System Verification

Tasks

TASK NAME	PERIOD, P (ms)	DEADLINE (ms)	*EXECUTION TIME, C (ms)
BUTTON_1_MONITOR	50	50	0.007
BUTTON_2_MONITOR	50	50	0.007
PERIODIC_TRANSMITTER	100	100	0.005
UART_RECEIVER	20	20	0.018
LOAD_1_SIMULATION	10	10	5
LOAD_2_SIMULATION	100	100	12

*Execution Times were calculated from Keil Simulator using GPIO and logic analyzer.

1. Using analytical methods

Hyperperiod (H)

H = LCM $(P_1, P_2, P_3, P_4, P_5, P_6)$ = LCM (50, 50, 100, 20, 10, 100) = 100 ms

CPU load (U)

U = $\sum_{i=1}^{n} \frac{C_i}{P_i}$ = $(\frac{0.007}{50} + \frac{0.007}{50} + \frac{0.005}{100} + \frac{0.018}{20} + \frac{5}{10} + \frac{12}{100})$ = 0.6212 (62.12%)

Utilized rate-monotonic (URM)

URM = $n\left(2^{1/n} - 1\right) = 6\left(2^{1/6} - 1\right)$ = 0.7348 (73.48%)

$\because$ U < URM

$\therefore$ The system is schedulable

Time demand analysis

$$w_i = e_i + \sum_{k=1}^{i-1} \frac{t}{P_k} e_k$$

Task 1 (Load_1_Simulation)

$w_1(10) = 5 + 0 = 5$

5 < 10

W(10) < D

Task 1 is schedulable

Task 2 (Uart_Receiver)

$w_2(10) = 0.018 + \frac{10}{10} \times 5 = 5.018$

$w_2(20) = 0.018 + \frac{20}{10} \times 5 = 10.018$

10.018 < 20

W(20) < D

Task 2 is schedulable

Task 3 (Button_1_Monitor)

$$w_3(10) = 0.007 + \frac{10}{20} \times 0.018 + \frac{10}{10} \times 5 = 5.025$$

$$w_3(20) = 0.007 + \frac{20}{20} \times 0.018 + \frac{20}{10} \times 5 = 10.025$$

$$w_3(30) = 0.007 + \frac{30}{20} \times 0.018 + \frac{30}{10} \times 5 = 15.043$$

$$w_3(40) = 0.007 + \frac{40}{20} \times 0.018 + \frac{40}{10} \times 5 = 20.043$$

$$w_3(50) = 0.007 + \frac{50}{20} \times 0.018 + \frac{50}{10} \times 5 = 25.061$$

25.061 < 50

W(50) < D

Task 3 is schedulable

Task 4 (Button_2_Monitor)

$$w_4(10) = 0.007 + \frac{10}{50} \times 0.007 + \frac{10}{20} \times 0.018 + \frac{10}{10} \times 5 = 5.032$$

$$w_4(20) = 0.007 + \frac{20}{50} \times 0.007 + \frac{20}{20} \times 0.018 + \frac{20}{10} \times 5 = 10.032$$

$$w_4(30) = 0.007 + \frac{30}{50} \times 0.007 + \frac{30}{20} \times 0.018 + \frac{30}{10} \times 5 = 15.050$$

$$w_4(40) = 0.007 + \frac{40}{50} \times 0.007 + \frac{40}{20} \times 0.018 + \frac{40}{10} \times 5 = 20.050$$

$$w_4(50) = 0.007 + \frac{50}{50} \times 0.007 + \frac{50}{20} \times 0.018 + \frac{50}{10} \times 5 = 25.068$$

25.068 < 50

W(50) < D

Task 4 is schedulable

Task 5 (Periodic_Transmitter)

$$w_5(10) = 0.005 + \frac{10}{50} \times 0.007 + \frac{10}{50} \times 0.007 + \frac{10}{20} \times 0.018 + \frac{10}{10} \times 5 = 5.037$$

$$w_5(20) = 0.005 + \frac{20}{50} \times 0.007 + \frac{20}{50} \times 0.007 + \frac{20}{20} \times 0.018 + \frac{20}{10} \times 5 = 10.037$$

$$w_5(30) = 0.005 + \frac{30}{50} \times 0.007 + \frac{30}{50} \times 0.007 + \frac{30}{40} \times 0.018 + \frac{30}{10} \times 5 = 15.055$$

$$w_5(40) = 0.005 + \frac{40}{50} \times 0.007 + \frac{40}{50} \times 0.007 + \frac{40}{20} \times 0.018 + \frac{40}{10} \times 5 = 20.055$$

