Verification of EDF Scheduler Implementation

- Let the "Button 1 Monitor" task be T1, "Button 2 Monitor" task be T2, "Periodic Transmitter" task be T3, "UART Receiver" task be T4, "Load 1 Simulation" be T5, and "Load 2 Simulation" be T6.

- Requirements and implementations of the EDF scheduler give us the following task properties:

  a. $T1\{P: 50, \quad E: 0.021, \quad D: 50\}$
  b. $T2\{P: 50, \quad E: 0.021, \quad D: 50\}$
  c. $T3\{P: 100, \quad E: 0.023, \quad D: 100\}$
  d. $T4\{P: 20, \quad E: 0.035, \quad D: 20\}$
  e. $T5\{P: 10, \quad E: 5, \quad D: 10\}$
  f. $T6\{P: 100, \quad E: 12, \quad D: 100\}$

  Where *P* is periodicity, *E* is execution time, and *D* is deadline in milliseconds.

1. *Using Analytical Methods:*

- The system hyper-period, denoted by *H*, is equal to the largest task periodicity in the system which is equal to 100 milliseconds.

- The CPU load, denoted by *U*, is obtained using the following equation:

$$U = \sum_{k=1}^{n} \frac{(E_k * r_k)}{H}$$

where *n* is the number of tasks and *r* is the number of executions of the task in the hyper-period. Therefore, the CPU load of the system is:

$$U = \frac{(0.021 * 2) + (0.021 * 2) + (0.023 * 1) + (0.035 * 5) + (5 * 10) + (12 * 1)}{100}$$
$$= 0.062282 \ (62.28\%)$$

- Assuming the given set of tasks is scheduled using a fixed priority rate-monotonic scheduler, the CPU utilization, denoted by U_{CPU}, should not exceed the rate-monotonic utilization bound denoted by U_{RM}. The condition is as follows:

$$U_{CPU} = \sum_{k=1}^{n} \frac{E_k}{P_k} \leq \left[n(2^{1/n} - 1)\right] = U_{RM}$$

Therefore the CPU utilization and the rate-monotonic utilization bound are respectively:

$$U_{CPU} = \frac{0.021}{50} + \frac{0.021}{50} + \frac{0.023}{100} + \frac{0.035}{20} + \frac{5}{10} + \frac{12}{100} = 0.62282$$

$$U_{RM} = 6 * \left(2^{1/6} - 1\right) \cong 0.73479$$

Since $U_{CPU} < U_{RM}$, the system satisfies the condition and is schedulable.

For time demand analysis, the time provided for each task is measured against the time required. The worst response time for the task is calculated as follows:

$$w_i(t) = E_i + \sum_{k=1}^{j} ceil\left(\frac{t}{P_k}\right) * E_k$$

where *t* is the time instant, *i* is the task index and *j* is the number of tasks with higher priority than task *i*. The condition for each task to be schedulable is for the task periodicity P_i to be greater than or equal to the response time of the task $w_i(t)$ $\forall$ $0 < t \leq P_i$. To execute the time demand analysis, the approach is as follows:

a. List all tasks at the critical instant i.e.: hyper-period from the highest-priority task to the lowest-priority task.

$$T5 > T4 > T1 = T2 > T3 = T6$$

b. Compute the task demand for each task from the highest-priority task to the lowest-priority task.

Task 5:

$w_5(t) = E_5$

$w_5(1) = 5 + 0 = 5$

$w_5(2) = 5 + 0 = 5$

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$w_5(10) = 5 + 0 = 5$

$P_5 = 10$

Since $w_5(P_5) < P_5$, T5 is schedulable.

Task 4:

$w_4(t) = E_4 + \left[ceil\left(\frac{t}{P_5}\right) * E_5\right]$

$w_4(1) = 0.035 + \left[ceil\left(\frac{1}{10}\right) * 5\right] = 0.035 + (1 * 5) = 5.035$

$w_4(2) = 0.035 + \left[ceil\left(\frac{2}{10}\right) * 5\right] = 0.035 + (1 * 5) = 5.035$

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$w_4(11) = 0.035 + \left[ceil\left(\frac{11}{10}\right) * 5\right] = 0.035 + (2 * 5) = 10.035$

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$w_4(20) = 0.035 + \left[ceil\left(\frac{20}{10}\right) * 5\right] = 0.035 + (2 * 5) = 10.035$

$P_4 = 20$

Since $w_4(P_4) < P_4$, T4 is schedulable.

