLE;

// Configure Channel 1

if (HAL\_TIM\_PWM\_ConfigChannel(&htim2, &sConfigOC, TIM\_CHANNEL\_1) != HAL\_OK) {

Error\_Handler();

}

// Configure Channel 2

if (HAL\_TIM\_PWM\_ConfigChannel(&htim2, &sConfigOC, TIM\_CHANNEL\_2) != HAL\_OK) {

Error\_Handler();

}

// Configure Channel 3

if (HAL\_TIM\_PWM\_ConfigChannel(&htim2, &sConfigOC, TIM\_CHANNEL\_3) != HAL\_OK) {

Error\_Handler();

}

HAL\_TIM\_MspPostInit(&htim2);

}

static void MX\_GPIO\_Init(void) {

\_\_HAL\_RCC\_GPIOA\_CLK\_ENABLE();

GPIO\_InitTypeDef GPIO\_InitStruct = {0};

GPIO\_InitStruct.Pin = GPIO\_PIN\_0 | GPIO\_PIN\_1 | GPIO\_PIN\_2; // PA0 for TIM2\_CH1, PA1 for TIM2\_CH2, PA2 for TIM2\_CH3

GPIO\_InitStruct.Mode = GPIO\_MODE\_AF\_PP;

GPIO\_InitStruct.Speed = GPIO\_SPEED\_FREQ\_LOW;

HAL\_GPIO\_Init(GPIOA, &GPIO\_InitStruct);

}

void SystemClock\_Config(void) {

RCC\_OscInitTypeDef RCC\_OscInitStruct = {0};

RCC\_ClkInitTypeDef RCC\_ClkInitStruct = {0};

RCC\_OscInitStruct.OscillatorType = RCC\_OSCILLATORTYPE\_HSE;

RCC\_OscInitStruct.HSEState = RCC\_HSE\_ON;

RCC\_OscInitStruct.HSEPredivValue = RCC\_HSE\_PREDIV\_DIV1;

RCC\_OscInitStruct.PLL.PLLState = RCC\_PLL\_ON;

RCC\_OscInitStruct.PLL.PLLSource = RCC\_PLLSOURCE\_HSE;

RCC\_OscInitStruct.PLL.PLLMUL = RCC\_PLL\_MUL9; // 72 MHz

if (HAL\_RCC\_OscConfig(&RCC\_OscInitStruct) != HAL\_OK) {

Error\_Handler();

}

RCC\_ClkInitStruct.ClockType = (RCC\_CLOCKTYPE\_HCLK | RCC\_CLOCKTYPE\_SYSCLK | RCC\_CLOCKTYPE\_PCLK1 | RCC\_CLOCKTYPE\_PCLK2);

RCC\_ClkInitStruct.SYSCLKSource = RCC\_SYSCLKSOURCE\_PLLCLK;

RCC\_ClkInitStruct.AHBCLKDivider = RCC\_SYSCLK\_DIV1;

RCC\_ClkInitStruct.APB1CLKDivider = RCC\_HCLK\_DIV2;

RCC\_ClkInitStruct.APB2CLKDivider = RCC\_HCLK\_DIV1;

if (HAL\_RCC\_ClockConfig(&RCC\_ClkInitStruct, FLASH\_LATENCY\_2) != HAL\_OK) {

Error\_Handler();

}

}

void Error\_Handler(void) {

while (1) {

// Stay

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continue

Certainly! Let's complete the Error\_Handler function and finalize the code structure:

**Completion of Error\_Handler and Final Code Structure**

while (1) {

// Stay in an infinite loop to indicate an error

// Optionally, you could toggle an LED or provide other indications here

}

}

#ifdef USE\_FULL\_ASSERT

void assert\_failed(uint8\_t \*file, uint32\_t line) {

// Report the file name and line number where assert failure occurred

printf("Assertion failed: file %s on line %lu\r\n", file, line);

