

# EDF SCHDUELER IN RTOS

2022

*[You can add an abstract or other key statement here. An abstract is typically a short summary of the document content.]*

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# SYSTEM VALIDATION

## Tasks Exe. Time

### USING TRACE MACROS AND DIGITAL ANALYZER

Load1 Sim. Task exe = 5ms.

Load2 Sim. Task exe = 12 ms.

Button1 Monitor Task = 16 us

Button2 Monitor Task = 16 us

Transmitter Task = 23 us.

UART Task = 18 us.

### SYSTEM HYPERPERIOD

LCM[All Tasks Periods]=LCM[10,100,50,50,100,20]=100 ms.

### CPU LOAD

CPU Load=  $\frac{\sum \text{Task Exe. Time}}{\text{Hyper Period}} = \frac{5*10+12*1+0.016*2+0.016*2+0.023+0.018*5}{100} = 62.18\%$

### CHECK SYSTEM SCHEDULABILITY USING URM

$U = \sum T_i/P_i = 5/10+12/100+0.016/50+0.016/50+0.023/100+0.018/20 = 0.6218 < 1.$

$U_{RM} = 6*(2^{1/6}-1)=1.559.$

$U < U_{RM} \rightarrow$  System is schedulable using RM.

### CHECK SYSTEM SCHEDULABILITY USING TIME-DEMAND ANALYSIS

# SYSTEM VALIDATION

## Check System Shedulability using Time Analysis

Implementation :I have created Function to calculate Time analysis for tasks and send it to uart .

```
void CalcTimeDemand(void)
{
    int i,j,k,l;
    float TaskPeriodList[6]={10,20,50,50,100,100};
    float TaskExeTimeList[6]={5,0.018,0.017,0.017,12,0.023};
    char TaskName[6][10]={"LD1","UART","B1","B2","LD2","TRANS."};
    float w;
    char RString[40];

    for(j=0;j<6;j++)//calculate Time Analysis for each Task
    {
        sprintf(RString,"Time Analysis %s Task \n",TaskName[j]); //Print Task Name
        vSerialPutString((const signed char*)RString,strlen((const char*)RString));
        for(l=0;l<40000;l++) //Delay to prevent serial buffer overflow
        {
            w=0;//init worst case exe to 0
            for(i=0;i<(TaskPeriodList[j]);i++) //calculate W for every Time instance for Task j from 1->Task Period
            {
                w=TaskExeTimeList[j];
                for(k=0;k<=(j-1);k++)
                {
                    w+=(ceil((i+1)/TaskPeriodList[k])*TaskExeTimeList[k]);
                }
                sprintf(RString,"w[%d] = %5.5f \n",i,w);//Print Wi
                vSerialPutString((const signed char*)RString,strlen((const char*)RString));
                for(l=0;l<40000;l++)//Delay to prevent serial buffer overflow
                {
                    if(w<TaskPeriodList[j]) //check Task Shedulablity if Wi < Pi then task schedulable
                    {
                        sprintf(RString,"w[%d] < Task Period, Task is Schedulable\n",i);
                        vSerialPutString((const signed char*)RString,strlen((const char*)RString));
                    }
                    else //Wi>Pi Task is not schedulable
                    {
                        sprintf(RString,"w[%d] > Task Period, Task is not Schedulable\n",i);
                        vSerialPutString((const signed char*)RString,strlen((const char*)RString));
                    }
                }
            }
        }
    }
}
```