Task 1:

$w_1(t) = E_1 + \left[ceil\left(\frac{t}{P_5}\right) * E_5\right] + \left[ceil\left(\frac{t}{P_4}\right) * E_4\right]$

$$w_1(1) = 0.021 + \left[ceil\left(\frac{1}{10}\right) * 5\right] + \left[ceil\left(\frac{1}{20}\right) * 0.035\right] = 0.021 + (1 * 5) + (1 * 0.035)$$
$$= 5.056$$
$$w_1(2) = 0.021 + \left[ceil\left(\frac{2}{10}\right) * 5\right] + \left[ceil\left(\frac{2}{20}\right) * 0.035\right] = 0.021 + (1 * 5) + (1 * 0.035)$$
$$= 5.056$$

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$$w_1(11) = 0.021 + \left[ceil\left(\frac{11}{10}\right) * 5\right] + \left[ceil\left(\frac{11}{20}\right) * 0.035\right] = 0.021 + (2 * 5) + (1 * 0.035)$$
$$= 10.056$$

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$$w_1(21) = 0.021 + \left[ceil\left(\frac{21}{10}\right) * 5\right] + \left[ceil\left(\frac{21}{20}\right) * 0.035\right] = 0.021 + (3 * 5) + (2 * 0.035)$$
$$= 15.091$$

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$$w_1(31) = 0.021 + \left[ceil\left(\frac{31}{10}\right) * 5\right] + \left[ceil\left(\frac{31}{20}\right) * 0.035\right] = 0.021 + (4 * 5) + (2 * 0.035)$$
$$= 20.091$$

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$$w_1(41) = 0.021 + \left[ceil\left(\frac{41}{10}\right) * 5\right] + \left[ceil\left(\frac{41}{20}\right) * 0.035\right] = 0.021 + (5 * 5) + (3 * 0.035)$$
$$= 25.126$$

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$$w_1(50) = 0.021 + \left[ceil\left(\frac{50}{10}\right) * 5\right] + \left[ceil\left(\frac{50}{20}\right) * 0.035\right] = 0.021 + (5 * 5) + (3 * 0.035)$$
$$= 25.126$$

$P_1 = 50$

Since $w_1(P_1) < P_1$, T1 is schedulable.

Task 2:

$$w_2(t) = E_2 + \left\lceil ceil\left(\frac{t}{P_5}\right) * E_5 \right\rceil + \left\lceil ceil\left(\frac{t}{P_4}\right) * E_4 \right\rceil + \left\lceil ceil\left(\frac{t}{P_1}\right) * E_1 \right\rceil$$

$$w_2(1) = 0.021 + \left\lceil ceil\left(\frac{1}{10}\right) * 5 \right\rceil + \left\lceil ceil\left(\frac{1}{20}\right) * 0.035 \right\rceil + \left\lceil ceil\left(\frac{1}{50}\right) * 0.021 \right\rceil$$
$$= 0.021 + (1 * 5) + (1 * 0.035) + (1 * 0.021) = 5.077$$

$$w_2(2) = 0.021 + \left\lceil ceil\left(\frac{2}{10}\right) * 5 \right\rceil + \left\lceil ceil\left(\frac{2}{20}\right) * 0.035 \right\rceil + \left\lceil ceil\left(\frac{2}{50}\right) * 0.021 \right\rceil$$
$$= 0.021 + (1 * 5) + (1 * 0.035) + (1 * 0.021) = 5.077$$

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$$w_2(11) = 0.021 + \left\lceil ceil\left(\frac{11}{10}\right) * 5 \right\rceil + \left\lceil ceil\left(\frac{11}{20}\right) * 0.035 \right\rceil + \left\lceil ceil\left(\frac{11}{50}\right) * 0.021 \right\rceil$$
$$= 0.021 + (2 * 5) + (1 * 0.035) + (1 * 0.021) = 10.077$$

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$$w_2(21) = 0.021 + \left\lceil ceil\left(\frac{21}{10}\right) * 5 \right\rceil + \left\lceil ceil\left(\frac{21}{20}\right) * 0.035 \right\rceil + \left\lceil ceil\left(\frac{21}{50}\right) * 0.021 \right\rceil$$
$$= 0.021 + (3 * 5) + (2 * 0.035) + (1 * 0.021) = 15.112$$