// Optionally, add LED indication or logging

}

#endif /\* USE\_FULL\_ASSERT \*/

int main(void) {

/\* Reset of all peripherals, Initialize the Flash interface and the Systick. \*/

HAL\_Init();

/\* Configure the system clock \*/

SystemClock\_Config();

/\* Initialize all configured peripherals \*/

MX\_GPIO\_Init();

MX\_TIM2\_Init();

/\* Start PWM for all channels \*/

HAL\_TIM\_PWM\_Start(&htim2, TIM\_CHANNEL\_1);

HAL\_TIM\_PWM\_Start(&htim2, TIM\_CHANNEL\_2);

HAL\_TIM\_PWM\_Start(&htim2, TIM\_CHANNEL\_3);

uint16\_t pwmValueX = 0, pwmValueY = 0, pwmValueZ = 0;

uint16\_t maxPWMValue = \_\_HAL\_TIM\_GET\_AUTORELOAD(&htim2);

float startTime = 0;

float endTime = 100.0; // 100 time intervals, adjust as necessary

while (1) {

// Acceleration phase for all three axes

for (float currentTime = startTime; currentTime <= endTime; currentTime += 1) {

pwmValueX = static\_cast<uint16\_t>(linearInterpolate(currentTime, startTime, endTime, 0, maxPWMValue));

pwmValueY = static\_cast<uint16\_t>(linearInterpolate(currentTime, startTime, endTime, 0, maxPWMValue));

pwmValueZ = static\_cast<uint16\_t>(linearInterpolate(currentTime, startTime, endTime, 0, maxPWMValue));

setPWM(pwmValueX, TIM\_CHANNEL\_1);

setPWM(pwmValueY, TIM\_CHANNEL\_2);

setPWM(pwmValueZ, TIM\_CHANNEL\_3);

HAL\_Delay(10); // Adjust delay for acceleration rate

}

// Full speed for 1 second

HAL\_Delay(1000);

// Deceleration phase for all three axes

for (float currentTime = startTime; currentTime <= endTime; currentTime += 1) {

pwmValueX = static\_cast<uint16\_t>(linearInterpolate(currentTime, startTime, endTime, maxPWMValue, 0));

pwmValueY = static\_cast<uint16\_t>(linearInterpolate(currentTime, startTime, endTime, maxPWMValue, 0));

pwmValueZ = static\_cast<uint16\_t>(linearInterpolate(currentTime, startTime, endTime, maxPWMValue, 0));

setPWM(pwmValueX, TIM\_CHANNEL\_1);

setPWM(pwmValueY, TIM\_CHANNEL\_2);

setPWM(pwmValueZ, TIM\_CHANNEL\_3);

HAL\_Delay(10); // Adjust delay for deceleration rate

}

// Stop for 1 second

HAL\_Delay(1000);

}

}

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**Explanation:**

1. **Main Loop Phases**:
   * **Acceleration Phase**: PWM values for X, Y, Z axes increase from 0 to maxPWMValue.
   * **Full Speed Phase**: PWM values stay at maxPWMValue for 1 second.
   * **Deceleration Phase**: PWM values for X, Y, Z axes decrease from maxPWMValue to 0.
   * **Stop Phase**: The system stops for 1 second.
2. **Helper Functions**:
   * linearInterpolate: A helper function for linear interpolation.
   * setPWM: A function to set the PWM value for a given channel.
3. **Peripheral Configuration**:
   * MX\_TIM2\_Init: Configures and initializes the TIM2 peripheral for PWM generation.
   * MX\_GPIO\_Init: Initializes GPIO pins to act as PWM outputs.
   * SystemClock\_Config: Configures the system clock to run at 72 MHz.
4. **Error Handling**:
   * Error\_Handler: A simple infinite loop to indicate an error.
   * assert\_failed: Reports assertion errors (enabled through the USE\_FULL\_ASSERT macro).

Would you like any more specific details or explanations about any part of the code?