### Analysis Result

Time Analysis LD1 Task

w[0] = 5.00000

w[1] = 5.00000

w[2] = 5.00000

w[3] = 5.00000

w[4] = 5.00000

w[5] = 5.00000

w[6] = 5.00000

w[7] = 5.00000

# SYSTEM VALIDATION

$w[8] = 5.00000$

$w[9] = 5.00000$

$w[10] < \text{Task Period, Task is Schedulable}$

Time Analysis UART Task

$w[0] = 5.01800$

$w[1] = 5.01800$

$w[2] = 5.01800$

$w[3] = 5.01800$

$w[4] = 5.01800$

$w[5] = 5.01800$

$w[6] = 5.01800$

$w[7] = 5.01800$

$w[8] = 5.01800$

$w[9] = 5.01800$

$w[10] = 10.01800$

$w[11] = 10.01800$

$w[12] = 10.01800$

$w[13] = 10.01800$

$w[14] = 10.01800$

$w[15] = 10.01800$

$w[16] = 10.01800$

$w[17] = 10.01800$

$w[18] = 10.01800$

$w[19] = 10.01800$

$w[20] < \text{Task Period, Task is Schedulable}$

Time Analysis B1 Task

# SYSTEM VALIDATION

w[0] = 5.03500

w[1] = 5.03500

w[2] = 5.03500

w[3] = 5.03500

w[4] = 5.03500

w[5] = 5.03500

w[6] = 5.03500

w[7] = 5.03500

w[8] = 5.03500

w[9] = 5.03500

w[10] = 10.03500

w[11] = 10.03500

w[12] = 10.03500

w[13] = 10.03500

w[14] = 10.03500

w[15] = 10.03500

w[16] = 10.03500

w[17] = 10.03500

w[18] = 10.03500

w[19] = 10.03500

w[20] = 15.05300

w[21] = 15.05300

w[22] = 15.05300

w[23] = 15.05300

w[24] = 15.05300

w[25] = 15.05300

# SYSTEM VALIDATION

$w[26] = 15.05300$

$w[27] = 15.05300$

$w[28] = 15.05300$

$w[29] = 15.05300$

$w[30] = 20.05300$

$w[31] = 20.05300$

$w[32] = 20.05300$

$w[33] = 20.05300$

$w[34] = 20.05300$

$w[35] = 20.05300$

$w[36] = 20.05300$

$w[37] = 20.05300$

$w[38] = 20.05300$

$w[39] = 20.05300$

$w[40] = 25.07100$

$w[41] = 25.07100$

$w[42] = 25.07100$

$w[43] = 25.07100$

$w[44] = 25.07100$

$w[45] = 25.07100$

$w[46] = 25.07100$

$w[47] = 25.07100$

$w[48] = 25.07100$

$w[49] = 25.07100$

$w[50] < \text{Task Period, Task is Schedulable}$

Time Analysis B2 Task

# SYSTEM VALIDATION

w[0] = 5.05200

w[1] = 5.05200

w[2] = 5.05200

w[3] = 5.05200

w[4] = 5.05200

w[5] = 5.05200

w[6] = 5.05200

w[7] = 5.05200

w[8] = 5.05200

w[9] = 5.05200

w[10] = 10.05200

w[11] = 10.05200

w[12] = 10.05200

w[13] = 10.05200

w[14] = 10.05200

w[15] = 10.05200

w[16] = 10.05200

w[17] = 10.05200

w[18] = 10.05200

w[19] = 10.05200

w[20] = 15.07000

w[21] = 15.07000

w[22] = 15.07000

w[23] = 15.07000

w[24] = 15.07000

w[25] = 15.07000



# SYSTEM VALIDATION

$w[26] = 15.07000$

$w[27] = 15.07000$

$w[28] = 15.07000$

$w[29] = 15.07000$

$w[30] = 20.07000$

$w[31] = 20.07000$

$w[32] = 20.07000$

$w[33] = 20.07000$

$w[34] = 20.07000$

$w[35] = 20.07000$

$w[36] = 20.07000$

$w[37] = 20.07000$

$w[38] = 20.07000$

$w[39] = 20.07000$

$w[40] = 25.08800$

$w[41] = 25.08800$

$w[42] = 25.08800$

$w[43] = 25.08800$

$w[44] = 25.08800$

$w[45] = 25.08800$

$w[46] = 25.08800$

$w[47] = 25.08800$

$w[48] = 25.08800$

$w[49] = 25.08800$

$w[50] < \text{Task Period, Task is Schedulable}$

Time Analysis LD2 Task

# SYSTEM VALIDATION

w[0] = 17.05200  
w[1] = 17.05200  
w[2] = 17.05200  
w[3] = 17.05200  
w[4] = 17.05200  
w[5] = 17.05200  
w[6] = 17.05200  
w[7] = 17.05200  
w[8] = 17.05200  
w[9] = 17.05200  
w[10] = 22.05200  
w[11] = 22.05200  
w[12] = 22.05200  
w[13] = 22.05200  
w[14] = 22.05200  
w[15] = 22.05200  
w[16] = 22.05200  
w[17] = 22.05200  
w[18] = 22.05200  
w[19] = 22.05200  
w[20] = 27.07000  
w[21] = 27.07000  
w[22] = 27.07000  
w[23] = 27.07000  
w[24] = 27.07000  
w[25] = 27.07000