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$$w_2(31) = 0.021 + \left\lceil ceil\left(\frac{31}{10}\right) * 5 \right\rceil + \left\lceil ceil\left(\frac{31}{20}\right) * 0.035 \right\rceil + \left\lceil ceil\left(\frac{31}{50}\right) * 0.021 \right\rceil$$
$$= 0.021 + (4 * 5) + (2 * 0.035) + (1 * 0.021) = 20.112$$

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$$w_2(41) = 0.021 + \left\lceil ceil\left(\frac{41}{10}\right) * 5 \right\rceil + \left\lceil ceil\left(\frac{41}{20}\right) * 0.035 \right\rceil + \left\lceil ceil\left(\frac{41}{50}\right) * 0.021 \right\rceil$$
$$= 0.021 + (5 * 5) + (3 * 0.035) + (1 * 0.021) = 25.147$$

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$$w_2(50) = 0.021 + \left\lceil ceil\left(\frac{50}{10}\right) * 5 \right\rceil + \left\lceil ceil\left(\frac{50}{20}\right) * 0.035 \right\rceil + \left\lceil ceil\left(\frac{50}{50}\right) * 0.021 \right\rceil$$
$$= 0.021 + (5 * 5) + (3 * 0.035) + (1 * 0.021) = 25.147$$

$P_2 = 50$

Since $w_2(P_2) < P_2$, T2 is schedulable.

Task 3:

$$w_3(t) = E_3 + \left[ceil\left(\frac{t}{P_5}\right) * E_5\right] + \left[ceil\left(\frac{t}{P_4}\right) * E_4\right] + \left[ceil\left(\frac{t}{P_1}\right) * E_1\right] + \left[ceil\left(\frac{t}{P_2}\right) * E_2\right]$$

$$w_3(1) = 0.023 + \left[ceil\left(\frac{1}{10}\right) * 5\right] + \left[ceil\left(\frac{1}{20}\right) * 0.035\right] + \left[ceil\left(\frac{1}{50}\right) * 0.021\right] + \left[ceil\left(\frac{1}{50}\right) * 0.021\right]$$
$$= 0.023 + (1 * 5) + (1 * 0.035) + (1 * 0.021) + (1 * 0.021) = 5.1$$

$$w_3(2) = 0.023 + \left[ceil\left(\frac{2}{10}\right) * 5\right] + \left[ceil\left(\frac{2}{20}\right) * 0.035\right] + \left[ceil\left(\frac{2}{50}\right) * 0.021\right] + \left[ceil\left(\frac{2}{50}\right) * 0.021\right]$$
$$= 0.023 + (1 * 5) + (1 * 0.035) + (1 * 0.021) + (1 * 0.021) = 5.1$$

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$$w_3(11) = 0.023 + \left[ceil\left(\frac{11}{10}\right) * 5\right] + \left[ceil\left(\frac{11}{20}\right) * 0.035\right] + \left[ceil\left(\frac{11}{50}\right) * 0.021\right] + \left[ceil\left(\frac{11}{50}\right) * 0.021\right]$$
$$= 0.023 + (2 * 5) + (1 * 0.035) + (1 * 0.021) + (1 * 0.021) = 10.1$$

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$$w_3(21) = 0.023 + \left[ceil\left(\frac{21}{10}\right) * 5\right] + \left[ceil\left(\frac{21}{20}\right) * 0.035\right] + \left[ceil\left(\frac{21}{50}\right) * 0.021\right] + \left[ceil\left(\frac{21}{50}\right) * 0.021\right]$$
$$= 0.023 + (3 * 5) + (2 * 0.035) + (1 * 0.021) + (1 * 0.021) = 15.135$$

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$$w_3(31) = 0.023 + \left[ceil\left(\frac{31}{10}\right) * 5\right] + \left[ceil\left(\frac{31}{20}\right) * 0.035\right] + \left[ceil\left(\frac{31}{50}\right) * 0.021\right] + \left[ceil\left(\frac{31}{50}\right) * 0.021\right]$$
$$= 0.023 + (4 * 5) + (2 * 0.035) + (1 * 0.021) + (1 * 0.021) = 20.135$$

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$$w_3(41) = 0.023 + \left[ceil\left(\frac{41}{10}\right) * 5\right] + \left[ceil\left(\frac{41}{20}\right) * 0.035\right] + \left[ceil\left(\frac{41}{50}\right) * 0.021\right] + \left[ceil\left(\frac{41}{50}\right) * 0.021\right] = 0.023 + (5 * 5) + (3 * 0.035) + (1 * 0.021) + (1 * 0.021) = 25.17$$