$$w_5(50) = 0.005 + \frac{50}{50} \times 0.007 + \frac{50}{50} \times 0.007 + \frac{50}{20} \times 0.018 + \frac{50}{10} \times 5 = 25.073$$

$$w_5(60) = 0.005 + \frac{60}{50} \times 0.007 + \frac{60}{50} \times 0.007 + \frac{60}{20} \times 0.018 + \frac{60}{10} \times 5 = 30.087$$

$$w_5(70) = 0.005 + \frac{70}{50} \times 0.007 + \frac{70}{50} \times 0.007 + \frac{70}{20} \times 0.018 + \frac{70}{10} \times 5 = 35.105$$

$$w_5(80) = 0.005 + \frac{80}{50} \times 0.007 + \frac{80}{50} \times 0.007 + \frac{80}{40} \times 0.018 + \frac{80}{10} \times 5 = 40.105$$

$$w_5(90) = 0.005 + \frac{90}{50} \times 0.007 + \frac{90}{50} \times 0.007 + \frac{90}{20} \times 0.018 + \frac{90}{10} \times 5 = 45.123$$

$$w_5(100) = 0.005 + \frac{100}{50} \times 0.007 + \frac{100}{50} \times 0.007 + \frac{100}{20} \times 0.018 + \frac{100}{10} \times 5 = 50.123$$

50.123 < 100

W(100) < D

Task 5 is schedulable

Task 6 (Load_2_Simulation)

$$w_6(10) = 0.005 + \frac{10}{50} \times 0.007 + \frac{10}{50} \times 0.007 + \frac{10}{20} \times 0.018 + \frac{10}{10} \times 5 = 17.037$$

$$w_6(20) = 0.005 + \frac{20}{50} \times 0.007 + \frac{20}{50} \times 0.007 + \frac{20}{20} \times 0.018 + \frac{20}{10} \times 5 = 22.037$$

$$w_6(30) = 0.005 + \frac{30}{50} \times 0.007 + \frac{30}{50} \times 0.007 + \frac{30}{40} \times 0.018 + \frac{30}{10} \times 5 = 27.055$$

$$w_6(40) = 0.005 + \frac{40}{50} \times 0.007 + \frac{40}{50} \times 0.007 + \frac{40}{20} \times 0.018 + \frac{40}{10} \times 5 = 32.055$$

$$w_6(50) = 0.005 + \frac{50}{50} \times 0.007 + \frac{50}{50} \times 0.007 + \frac{50}{20} \times 0.018 + \frac{50}{10} \times 5 = 37.073$$

$$w_6(60) = 0.005 + \frac{60}{50} \times 0.007 + \frac{60}{50} \times 0.007 + \frac{60}{20} \times 0.018 + \frac{60}{10} \times 5 = 42.087$$

$$w_6(70) = 0.005 + \frac{70}{50} \times 0.007 + \frac{70}{50} \times 0.007 + \frac{70}{20} \times 0.018 + \frac{70}{10} \times 5 = 47.105$$

$$w_6(80) = 0.005 + \frac{80}{50} \times 0.007 + \frac{80}{50} \times 0.007 + \frac{80}{40} \times 0.018 + \frac{80}{10} \times 5 = 52.105$$

$$w_6(90) = 0.005 + \frac{90}{50} \times 0.007 + \frac{90}{50} \times 0.007 + \frac{90}{20} \times 0.018 + \frac{90}{10} \times 5 = 57.123$$

$$w_6(100) = 0.005 + \frac{100}{50} \times 0.007 + \frac{100}{50} \times 0.007 + \frac{100}{20} \times 0.018 + \frac{100}{10} \times = 62.123$$