# SYSTEM VALIDATION

w[26] = 27.07000

w[27] = 27.07000

w[28] = 27.07000

w[29] = 27.07000

w[30] = 32.07000

w[31] = 32.07000

w[32] = 32.07000

w[33] = 32.07000

w[34] = 32.07000

w[35] = 32.07000

w[36] = 32.07000

w[37] = 32.07000

w[38] = 32.07000

w[39] = 32.07000

w[40] = 37.08800

w[41] = 37.08800

w[42] = 37.08800

w[43] = 37.08800

w[44] = 37.08800

w[45] = 37.08800

w[46] = 37.08800

w[47] = 37.08800

w[48] = 37.08800

w[49] = 37.08800

w[50] = 42.12200

w[51] = 42.12200

# SYSTEM VALIDATION

w[52] = 42.12200

w[53] = 42.12200

w[54] = 42.12200

w[55] = 42.12200

w[56] = 42.12200

w[57] = 42.12200

w[58] = 42.12200

w[59] = 42.12200

w[60] = 47.14000

w[61] = 47.14000

w[62] = 47.14000

w[63] = 47.14000

w[64] = 47.14000

w[65] = 47.14000

w[66] = 47.14000

w[67] = 47.14000

w[68] = 47.14000

w[69] = 47.14000

w[70] = 52.14000

w[71] = 52.14000

w[72] = 52.14000

w[73] = 52.14000

w[74] = 52.14000

w[75] = 52.14000

w[76] = 52.14000

w[77] = 52.14000

# SYSTEM VALIDATION

$w[78] = 52.14000$

$w[79] = 52.14000$

$w[80] = 57.15800$

$w[81] = 57.15800$

$w[82] = 57.15800$

$w[83] = 57.15800$

$w[84] = 57.15800$

$w[85] = 57.15800$

$w[86] = 57.15800$

$w[87] = 57.15800$

$w[88] = 57.15800$

$w[89] = 57.15800$

$w[90] = 62.15800$

$w[91] = 62.15800$

$w[92] = 62.15800$

$w[93] = 62.15800$

$w[94] = 62.15800$

$w[95] = 62.15800$

$w[96] = 62.15800$

$w[97] = 62.15800$

$w[98] = 62.15800$

$w[99] = 62.15800$

$w[100] < \text{Task Period, Task is Schedulable}$

Time Analysis TRANS. Task

$w[0] = 17.07500$

$w[1] = 17.07500$

# SYSTEM VALIDATION

w[2] = 17.07500

w[3] = 17.07500

w[4] = 17.07500

w[5] = 17.07500

w[6] = 17.07500

w[7] = 17.07500

w[8] = 17.07500

w[9] = 17.07500

w[10] = 22.07500

w[11] = 22.07500

w[12] = 22.07500

w[13] = 22.07500

w[14] = 22.07500