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$$w_3(51) = 0.023 + \left[ceil\left(\frac{51}{10}\right) * 5\right] + \left[ceil\left(\frac{51}{20}\right) * 0.035\right] + \left[ceil\left(\frac{51}{50}\right) * 0.021\right] + \left[ceil\left(\frac{51}{50}\right) * 0.021\right] = 0.023 + (6 * 5) + (3 * 0.035) + (2 * 0.021) + (2 * 0.021) = 30.212$$

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$$w_3(61) = 0.023 + \left[ceil\left(\frac{61}{10}\right) * 5\right] + \left[ceil\left(\frac{61}{20}\right) * 0.035\right] + \left[ceil\left(\frac{61}{50}\right) * 0.021\right] + \left[ceil\left(\frac{61}{50}\right) * 0.021\right] = 0.023 + (7 * 5) + (4 * 0.035) + (2 * 0.021) + (2 * 0.021) = 35.247$$

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$$w_3(71) = 0.023 + \left[ceil\left(\frac{71}{10}\right) * 5\right] + \left[ceil\left(\frac{71}{20}\right) * 0.035\right] + \left[ceil\left(\frac{71}{50}\right) * 0.021\right] + \left[ceil\left(\frac{71}{50}\right) * 0.021\right] = 0.023 + (8 * 5) + (4 * 0.035) + (2 * 0.021) + (2 * 0.021) = 40.247$$

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$$w_3(81) = 0.023 + \left[ceil\left(\frac{81}{10}\right) * 5\right] + \left[ceil\left(\frac{81}{20}\right) * 0.035\right] + \left[ceil\left(\frac{81}{50}\right) * 0.021\right] + \left[ceil\left(\frac{81}{50}\right) * 0.021\right] = 0.023 + (9 * 5) + (5 * 0.035) + (2 * 0.021) + (2 * 0.021) = 45.282$$

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$$w_3(91) = 0.023 + \left\lceil ceil\left(\frac{91}{10}\right) * 5\right\rceil + \left\lceil ceil\left(\frac{91}{20}\right) * 0.035\right\rceil + \left\lceil ceil\left(\frac{91}{50}\right) * 0.021\right\rceil + \left\lceil ceil\left(\frac{91}{50}\right) * 0.021\right\rceil = 0.023 + (10 * 5) + (5 * 0.035) + (2 * 0.021) + (2 * 0.021) = 50.282$$

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$$w_3(100) = 0.023 + \left\lceil ceil\left(\frac{100}{10}\right) * 5\right\rceil + \left\lceil ceil\left(\frac{100}{20}\right) * 0.035\right\rceil + \left\lceil ceil\left(\frac{100}{50}\right) * 0.021\right\rceil + \left\lceil ceil\left(\frac{100}{50}\right) * 0.021\right\rceil = 0.023 + (10 * 5) + (5 * 0.035) + (2 * 0.021) + (2 * 0.021) = 50.282$$

$P_3 = 100$

Since $w_3(P_3) < P_3$, T3 is schedulable.

Task 6:

$$w_6(t) = E_6 + \left\lceil ceil\left(\frac{t}{P_5}\right) * E_5\right\rceil + \left\lceil ceil\left(\frac{t}{P_4}\right) * E_4\right\rceil + \left\lceil ceil\left(\frac{t}{P_1}\right) * E_1\right\rceil + \left\lceil ceil\left(\frac{t}{P_2}\right) * E_2\right\rceil + \left\lceil ceil\left(\frac{t}{P_3}\right) * E_3\right\rceil$$

$$w_6(1) = 12 + \left\lceil ceil\left(\frac{1}{10}\right) * 5\right\rceil + \left\lceil ceil\left(\frac{1}{20}\right) * 0.035\right\rceil + \left\lceil ceil\left(\frac{1}{50}\right) * 0.021\right\rceil + \left\lceil ceil\left(\frac{1}{50}\right) * 0.021\right\rceil + \left\lceil ceil\left(\frac{1}{100}\right) * 0.023\right\rceil = 12 + (1 * 5) + (1 * 0.035) + (1 * 0.021) + (1 * 0.021) + (1 * 0.023) = 17.1$$

$$w_6(2) = 12 + \left\lceil ceil\left(\frac{2}{10}\right) * 5\right\rceil + \left\lceil ceil\left(\frac{2}{20}\right) * 0.035\right\rceil + \left\lceil ceil\left(\frac{2}{50}\right) * 0.021\right\rceil + \left\lceil ceil\left(\frac{2}{50}\right) * 0.021\right\rceil + \left\lceil ceil\left(\frac{2}{100}\right) * 0.023\right\rceil = 12 + (1 * 5) + (1 * 0.035) + (1 * 0.021) + (1 * 0.021) + (1 * 0.023) = 17.1$$

