Experiment No 9

General Purpose Timers in STM32 and their Programming

Objectives:

To have an introduction with all Timers of STM32F103 and to study the General Purpose Timersand their modes in detail and program them using Keil.

Timers in STM32F103:

The STM32F103xx devices include:

- One Advanced-control timers (TIM-1)
- Three general-purpose timers (TIM-2, TIM3 & TIM-4) All timer counters can be frozen in debug mode.

Peripheral		STM32F103Cx		STM32F103Rx			STM32F103Vx	
Flash - Kbytes		32	64	32	64	128	64	128
SRAM - Kbytes		10	20	10	20		20	
Timers	General purpose	2	3	2	3		3	
	Advanced Control	1		1			1	

Figure 1: Peripherals of STM32F103xx

General-purpose timers:

There are up to 3 synchronizable standard timers embedded in the STM32F103xx performance line devices. These timers are based on a 16-bit auto-reload up/down counter, a 16-bit prescaler and feature 4 independent channels each for input capture/output compare, PWM or one pulse mode output. This gives up to 12 input captures / output compares / PWMs on the largest packages. They can work together with the Advanced Control Timer via the Timer Link feature for synchronization or event chaining. The counter can be frozen in debug mode.

TIM2 to TIM4 introduction:

The general-purpose timers consist of a 16-bit auto-reload counter driven by a programmable prescaler. They may be used for a variety of purposes, including measuring the pulse lengths of input signals (input capture) or generating output waveforms (output compare and PWM). Pulse lengths and waveform periods can be modulated from a few microseconds to several milliseconds using the timer prescaler and the RCC clock controller prescalers. The timers are completely independent, and do not share any resources. They can be synchronized together

TIMx main features:

General-purpose TIMx timer features include:

- 16-bit up, down, up/down auto-reload counter.
- 16-bit programmable prescaler used to divide (also “on the fly”) the counter clock frequency byany factor between 1 and 65536.
- Up to 4 independent channels for:
  - Input capture
  - Output compare
  - PWM generation (Edge- and Center-aligned modes)
  - One-pulse mode output
- Synchronization circuit to control the timer with external signals and to interconnect severaltimers.
- Interrupt/DMA generation on the following events:
  - Update: counter overflow/underflow, counter initialization (by software or internal/external trigger)
  - Trigger event (counter start, stop, initialization or count by internal/external trigger)
  - Input capture
  - Output compare
- Supports incremental (quadrature) encoder and hall-sensor circuitry for positioning purposes
- Trigger input for external clock or cycle-by-cycle current management