w[15] = 22.07500

w[16] = 22.07500

w[17] = 22.07500

w[18] = 22.07500

w[19] = 22.07500

w[20] = 27.09300

w[21] = 27.09300

w[22] = 27.09300

w[23] = 27.09300

w[24] = 27.09300

w[25] = 27.09300

w[26] = 27.09300

w[27] = 27.09300

# SYSTEM VALIDATION

w[28] = 27.09300

w[29] = 27.09300

w[30] = 32.09300

w[31] = 32.09300

w[32] = 32.09300

w[33] = 32.09300

w[34] = 32.09300

w[35] = 32.09300

w[36] = 32.09300

w[37] = 32.09300

w[38] = 32.09300

w[39] = 32.09300

w[40] = 37.11100

w[41] = 37.11100

w[42] = 37.11100

w[43] = 37.11100

w[44] = 37.11100

w[45] = 37.11100

w[46] = 37.11100

w[47] = 37.11100

w[48] = 37.11100

w[49] = 37.11100

w[50] = 42.14500

w[51] = 42.14500

w[52] = 42.14500

w[53] = 42.14500

# SYSTEM VALIDATION

w[54] = 42.14500

w[55] = 42.14500

w[56] = 42.14500

w[57] = 42.14500

w[58] = 42.14500

w[59] = 42.14500

w[60] = 47.16300

w[61] = 47.16300

w[62] = 47.16300

w[63] = 47.16300

w[64] = 47.16300

w[65] = 47.16300

w[66] = 47.16300

w[67] = 47.16300

w[68] = 47.16300

w[69] = 47.16300

w[70] = 52.16300

w[71] = 52.16300

w[72] = 52.16300

w[73] = 52.16300

w[74] = 52.16300

w[75] = 52.16300

w[76] = 52.16300

w[77] = 52.16300

w[78] = 52.16300

w[79] = 52.16300



# SYSTEM VALIDATION

$w[80] = 57.18100$

$w[81] = 57.18100$

$w[82] = 57.18100$

$w[83] = 57.18100$

$w[84] = 57.18100$

$w[85] = 57.18100$

$w[86] = 57.18100$

$w[87] = 57.18100$

$w[88] = 57.18100$

$w[89] = 57.18100$

$w[90] = 62.18100$

$w[91] = 62.18100$

$w[92] = 62.18100$

$w[93] = 62.18100$

$w[94] = 62.18100$

$w[95] = 62.18100$

$w[96] = 62.18100$

$w[97] = 62.18100$

$w[98] = 62.18100$

$w[99] = 62.18100$

$w[100] < \text{Task Period, Task is Schedulable}$

## **Summary:**

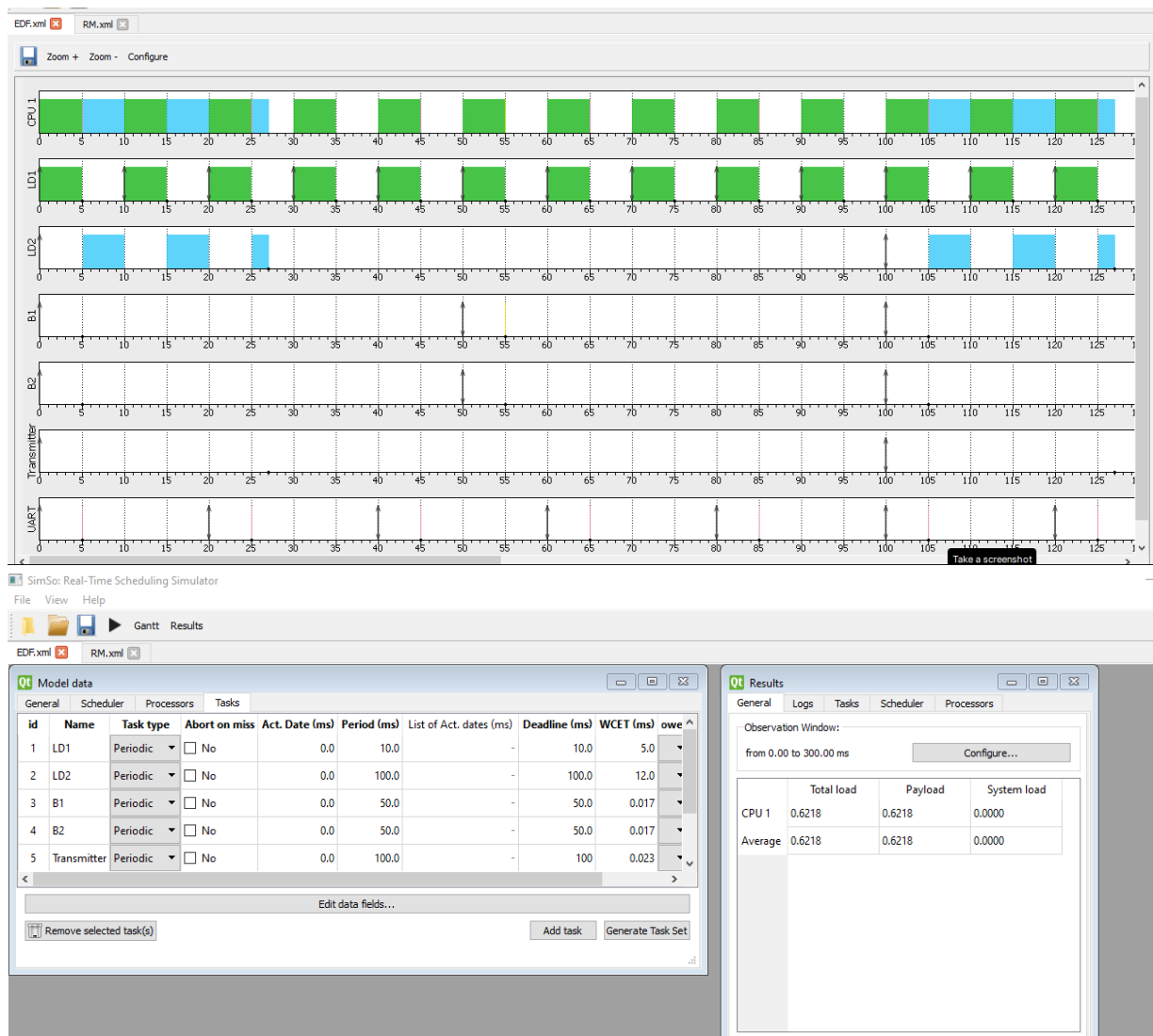
Time Analysis result for Given Task set , System is scheduable.

