Help

One of the important tasks in debugging a system is to observe when and where our software is executing. A debugging tool that works well for real-time systems is the monitor. In a real-time system, we need the execution time of the debugging tool to be small compared to the execution time of the program itself. **Intrusiveness** is defined as the degree to which the debugging code itself alters the performance of the system being tested. A monitor is an independent output process, somewhat similar to the print statement, but one that executes much faster and thus is much less intrusive. An LED attached to an output port of the microcontroller is an example of a BOOLEAN monitor. You can place LEDs on unused output pins. Software toggles these LEDs to let you know where and when your program is running. Assume an LED is attached to Port F bit 2. Program 6.2 will toggle the LED. We create a bit-specific address constant to access just PF2:

```
PF2 EQU 0x40025010
Toggle
  LDR R1, =PF2
  LDR R0, [R1]
  EOR R0, R0, #0x04
  STR R0, [R1]
  BX  LR
```

```
#define PF2 (*((volatile unsigned long *)0x40025010))
void Toggle(void){
  PF2 ^= 0x04;  // toggle LED
}
```

Program 6.2. An LED monitor.

A **heartbeat** is a pulsing output that is not required for the correct operation of the system, but it is useful to see while the program is running. In particular, you add **`BL Toggle`** statements at strategic places within your system. It only takes 13 bus cycles to execute. Port F must be initialized so that bit 2 is an output before the debugging begins. You can either observe the LED directly or look at the LED control signals with a high-speed oscilloscope or logic analyzer. An LCD can be an effective monitor for small amounts of information. Inexpensive LCDs can display from 8 to 160 characters. Unfortunately, it takes about 50 µs to output each character, so the use of an LCD monitor might be intrusive. When using LED monitors it is better to modify just the one bit, leaving the other 7 as is. In this way, you can have additional LED monitors.

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