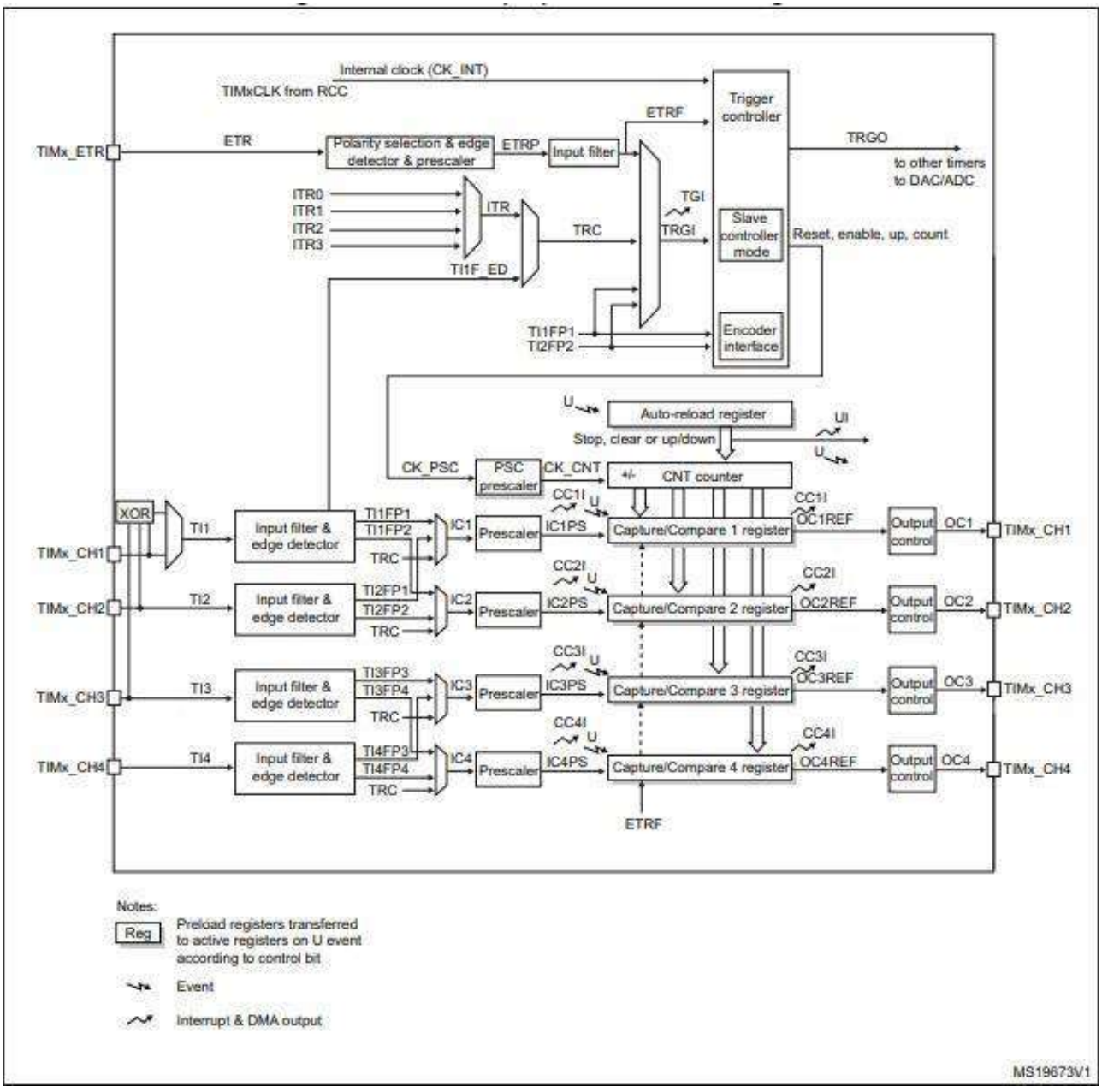


Figure 2: General Purpose Timer Block Diagram

Timer Simulation in Keil:

First of all, you need to implement the following code in Keil.

```
#include "stm32f10x.h"
#include "stm32f10x_rcc.h"
#include "stm32f10x_tim.h"
#include "stm32f10x_gpio.h"

void LED_Config();
void delay(unsigned int nCount);
void TIM_config(void);

TIM_TimeBaseInitTypeDef MyTimer;
GPIO_InitTypeDef My_LED;

int main (void)
{

    LED_Config();
    TIM_config();

    TIM_Cmd(TIM3,ENABLE);

    while (1)
    {
      if(TIM_GetCounter(TIM3)> 0 && TIM_GetCounter(TIM3) < 7999)
      {
        GPIO_ResetBits(GPIOA, GPIO_Pin_1);
      }
      else
      {
        GPIO_SetBits(GPIOA, GPIO_Pin_1);
      }
    }
}

// Function for LED_Configuration
void LED_Config()
{
     // Enable clock for GPIOA
     RCC_APB2PeriphClockCmd(RCC_APB2Periph_GPIOA, ENABLE);

     // Configure PA1 as push-pull output
     My_LED.GPIO_Pin = GPIO_Pin_1;
     My_LED.GPIO_Speed = GPIO_Speed_2MHz;
     My_LED.GPIO_Mode = GPIO_Mode_Out_PP;

     GPIO_Init(GPIOA, &My_LED);
}
```

```
48  void TIM_config(void)
49  {
50      RCC_APB1PeriphClockCmd(RCC_APB1Periph_TIM3,ENABLE);
51
52
53      MyTimer.TIM_ClockDivision = TIM_CKD_DIV1;
54      MyTimer.TIM_CounterMode = TIM_CounterMode_Up;
55      MyTimer.TIM_RepetitionCounter=0;
56
57      MyTimer.TIM_Prescaler =499;
58      MyTimer.TIM_Period=15999;
59
60      TIM_TimeBaseInit(TIM3,&MyTimer);
61
62  }
63
64  // Delay function
65  void delay(unsigned int nCount)
66  {
67    unsigned int i, j;
68      for (i = 0; i < nCount; i++)
69        for (j = 0; j < 0x2AFF; j++);
70  }
```

Lab Task (Psycomotor)

Activity 01:

Build and Run the given Code.

- **Follow the steps and Simulate your code and show the output.**
- **Observe the output and evaluate that how many times the LED will blink in 15 seconds. Write the time period as well.**

Lab Task (Cognitive)

Question 1:

A general-purpose timer is clocked at 16 MHz. The prescaler is set to PSC = 15999 and the auto-reload register to ARR = 999. The timer counts up and generates an update event when it overflows. Counter clock = fclk / (PSC + 1).

a) Determine the timer counter clock frequency. **[3 Marks]**

b) Determine the time between two successive update events. **[3 Marks]**

c) Keeping the same prescaler, determine the ARR value required for an update period of 250 ms. **[2 Marks]**

d) If an LED is toggled at every update event of the original configuration, determine the LED blinking period (one full ON-OFF cycle) and frequency. **[2 Marks]**

