

Solution 1

1.

```
#define PBIN (volatile char *) 0xFFFFFFFF3
#define PBOUT (volatile char *) 0xFFFFFFFF4
#define PBDIR (volatile char *) 0xFFFFFFFF5
#define PCONT (volatile char *) 0xFFFFFFFF7
#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 led = 0x4;          /* 0x0 = LED on, 0x4 = LED off */
signed char digit = 0;           /* digit for display */

int main() {
    *PBDIR = 0xF4;                /* Set Port B direction */
    *IVECT = (volatile int *) &intserv; /* Set interrupt vector */
    asm("MoveControl PSR,#0x40"); /* CPU responds to IRQ */
    *PCONT = 0x40;                /* Enable PBIN interrupts */
    *PBOUT = 0x4;                /* Turn off LED, display 0 */
    *CNTM = 100000000;            /* 1-second timeout */
    *CTCON = 0x1;                /* Start countdown */
    while (1) {
        *CTSTAT = 0x0;           /* Clear "Reached 0" flag */
        while ((*CTSTAT & 0x1) == 0); /* Wait until 0 reached */
        if (led == 0x4) led = 0x0; /* If off, turn LED on */
        else led = 0x4;          /* Else, turn LED off */
        *PBOUT = ((digit << 4) | led); /* Update LED, same display */
    }
    exit(0);
}

interrupt void intserv() {
    if ((*PBIN & 0x1) == 0) digit = (digit + 1)%10; /* INC pressed */
    if ((*PBIN & 0x2) == 0) digit = (digit - 1)%10; /* DEC pressed */
    *PBOUT = ((digit << 4) | led); /* Update display, same LED */
}
```

2.

```
#define PAOUT (volatile char *) 0xFFFFFFFF1
#define PADIR (volatile char *) 0xFFFFFFFF2
#define PBIN (volatile char *) 0xFFFFFFFF3
#define PBDIR (volatile char *) 0xFFFFFFFF5
#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 led = 0x1;          /* 0x0 = LED on, 0x1 = LED off */
unsigned char digit = 0;          /* digit for display */

int main() {
    *PADIR = 0xFF;                /* Configure Port A direction */
    *PBDIR = 0x0;                /* Configure Port B direction */
    *CNTM = 100000000;           /* 100,000,000 cycles = 1 sec */
    *CTSTAT = 0x0;               /* Clear "Reached 0" flag */

    *IVECT = (volatile int *) &intserv; /* Set up interrupt vector */
    asm("MoveControl PSR,#0x40");      /* CPU responds to IRQ */
    *CTCON = 0x11;               /* Enable timer interrupts
                                and start countdown */
    *PAOUT = 0x1;                /* Turn off LED, display 0 */
    while (1) {                  /* Infinite loop */
        while ((*PBIN & 0x1) != 0);    /* Wait for SW to be pressed */
        while ((*PBIN & 0x1) == 0);    /* Wait for SW to be released */
        digit = (digit + 1)%10;        /* Increment digit */
        *PAOUT = ((digit < 4) | led);  /* Update display, same LED */
    }
    exit(0);
}

interrupt void intserv() {
    *CTSTAT = 0x0;               /* Clear "Reached 0" flag */
    if (led == 0x0) led = 0x1;      /* If on, turn LED off */
    else led = 0x0;               /* If off, turn LED on */
    *PAOUT = ((digit < 4) | led);    /* Update LED, same display */
}

```

3.

Let x denote the I/O device activity percentage to be determined.

Maximum I/O data rate for DMA transfer is $R_{I/O}/d_{I/O-DMA} = 1K$ transfers/s. DMA cost: $(x*1K)(N_{DMA-start} + N_{DMA-end}) = x*2.4M$ cycles/s.

Maximum I/O data rate for polling is $R_{I/O}/d_{I/O} = 128K$ transfers/s. Polling cost: $(x*128K)N_{poll-ready} + ((1-x)*128K)N_{poll-not-ready} = x*51.2M + 51.2M$ cycles/s.

We know that the DMA cost is 100 times cheaper than the polling cost; therefore, $100*(x*2.4M) = x*51.2M + 51.2M$, which yields $x \approx 0.27$ (i.e., 27%).

(Note: $1K = 2^{10}$ and $1M = 2^{20}$.)