



Module 11

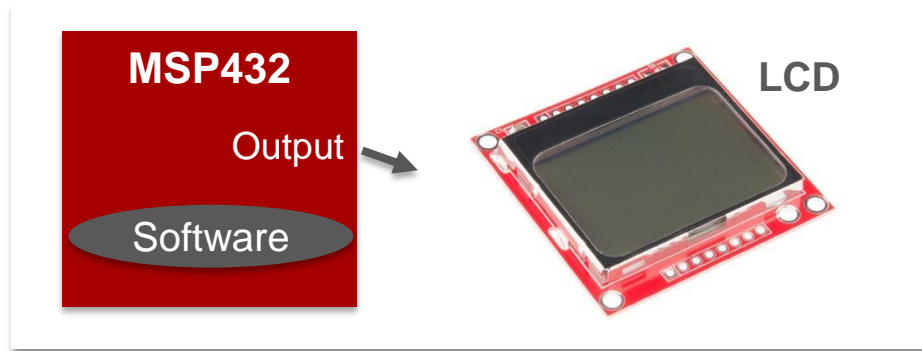
Lecture: Liquid Crystal Display



Liquid Crystal Display

You will learn in this module

- Busy-wait hardware/software synchronization
- Fundamentals of synchronous serial communication
- How to interface an LCD to TI's Launchpad Development board
- Software driver (set of functions to create an abstract module)
- Create a minimally intrusive debugging monitor

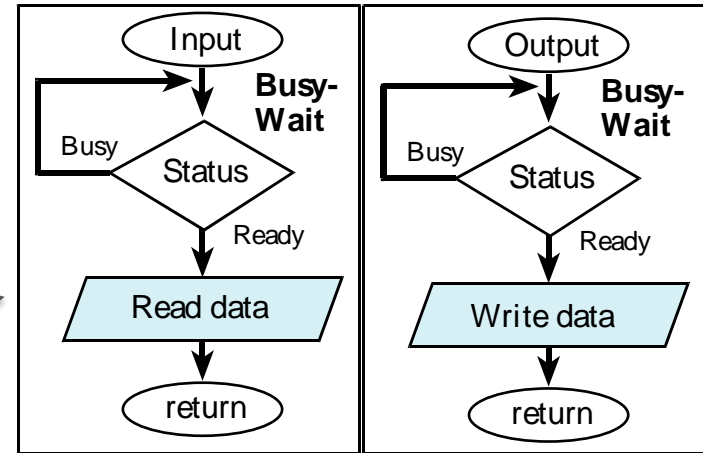




Hardware/software synchronization

The fundamental problem

- Software executes quickly (48 MHz)
 - Instruction takes 42 ns
- Hardware operates slowly
 - LCD takes 6 μ s to output a character
- Solutions
 - Blind (fixed wait time)
 - Busy-wait
 - Interrupts (Labs 10,13,14)
 - Direct memory access