LABORATORY SKILLS ASSESSMENT (Cognitive)

Obtained Marks	**/10**

Instructor's Signature: _____ Date: _____

LABORATORY SKILLS ASSESSMENT (Psychomotor)

Psychomotor Activity 1: Experimental Setup

S. No	Criteria	Performance	Description	Marks
1	**Timer Software & Hardware Setup (4)**	Level 4	Correctly prepares the required timer software and hardware setup for the experiment independently and according to the laboratory requirements.	4
		Level 3	Correctly prepares the required timer software and hardware setup with minor errors or assistance.	3
		Level 2	Partially prepares the required timer software and hardware setup and requires considerable assistance.	2
		Level 1	Shows limited ability to prepare the required timer software and hardware setup and requires substantial assistance.	1
2	**Prescaler & Auto-Reload Configuration (4)**	Level 4	Correctly prepares the required prescaler and auto-reload configuration for the experiment independently and according to the laboratory requirements.	4
		Level 3	Correctly prepares the required prescaler and auto-reload configuration with minor errors or assistance.	3
		Level 2	Partially prepares the required prescaler and auto-reload configuration and requires considerable assistance.	2
		Level 1	Shows limited ability to prepare the required prescaler and auto-reload configuration and requires substantial assistance.	1
3	**Timer Mode & Debug Parameters (2)**	Level 2	Correctly sets the required timer mode and debug parameters for the experiment.	2
		Level 1	Sets the basic timer mode and debug parameters with minor errors or assistance.	1
Total Obtained				**/10**

If a student is absent:

Criteria	Description	Marks
Absent	Student is absent from the laboratory activity.	**0**

Psychomotor Activity 2: Implementation + Results

S. No	Criteria	Performance	Description	Marks
1	**Timer C Program (4)**	Level 4	Correctly implements the assigned timer C program independently while following appropriate laboratory practices.	4
		Level 3	Implements the assigned timer C program with minor errors or assistance and generally follows proper laboratory practices.	3
		Level 2	Partially implements the assigned timer C program and requires considerable assistance or repeated guidance.	2
		Level 1	Implementation of the assigned timer C program is largely incomplete, requires substantial assistance, or shows poor adherence to proper laboratory and safety practices.	1
2	**Execution & Debugging (2)**	Level 2	Correctly performs the required execution and debugging and verifies the expected operation.	2
		Level 1	Performs the basic execution and debugging with minor errors or assistance.	1
3	**Timing & Output Analysis (4)**	Level 4	Obtains correct timing and output analysis and appropriately verifies and interprets the required experimental results.	4
		Level 3	Obtains mostly correct timing and output analysis with minor errors in verification or interpretation.	3
		Level 2	Obtains partially correct timing and output analysis with noticeable errors or omissions.	2
		Level 1	Timing and output analysis is largely incorrect or incomplete and requires substantial assistance.	1
Total Obtained				**/10**

If a student is absent:

Criteria	Description	Marks
Absent	Student is absent from the laboratory activity.	**0**

Instructor's Signature: _____ Date: _____

LABORATORY SKILLS ASSESSMENT (Affective)

Affective Activity: Lab Report + Viva Voce

S. No	Criteria	Performance	Description	Marks
1	**Lab Report Completeness & Organization (4)**	Level 4	Report is complete, well-organized, properly presented, and demonstrates responsible completion of the assigned laboratory work.	4
		Level 3	Report is complete with minor omissions or organizational issues and demonstrates satisfactory responsibility for the assigned work.	3
		Level 2	Report is partially complete with several omissions and demonstrates limited responsibility for the assigned work.	2
		Level 1	Report has major omissions or poor organization and demonstrates minimal responsibility for the assigned work.	1
2	**Timer Output & Conclusion (2)**	Level 2	The timer output and conclusion are correctly presented and discussed, demonstrating ownership of the assigned work.	2
		Level 1	The timer output and conclusion are presented with minor errors or omissions.	1
3	**Viva Voce (4)**	Level 4	Clearly explains the assigned experiment, timer registers, timing calculation, program explanation, working, and results, demonstrating individual responsibility, participation, and effective communication.	4
		Level 3	Explains most of the assigned experiment and results correctly, with minor difficulty, and demonstrates good individual participation.	3
		Level 2	Explains basic aspects of the assigned experiment with some prompting and demonstrates basic participation.	2
		Level 1	Demonstrates limited understanding or involvement and requires substantial prompting to explain the assigned work.	1
Total Obtained				**/10**

The student has not submitted the report and has not appeared in the Viva Voce.

Criteria	Description	Marks
Lab Report and Results Not Submitted	Student has not submitted the report and results file.	**0**
Absent in Viva Voce	Student is absent from the viva voce.	**0**

Instructor's Signature: _____ Date: _____