I. Analytical Methods

1. Hyperperiod & CPU Load

Assigning higher priorities to more frequent tasks.

	Highest Priority					Lowest Priority
Task	$T5$	$T4$	$T1$	$T2$	$T3$	$T6$
Execution time	$e_5 = 5$	$e_4 = 0.033$	$e_1 = 0.018$	$e_2 = 0.018$	$e_3 = 0.028$	$e_6 = 12$
Period	$p_5 = 10$	$p_4 = 20$	$p_1 = 50$	$p_2 = 50$	$p_3 = 100$	$p_6 = 100$

$$Hyperperiod = 100ms$$

$$CPU\ Load = \frac{5 \times \frac{100}{10} + 0.033 \times \frac{100}{20} + 0.018 \times \frac{100}{50} + 0.018 \times \frac{100}{50} + 0.028 \times \frac{100}{100} + 12 \times \frac{100}{100}}{100} = 62.265\ \%$$

2. Rate Monotonic Utilization Bound

$$U = \sum_{i=1}^{n} \frac{C_i}{P_i} \leq n\left(2^{\frac{1}{n}} - 1\right)$$

$$U = \frac{5}{10} + \frac{0.033}{20} + \frac{0.018}{50} + \frac{0.018}{50} + \frac{0.028}{100} + \frac{12}{100} = 0.62265$$

$$U_{RM-Bound} = 6\left(2^{1/6} - 1\right) = 0.73477$$

$$\boldsymbol{U < U_{RM-Bound} \rightarrow 0.62265 < 0.73477 \Longrightarrow System\ is\ guaranteed\ to\ be\ schedulable.}$$

3. Time Demand Analysis

Worst Case Response Time should be less than or equal to the deadline.

$$w_i(t) = e_i + \sum_{k=1}^{i-1} \left\lceil \frac{t}{p_k} \right\rceil e_k \qquad for\ 0 < t \leq p_i$$

$$\boldsymbol{w_i(t = p_i) \leq D_i \Longrightarrow Ti\ is\ schedulable}$$

$w_5(t = \mathbf{10}) = 5 + 0 = 5$

$w_5(t = p_5) \leq D_5 \rightarrow 5 \leq 10 \Longrightarrow T5\ is\ schedulable$

$w_4(t = \mathbf{20}) = 0.033 + \left\lceil \frac{\mathbf{20}}{10} \right\rceil 5 = 10.033$

$w_4(t = p_4) \leq D_4 \rightarrow 10.033 \leq 20 \Longrightarrow T4\ is\ schedulable$

$w_1(t = \mathbf{50}) = 0.018 + \left\lceil \frac{\mathbf{50}}{10} \right\rceil 5 + \left\lceil \frac{\mathbf{50}}{20} \right\rceil 0.033 = 25.117$

$w_1(t = p_1) \leq D_1 \rightarrow 25.117 \leq 50 \Longrightarrow T1\ is\ schedulable$

$w_2(t = \mathbf{50}) = 0.018 + \left\lceil \frac{\mathbf{50}}{10} \right\rceil 5 + \left\lceil \frac{\mathbf{50}}{20} \right\rceil 0.033 + \left\lceil \frac{\mathbf{50}}{50} \right\rceil 0.018 = 25.135$

$w_2(t = p_2) \leq D_2 \rightarrow 25.135 \leq 50 \Longrightarrow T2\ is\ schedulable$

$w_3(t = \mathbf{100}) = 0.028 + \left\lceil \frac{\mathbf{100}}{10} \right\rceil 5 + \left\lceil \frac{\mathbf{100}}{20} \right\rceil 0.033 + \left\lceil \frac{\mathbf{100}}{50} \right\rceil 0.018 + \left\lceil \frac{\mathbf{100}}{50} \right\rceil 0.018 = 50.265$

$w_3(t = p_3) \leq D_3 \rightarrow 50.265 \leq 100 \Longrightarrow T3\ is\ schedulable$

$w_6(t = \mathbf{100}) = 12 + \left\lceil \frac{\mathbf{100}}{10} \right\rceil 5 + \left\lceil \frac{\mathbf{100}}{20} \right\rceil 0.033 + \left\lceil \frac{\mathbf{100}}{50} \right\rceil 0.018 + \left\lceil \frac{\mathbf{100}}{50} \right\rceil 0.018 + \left\lceil \frac{\mathbf{100}}{100} \right\rceil 0.028 = 62.265$

$w_6(t = p_6) \leq D_6 \rightarrow 62.265 \leq 100 \Longrightarrow T6\ is\ schedulable$

II. SIMSO (Offline Simulator)

Task simulation assuming fixed-priority rate monotonic scheduler.