# SYSTEM VALIDATION

## System validation using Simso offline simulator

### USING EDF SCHEDULER

- Results

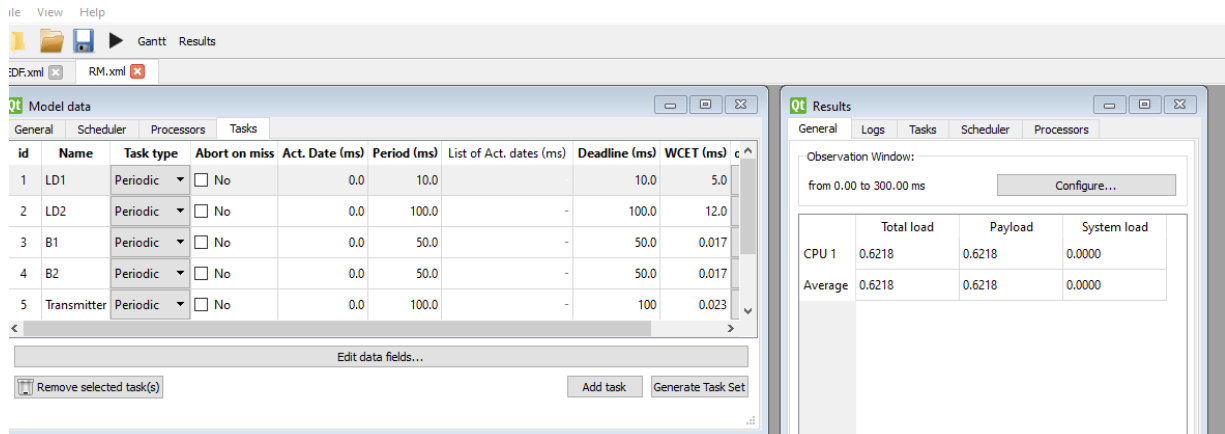


- Gantt chart

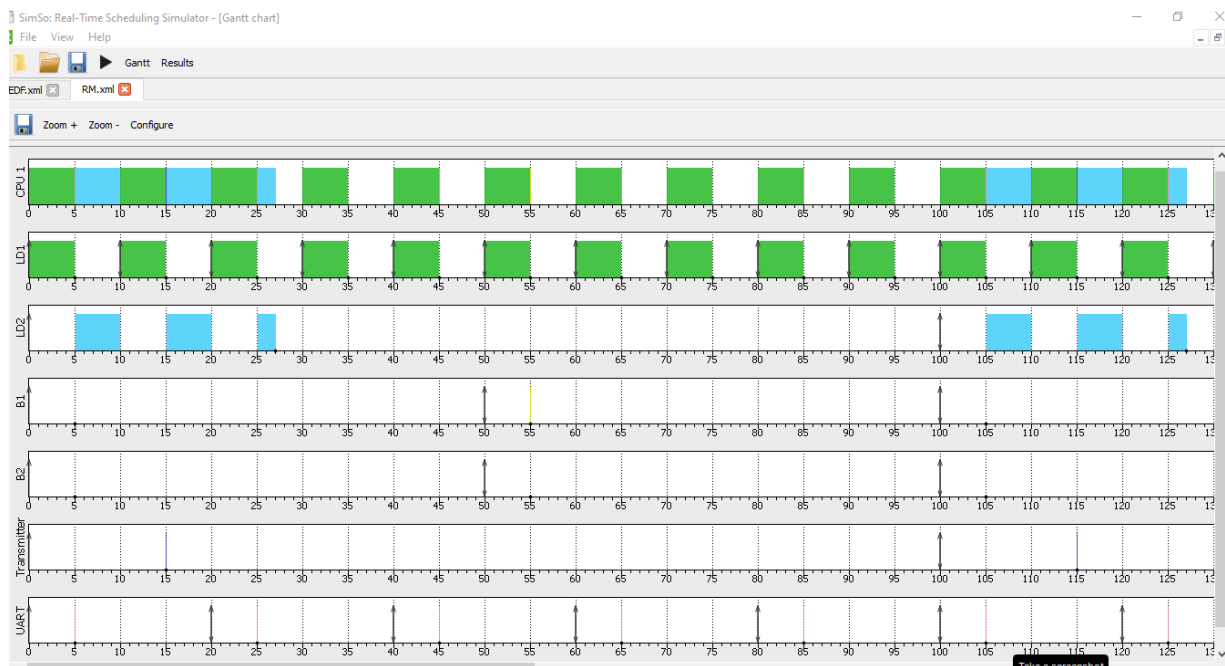
# SYSTEM VALIDATION

## USING RM SCHEDULER

- Results

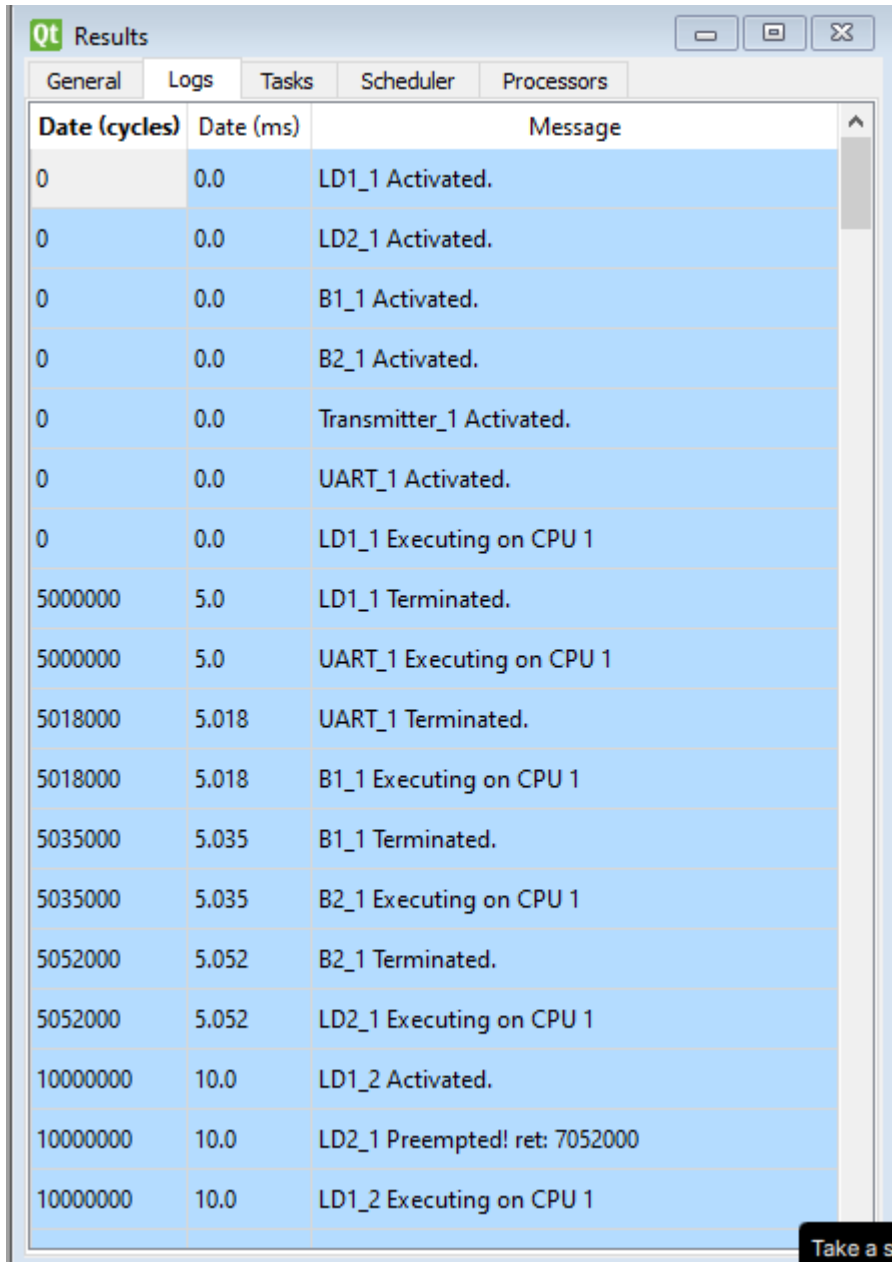


- Gantt chart



# SYSTEM VALIDATION

- Log