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$$w_6(11) = 12 + \left[ceil\left(\frac{11}{10}\right) * 5\right] + \left[ceil\left(\frac{11}{20}\right) * 0.035\right] + \left[ceil\left(\frac{11}{50}\right) * 0.021\right] + \left[ceil\left(\frac{11}{50}\right) * 0.021\right] + \left[ceil\left(\frac{11}{100}\right) * 0.023\right]$$
$$= 12 + (2 * 5) + (1 * 0.035) + (1 * 0.021) + (1 * 0.021) + (1 * 0.023)$$
$$= 22.1$$

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$$w_6(21) = 12 + \left[ceil\left(\frac{21}{10}\right) * 5\right] + \left[ceil\left(\frac{21}{20}\right) * 0.035\right] + \left[ceil\left(\frac{21}{50}\right) * 0.021\right] + \left[ceil\left(\frac{21}{50}\right) * 0.021\right] + \left[ceil\left(\frac{21}{100}\right) * 0.023\right]$$
$$= 12 + (3 * 5) + (2 * 0.035) + (1 * 0.021) + (1 * 0.021) + (1 * 0.023)$$
$$= 27.135$$

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$$w_6(31) = 12 + \left[ceil\left(\frac{31}{10}\right) * 5\right] + \left[ceil\left(\frac{31}{20}\right) * 0.035\right] + \left[ceil\left(\frac{31}{50}\right) * 0.021\right] + \left[ceil\left(\frac{31}{50}\right) * 0.021\right] + \left[ceil\left(\frac{31}{100}\right) * 0.023\right]$$
$$= 12 + (4 * 5) + (2 * 0.035) + (1 * 0.021) + (1 * 0.021) + (1 * 0.023)$$
$$= 32.135$$

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$$w_6(41) = 12 + \left[ceil\left(\frac{41}{10}\right) * 5\right] + \left[ceil\left(\frac{41}{20}\right) * 0.035\right] + \left[ceil\left(\frac{41}{50}\right) * 0.021\right] + \left[ceil\left(\frac{41}{50}\right) * 0.021\right] + \left[ceil\left(\frac{41}{100}\right) * 0.023\right]$$
$$= 12 + (5 * 5) + (3 * 0.035) + (1 * 0.021) + (1 * 0.021) + (1 * 0.023)$$
$$= 37.17$$

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$$w_6(51) = 12 + \left[ceil\left(\frac{51}{10}\right) * 5\right] + \left[ceil\left(\frac{51}{20}\right) * 0.035\right] + \left[ceil\left(\frac{51}{50}\right) * 0.021\right] + \left[ceil\left(\frac{51}{50}\right) * 0.021\right] + \left[ceil\left(\frac{51}{100}\right) * 0.023\right]$$
$$= 12 + (6 * 5) + (3 * 0.035) + (2 * 0.021) + (2 * 0.021) + (1 * 0.023)$$
$$= 42.212$$

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$$w_6(61) = 12 + \left[ceil\left(\frac{61}{10}\right) * 5\right] + \left[ceil\left(\frac{61}{20}\right) * 0.035\right] + \left[ceil\left(\frac{61}{50}\right) * 0.021\right] + \left[ceil\left(\frac{61}{50}\right) * 0.021\right] + \left[ceil\left(\frac{61}{100}\right) * 0.023\right]$$
$$= 12 + (7 * 5) + (4 * 0.035) + (2 * 0.021) + (2 * 0.021) + (1 * 0.023)$$
$$= 47.247$$

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$$w_6(71) = 12 + \left[ceil\left(\frac{71}{10}\right) * 5\right] + \left[ceil\left(\frac{71}{20}\right) * 0.035\right] + \left[ceil\left(\frac{71}{50}\right) * 0.021\right] + \left[ceil\left(\frac{71}{50}\right) * 0.021\right] + \left[ceil\left(\frac{71}{100}\right) * 0.023\right]$$
$$= 12 + (8 * 5) + (4 * 0.035) + (2 * 0.021) + (2 * 0.021) + (1 * 0.023)$$
$$= 52.247$$