1. Offline Simulation

- **Task setting**

id	Name	Task type	Abort on miss	Act. Date (ms)	Period (ms)	: of Act. dates (r	Deadline (ms)	WCET (ms)
1	TASK T1	Periodic	☑ Yes	0	50	-	50	0.018
2	TASK T2	Periodic	☑ Yes	0	50	-	50	0.018
3	TASK T3	Periodic	☑ Yes	0	100	-	100	0.028
4	TASK T4	Periodic	☑ Yes	0	20	-	20	0.033
5	TASK T5	Periodic	☑ Yes	0	10	-	10	5
6	TASK T6	Periodic	☑ Yes	0	100	-	100	12

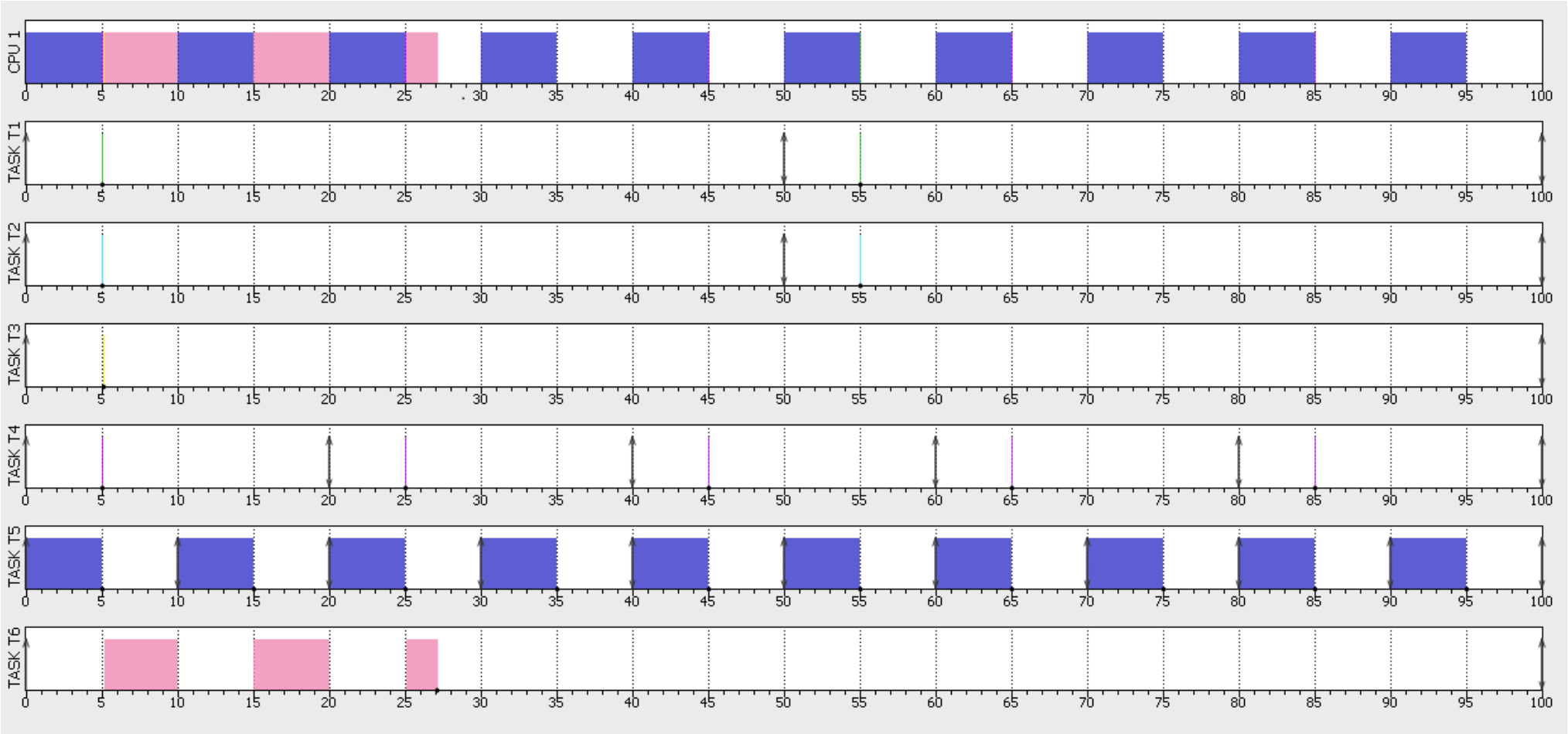
- **CPU Load**

Observation Window:

from 0.00 to 100.00 ms

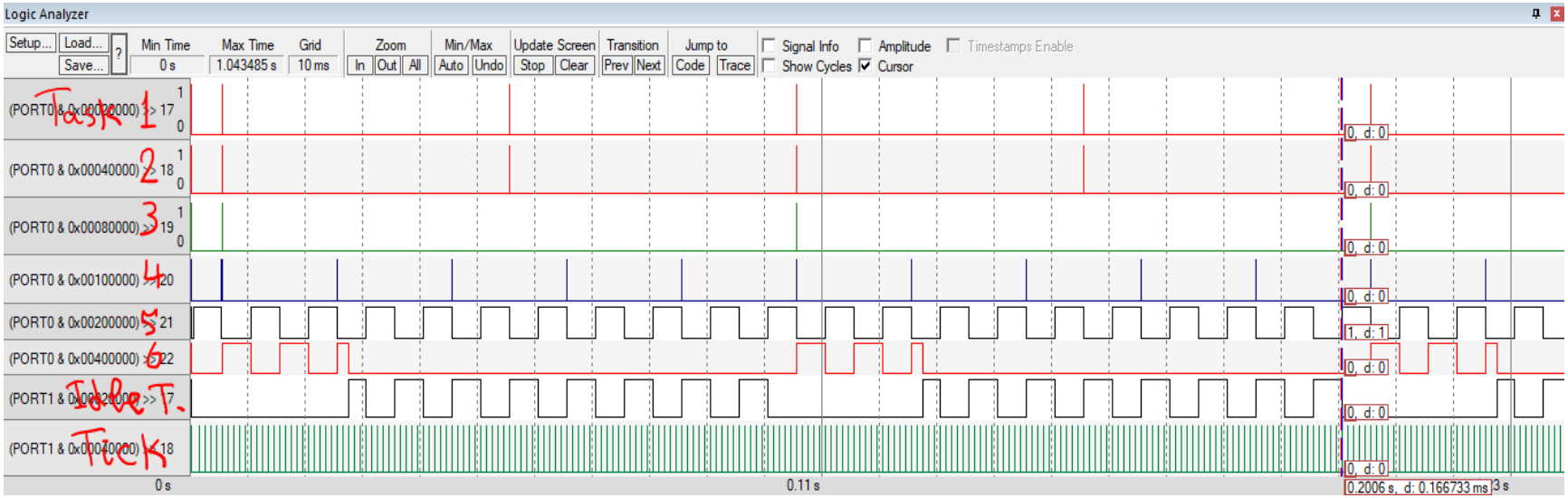
	Total load	Payload	System load
CPU 1	0.6227	0.6227	0.0000
Average	0.6227	0.6227	0.0000

2. Gant Chart


CPU 1
TASK T1
TASK T2
TASK T3
TASK T4
TASK T5
TASK T6
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100

III. Keil Simulation

- **Tasks Plot (Logic Analyzer and GPIO)**



- **CPU Load (Timer1 Method)**

Watch 1

Name	Value	Type
pxTCB->xStateListItem	<not in scope>	struct xLIST_ITEM
xTickCount	1043	uint
pxDelayedTaskList	0x400001E4 &xDelayedTaskList1	struct xLIST *
xReadyTasksListEDF	0x40000220 &xReadyTasksListEDF	struct xLIST
pxPreviousWakeTime	<cannot evaluate>	uchar
xConstTickCount	<cannot evaluate>	uchar
xSwitchRequired	<cannot evaluate>	uchar
pxCurrentTCB	0x40000CD8	struct tskTaskControlB...
eMsgs	<cannot evaluate>	uchar
xEdgeQueue	0x40000288	struct QueueDefinitio...
cpu_load	62	int
<Enter expression>		

IV. Comments

1. Both the analytical and offline simulator methods arrived at the same CPU load.
2. The Gant chart shows that no task misses its deadline, therefore the system as a whole is schedulable.
   This is in agreement with the analytical methods as well, i.e. the Rate-Monotonic Utilization Bound method and the Time Demand Analysis Method.
3. The simulation results in Keil confirms the results obtained from analytical methods and offline simulators (SIMSO).
   The CPU load is the same for all methods, and the system is schedulable, i.e. no task misses its deadline.