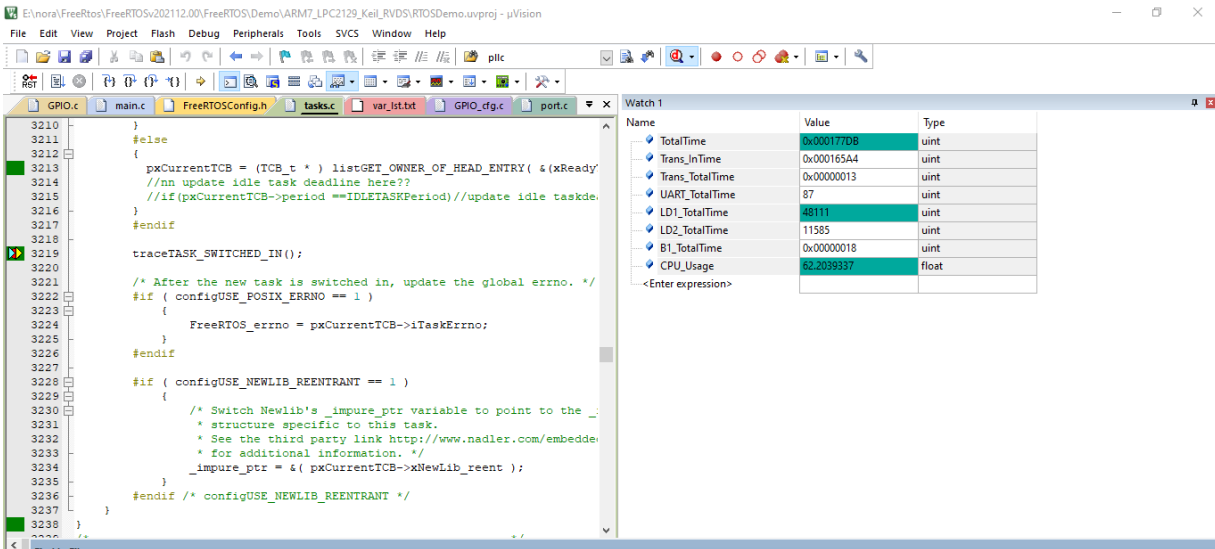


Date (cycles)	Date (ms)	Message
0	0.0	LD1_1 Activated.
0	0.0	LD2_1 Activated.
0	0.0	B1_1 Activated.
0	0.0	B2_1 Activated.
0	0.0	Transmitter_1 Activated.
0	0.0	UART_1 Activated.
0	0.0	LD1_1 Executing on CPU 1
5000000	5.0	LD1_1 Terminated.
5000000	5.0	UART_1 Executing on CPU 1
5018000	5.018	UART_1 Terminated.
5018000	5.018	B1_1 Executing on CPU 1