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$$w_6(81) = 12 + \left[ceil\left(\frac{81}{10}\right) * 5\right] + \left[ceil\left(\frac{81}{20}\right) * 0.035\right] + \left[ceil\left(\frac{81}{50}\right) * 0.021\right] + \left[ceil\left(\frac{81}{50}\right) * 0.021\right] + \left[ceil\left(\frac{81}{100}\right) * 0.023\right]$$
$$= 12 + (9 * 5) + (5 * 0.035) + (2 * 0.021) + (2 * 0.021) + (1 * 0.023)$$
$$= 57.282$$

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$$w_6(91) = 12 + \left[ceil\left(\frac{91}{10}\right) * 5\right] + \left[ceil\left(\frac{91}{20}\right) * 0.035\right] + \left[ceil\left(\frac{91}{50}\right) * 0.021\right] + \left[ceil\left(\frac{91}{50}\right) * 0.021\right] + \left[ceil\left(\frac{91}{100}\right) * 0.023\right]$$
$$= 12 + (10 * 5) + (5 * 0.035) + (2 * 0.021) + (2 * 0.021) + (1 * 0.023)$$
$$= 62.282$$

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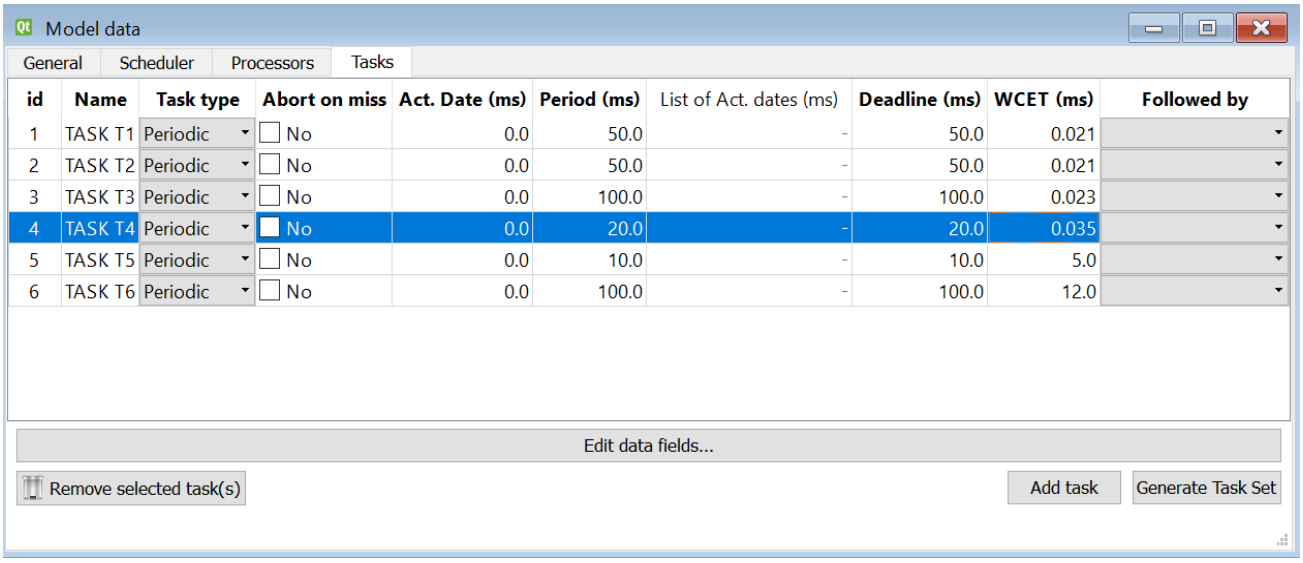
$$w_6(100) = 12 + \left[ceil\left(\frac{100}{10}\right) * 5\right] + \left[ceil\left(\frac{100}{20}\right) * 0.035\right] + \left[ceil\left(\frac{100}{50}\right) * 0.021\right] + \left[ceil\left(\frac{100}{50}\right) * 0.021\right] + \left[ceil\left(\frac{100}{100}\right) * 0.023\right]$$
$$= 12 + (10 * 5) + (5 * 0.035) + (2 * 0.021) + (2 * 0.021) + (1 * 0.023)$$
$$= 62.282$$

$P_6 = 100$

Since $w_6(P_6) < P_6$, T6 is schedulable. Finally, since all tasks are schedulable (i.e.: the time required for each task is less than the time provided), the whole system is schedulable.