62.123 < 100

W(100) < D

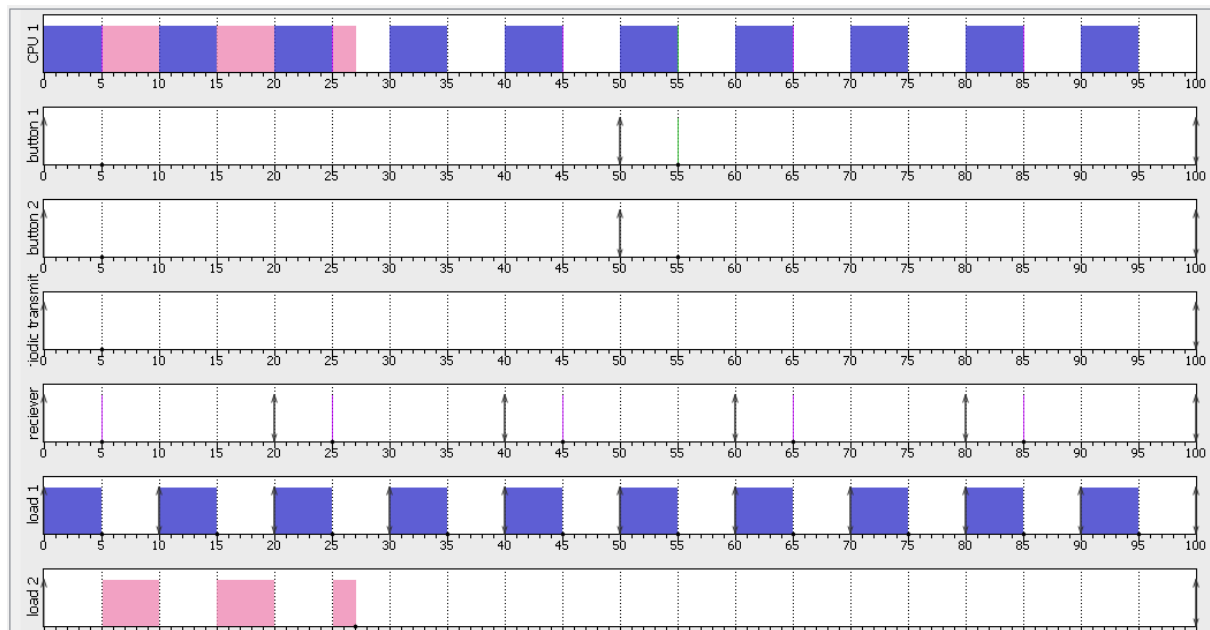**Task 6 is schedulable**

2. Using Simso offline simulator

Figure 1 Gantt Chart from Simso Simulator

	Total load	Payload	System load
CPU 1	0.6212	0.6212	0.0000
Average	0.6212	0.6212	0.0000

Figure 2 CPU Load

The results match with analytical methods

No task misses its deadline.

The system is feasible.

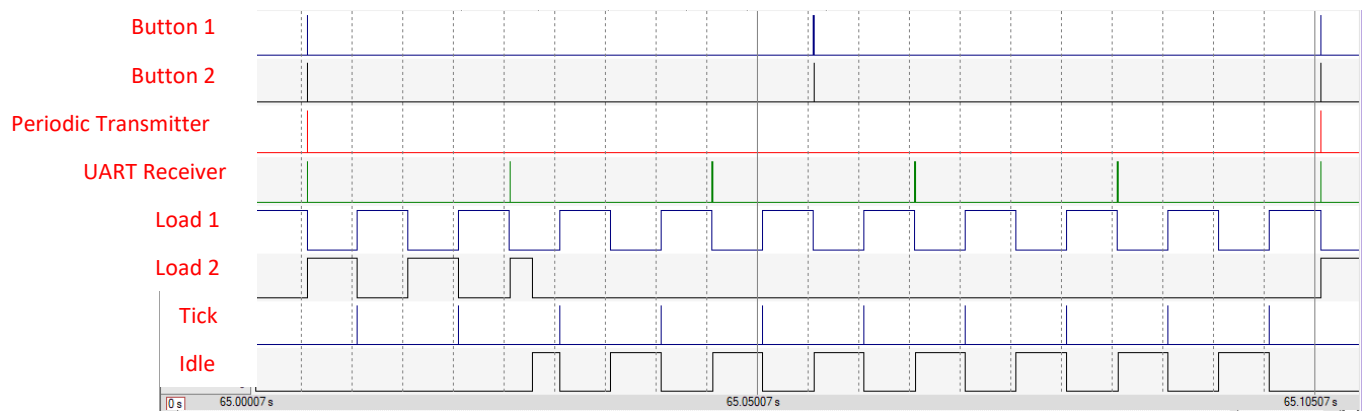# 3. Using Keil simulator in run-time

Figure 3 plot of the execution of all tasks, tick, and the idle task on the logic analyser

The above figure shows the execution of tasks

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CPU_Load = CPU_TotalTime / (T1TC / 100);
```

Figure 4 calculating the CPU load in runtime

Name	Value	Type
◆ CPU_Load	0x0000003E	uint

Figure 5 Watch window shows the value of CPU_Load variable

4. Conclusion

- Analytical methods, Offline simulator and online Debugger Provided the same results.
- The CPU load is estimated to be around 62%
- Tasks never missed their deadlines.
- Tasks with earlier deadline prempted tasks with farther deadlines as shown with task load 1 simulator and load 2 simulator.
- The results indicate successful implementation and system feasibility.