5035000	5.035	B1_1 Terminated.
5035000	5.035	B2_1 Executing on CPU 1
5052000	5.052	B2_1 Terminated.
5052000	5.052	LD2_1 Executing on CPU 1
10000000	10.0	LD1_2 Activated.
10000000	10.0	LD2_1 Preempted! ret: 7052000
10000000	10.0	LD1_2 Executing on CPU 1

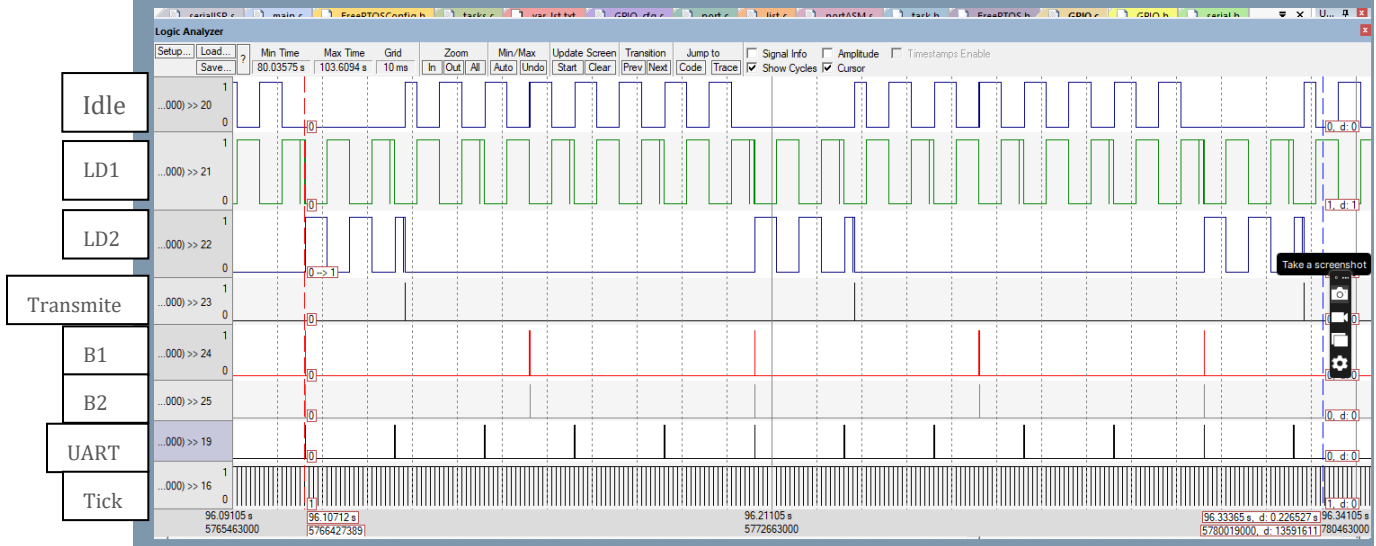
CALCULATION OF CPU LOAD USING KEIL SIM. (TIMER1,TRACE MACROS)