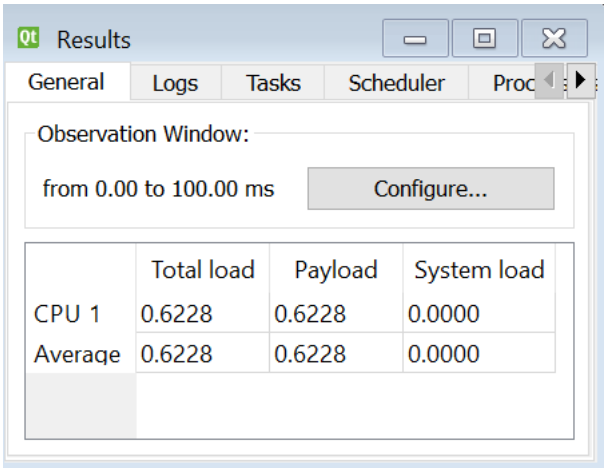
2. *<u>Using SimSo Offline Simulator:</u>*

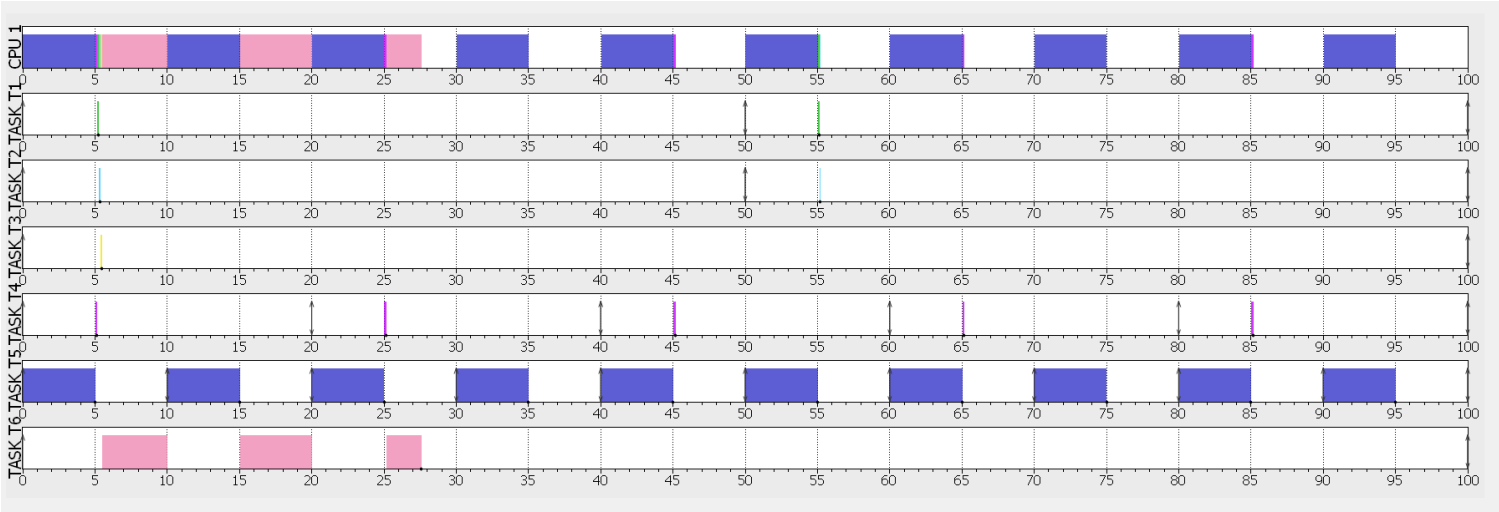
- The simulator is configured to run using the EDF scheduler to schedule the given set of tasks in the system. The tasks are configured based on the requirements and implementations as shown in the figure below.



id	Name	Task type	Abort on miss	Act. Date (ms)	Period (ms)	List of Act. dates (ms)	Deadline (ms)	WCET (ms)	Followed by
1	TASK T1	Periodic	No	0.0	50.0	-	50.0	0.021	
2	TASK T2	Periodic	No	0.0	50.0	-	50.0	0.021	
3	TASK T3	Periodic	No	0.0	100.0	-	100.0	0.023	
4	TASK T4	Periodic	No	0.0	20.0	-	20.0	0.035	
5	TASK T5	Periodic	No	0.0	10.0	-	10.0	5.0	
6	TASK T6	Periodic	No	0.0	100.0	-	100.0	12.0	

- It is shown from the results that the CPU load is equal to 62.28%. In addition the Gantt chart shows how the tasks are scheduled in one hyper-period which is equal to 100 milliseconds as shown in the figures below.





