

## Solution 2

1. There are many possible solutions. One of them is shown below.

```
#define PBIN (volatile char *) 0xFFFFFFF3
#define PBOUT (volatile char *) 0xFFFFFFF4
#define PBDIR (volatile char *) 0xFFFFFFF5
#define CNTM (volatile int *) 0xFFFFFDD0
#define CTCON (volatile char *) 0xFFFFFDD8
#define CTSTAT (volatile char *) 0xFFFFFDD9
#define IVECT (volatile int *) (0x20)

interrupt void intserv();

unsigned char digit = 0;                                /* digit for display */

int main() {
    unsigned char sample = 0;                            /* Port B input sample */
    *PBDIR = 0xF0;                                       /* Set Port B direction */
    *CNTM = 100000000;                                   /* 1-second timeout */
    *CTSTAT = 0x0;                                       /* Clear "Reached 0" flag */
    *IVECT = (volatile int *) &intserv;                /* Set interrupt vector */
    asm("MoveControl PSR,#0x40");                       /* CPU responds to IRQ */
    *CTCON = 0x11;                                       /* Enable Timer interrupts
                                                         and start */
    *PBOUT = 0x0;                                       /* Display 0 */
    asm("BitClear #6, PSR"); /* Incrementing not allowed initially */
    while (1) {
        sample = *PBIN & 0x3; /* Sample PBIN, isolate E and D */
        if (sample == 0x1) asm("BitSet #6, PSR"); /* ISR will run */
        if (sample == 0x2) asm("BitClear #6, PSR"); /* ISR will not run */
    }

    exit(0);
}

interrupt void intserv() {
    *CTSTAT = 0x0; /* Clear "Reached 0" flag */
    digit = (digit + 1)%10; /* Increment digit */
    *PBOUT = digit << 4; /* Update display */
}
```

2.

```
interrupt void intserv() {

    unsigned char buffer, stat, CTCON_saved, CTSTAT_saved;
    unsigned int CNTM_saved, COUNT_saved;

    buffer = *RBUF; /* Read Rx buffer */
```

```

stat = *PSTAT;                                /* Read Port A/B Status Register */

if ((stat & 0x2) == 0) {                       /* Port A is not ready */
    CTCON_saved = *CTCON;                     /* Save CTCON contents */
    CTSTAT_saved = *CTSTAT;                   /* Save CTSTAT contents */
    COUNT_saved = *COUNT;                   /* Save COUNT contents */
    CNTM_saved = *CNTM;                       /* Save CNTM contents */
    *CTCON = 0x2;                             /* Stop countdown (if running) */
    *CNTM = 100000;                           /* 0.001-second timeout */
    *CTSTAT = 0x0;                           /* Clear "Reached 0" flag */
    *CTCON = 0x1;                             /* Start countdown */
    while ((*CTSTAT & 0x1) == 0) {             /* Wait until 0 reached */
        if ((*PSTAT & 0x2) != 0x0) {         /* If Port A is ready... */
            *PAOUT = buffer;                 /* Output to Port A */
            break;                           /* Terminate timeout loop */
        }
    }
    *CTCON = 0x2;                             /* Stop countdown */
    *CNTM = CNTM_saved;                       /* Restore saved CNTM contents */
    *COUNT = COUNT_saved;                   /* Restore saved COUNT contents */
    *CTSTAT = CTSTAT_saved;                  /* Restore saved CTSTAT contents */
    *CTCON = CTCON_saved;                    /* Restore saved CTCON contents */
}

else *PAOUT = buffer;                         /* (stat & 0x2) != 0: Ready */
}

```

### 3.

Within the reference timeframe of 120, **T1** is activated 4 times with the deadlines of 30 ( $t=0$ ,  $k=0$ ), 60 ( $t=30$ ,  $k=1$ ), 90 ( $t=60$ ,  $k=2$ ), 120 ( $t=90$ ,  $k=3$ ). Therefore, **T1**'s priorities are  $\tau_{10} = 1/30$ ,  $\tau_{11} = 1/60$ ,  $\tau_{12} = 1/90$ ,  $\tau_{13} = 1/120$ . Task **T2** is activated 3 times with the deadlines of 30 ( $t=0$ ,  $k=0$ ), 70 ( $t=40$ ,  $k=1$ ), 110 ( $t=80$ ,  $k=2$ ). Therefore, **T2**'s priorities are  $\tau_{20} = 1/30$ ,  $\tau_{21} = 1/70$ ,  $\tau_{22} = 1/110$ . **T3** is activated once with the deadline of 120 ( $t=0$ ,  $k=0$ ); therefore, **T3**'s priority is  $\tau_{30} = 1/120$ .

$t=0$ : **T1** [ $\tau_{10}$ ], **T2** [ $\tau_{20}$ ], **T3** [ $\tau_{30}$ ] ready. Both **T1** and **T2** have the highest priority of  $1/30$ . Dispatch **T1** (e.g., because its period is shorter than **T2**'s).

$t=10$ : **T2** [ $\tau_{20}$ ], **T3** [ $\tau_{30}$ ] ready. **T2** has the highest priority of  $1/30$ . Dispatch **T2**.

$t=27$ : **T3** [ $\tau_{30}$ ] ready. Dispatch **T3**.

$t=30$ : **T1** [ $\tau_{11}$ ], **T3** [ $\tau_{30}$ ] (WCET of 7 remains) ready. **T1** has the highest priority of  $1/60$ . Dispatch **T1** (**T3** is suspended).

$t=40$ : **T2** [ $\tau_{21}$ ], **T3** [ $\tau_{30}$ ] (WCET of 7 remains) ready. **T2** has the highest priority of  $1/70$ . Dispatch **T2** (**T3** is suspended).

$t=57$ : **T3** [ $\tau_{30}$ ] (WCET of 7 remains) ready. Dispatch **T3**.

$t=60$ : **T1** [ $\tau_{12}$ ], **T3** [ $\tau_{30}$ ] (WCET of 4 remains) ready. **T1** has the highest priority of  $1/90$ . Dispatch **T1** (**T3** is suspended).

t=70: **T3** [ $\tau_{30}$ ] (WCET of 4 remains) ready. Dispatch **T3**.

t=74: Idle – no tasks to execute.

t=80: **T2** [ $\tau_{22}$ ] ready. Dispatch **T2**.

t=90: **T1** [ $\tau_{13}$ ], **T2** [ $\tau_{22}$ ] (WCET of 7 remains) ready. **T2** has the highest priority of 1/110. Dispatch **T2**.

t=97: **T1** [ $\tau_{13}$ ] ready. Dispatch **T1**.

t=107: Idle – no tasks to execute.

t=120: End.