Synchronous Serial Communication on the MSP432

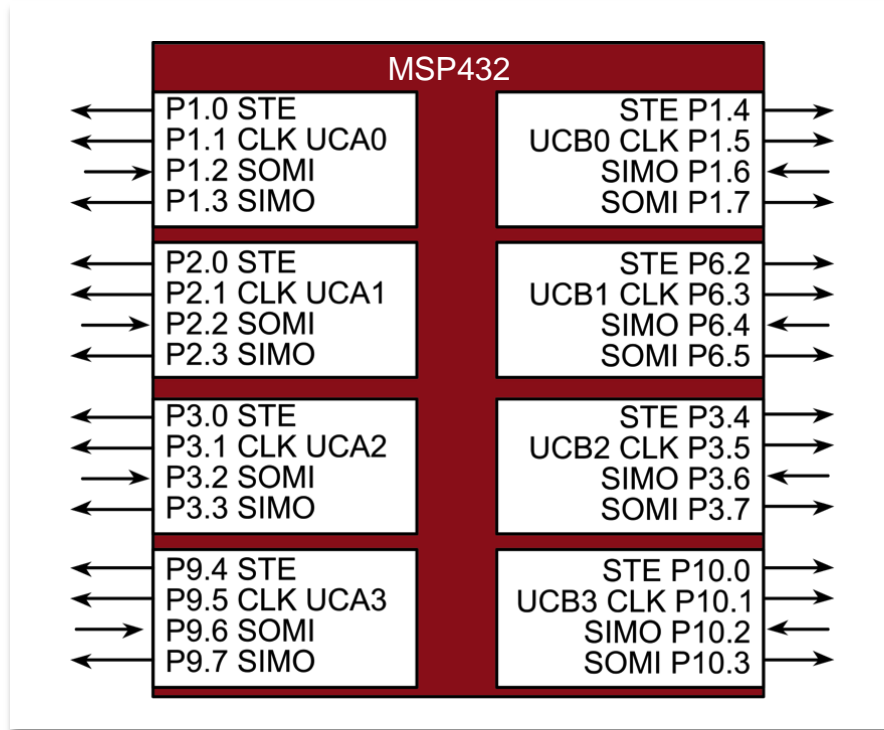
Components

- Enable
- Clock
- Data out
- Data in

MSP432 is master

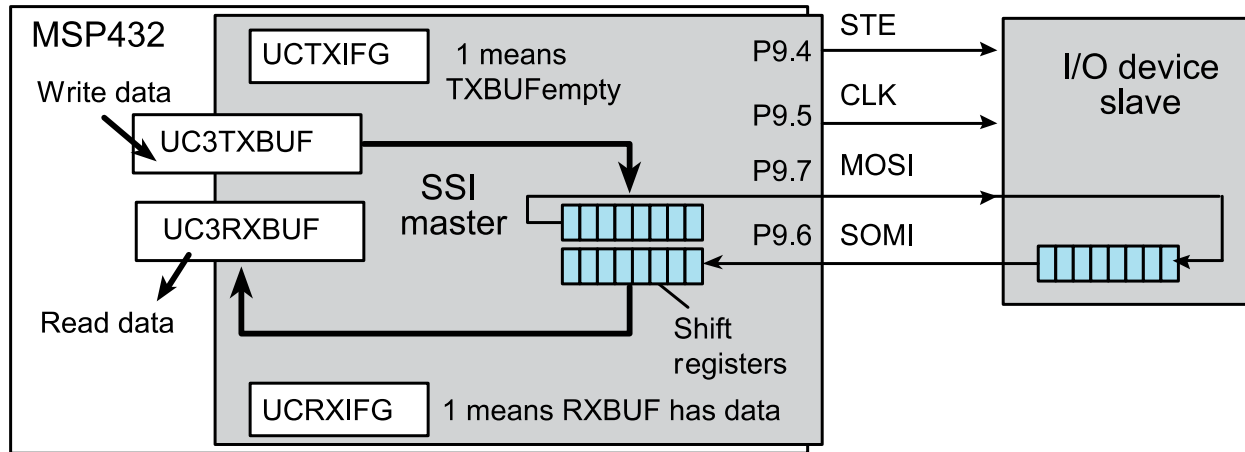
- Drives clock
- Drives enable
- Initiates transfer

LCD is slave



Synchronous Serial Communication on the MSP432

- Synchronous means send clock and data
 - Send data on one edge of clock
 - Receive data on other edge
- Serial Peripheral Interface (SPI) Protocol