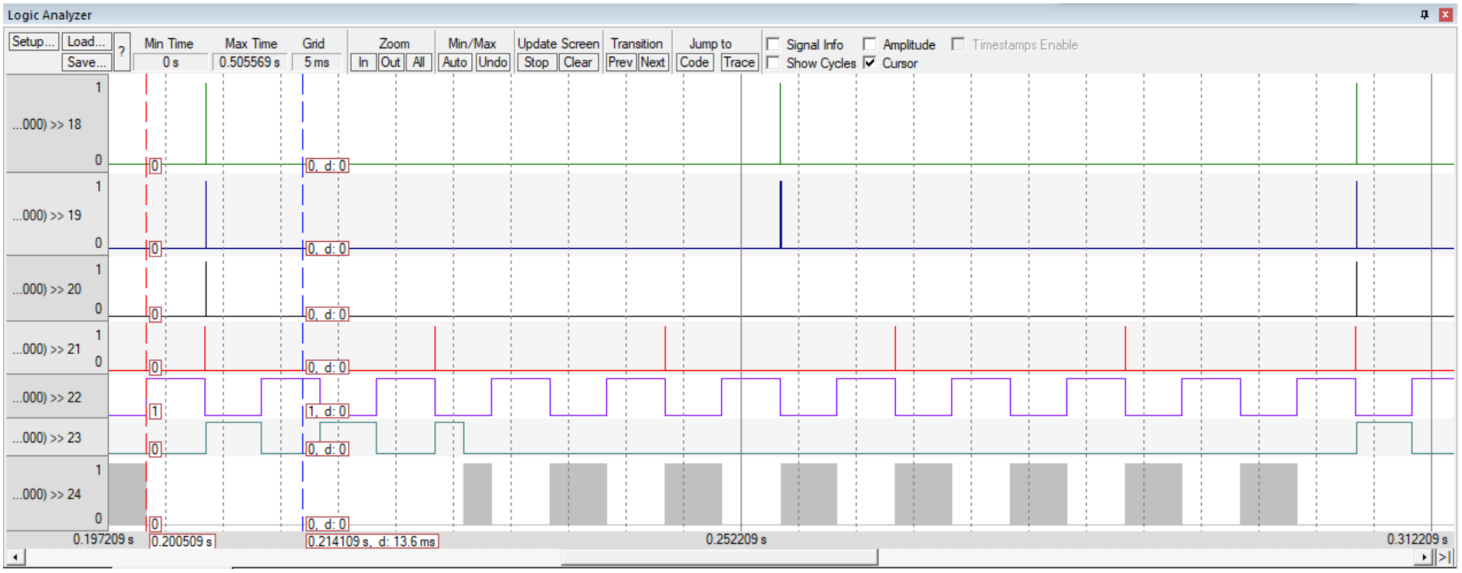
3. *<u>Using Keil Simulator in run-time:</u>*

- In order to obtain the CPU usage time and plot the execution of the given set of tasks, Timer 1 of LPC2129 is configured to count the number of ticks spent during each task and the total time of the system as well.

- The CPU usage time can be calculated by dividing the total execution time of all tasks by the system total time. It is shown during execution that the CPU usage time fluctuates between 62% and 64% as shown in the figure below. The total time of each task is in microseconds, the system time is in milliseconds, and the CPU load is in 0.1%.

Task_1_Time_Total	157	int
Task_2_Time_Total	158	int
Task_3_Time_Total	97	int
Task_4_Time_Total	590	int
Task_5_Time_Total	250320	int
Task_6_Time_Total	60286	int
CPU_Load	629	int
System_Time	495	int

- Each task has a GPIO assigned to it in order to plot its execution using the Logic Analyzer. Trace macros are used to clear the GPIO corresponding to its task when switching it out and setting the GPIO of the task when switching it in. The figure below shows the GPIOs corresponding to the given set of tasks ordered with T1 at the top to the idle task at the bottom.



- Using the above verification methods, the CPU load is approximately the same in all three methods, as well as, the execution plot of the tasks in both offline and run-time simulators. The system is schedulable analytically, and in offline and run-time simulations. Therefore, The results are as expected and indicate a successful implementation as well.