$$\text{CPU\_Usage} = \frac{(\text{LD1\_TotalTime} + \text{LD2\_TotalTime} + \text{B1\_TotalTime} + \text{B2\_TotalTime} + \text{Trans\_TotalTime} + \text{UART\_TotalTime})}{(\text{float})\text{TotalTime}} * 100 = 62.44\%$$

## SYSTEM VALIDATION



TOTAL SYSTEM TRACE USING KEIL SIM(TIMER1,GPIO,TRACE MACROS)



# SYSTEM VALIDATION

## Notes

### IMPLEMENTATION

Comparing Task Trace to Simso output for EDF I found results have identical task activation sequence .

Only when two tasks with same deadline become active together result may differ since any task can be chosen Randomly(as stated in EDF assumptions)

In the given Task set case: LD2 Task , Transmitter Task since they both same Deadline.

### RESULTS

System with given Task set was proved to be schedulable by both scheduling techniques: RM, EDF.

### EXTRA SYSTEM MODIFCATIONS NOTE

Extra changes were needed to complete EDF implementation:

- Problem: (In “prvAddNewTaskToReadyList ()”)

After Task creation a check for created task priority against current task priority if created task priority is equal or higher than current task make created task current task.

Since all tasks were created with same priority, the above condition resulted on last created task to run first though it is not the one having least deadline.

Solution:

Check if using EDF(i.e. configUSE\_EDF\_SCHEDULER==1) then get head of EDFReadyList instead of checking priority.

- In “xTaskIncrementTick” function , gaureded with EDF macro whenever a task gets unblocked Request CoTextSwitch.
- Made IdleTask Deadline with Macro define ” IDLE\_TASK\_DL” and chose value 150 (to be larger than farst task deadline in system).
- Updated Idle Task deadline every tick ,in “ xTaskIncrementTick()”  
Another better place is at “vTaskSwitchContext()” if switch is to Idle task .
- In validation stage call for set task tag should be done directly after task creation not at task start To ensure intial task startup is plotted.
- GPIO PINs 10→16 are used for uart1 so we can not use them in Task Trace with GPIO.
- Task execution time using Timer1and Trace Function:

# SYSTEM VALIDATION

Time is measured in terms of Timer1 Tick, where  $\text{Tick} = 1/\text{Timer}_1 \text{ freq} = 16.67 \mu\text{sec}$ ,  
 $\text{Timer}_1 \text{ freq} = \text{System Freq}/1000 = 60\text{MHZ}/1000 = 60\text{KHZ}$

LD1 Task EXE Time = 299 tick = 4.983ms

LD2 Task EXE Time = 725 tick = 12.083ms

Transmitter Task EXE Time = 1 tick = 16.67μsec

UART EXE Task = 1 tick = 16.67 μsec

B1 Task EXE Time = 1 tick = 16.67μsec

B2 Task EXE Time = 1 tick = 16.67μsec

NOTE :BECAUSE EXECUTION TIMES FOR B1,B2,UART,TRANSMITTER ARE SO SMALL(IN TERMS ON MICRO SECONDS)AND TIMER1 RESOULTION IS NOT ENOUGH TO GIVE PRECISE TIMMINGS FOR THESE TASKS.

# SYSTEM VALIDATION

Egypt FWD 2022  
Advanced Embedded  
Track  
RTOS Project