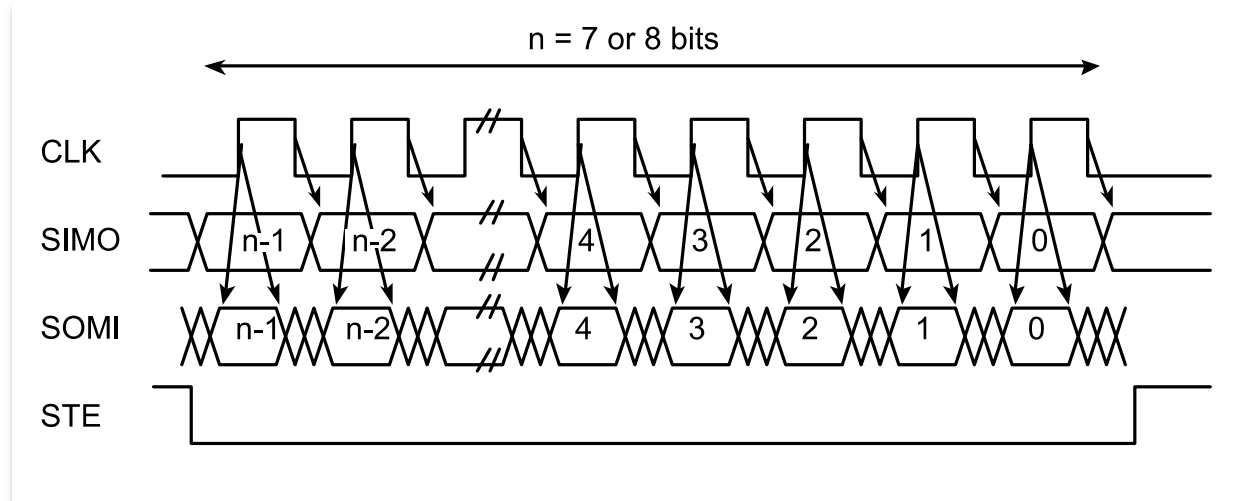




Serial Peripheral Interface (SPI) Timing

Signals

- Clock
- Data out
- Data in
- Enable

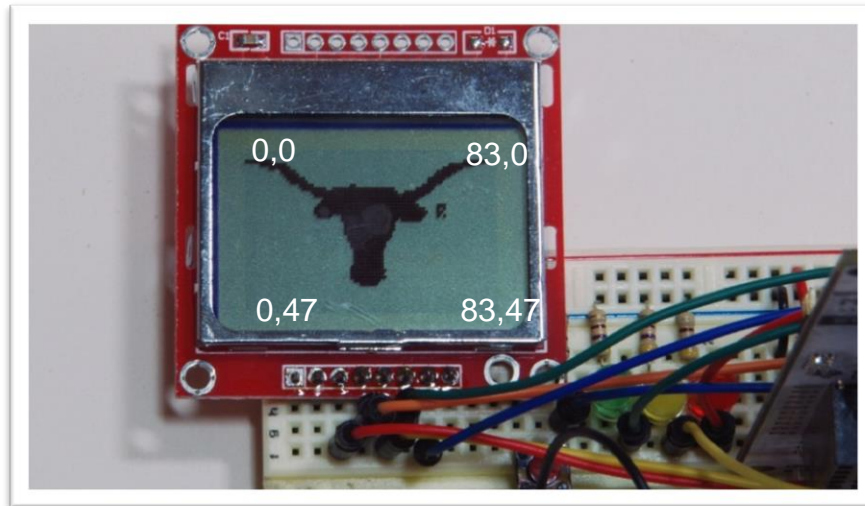




Nokia5110 LCD functionality

Monochrome

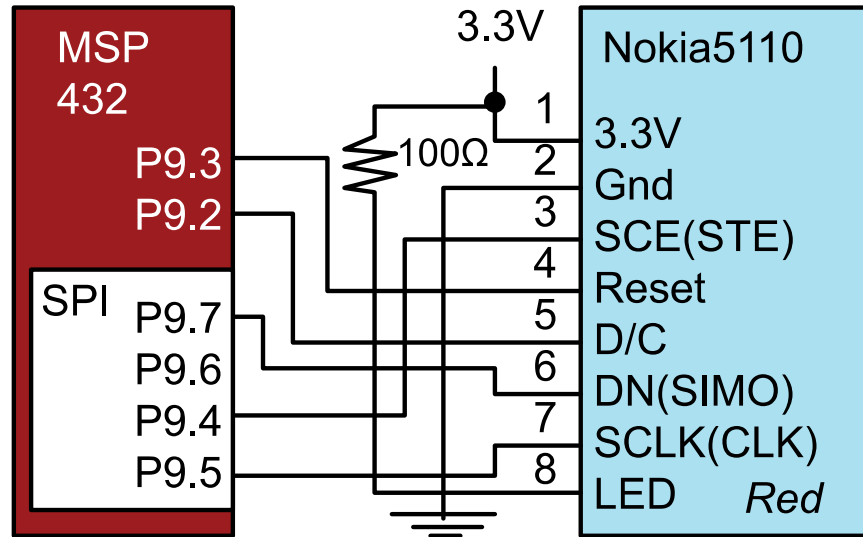
- Serial Peripheral Interface (SPI)
 - 5 pins
- 84 pixels wide
- 48 pixels high
- 12 MHz speed
- Low cost





LCD Interface

- SPI
 - P9.4 STE
 - P9.5 CLK
 - P9.7 SIMO
- GPIO
 - P9.3 Reset
 - P9.2 Data/command





Decimal output

Output an unsigned integer, n

- Assume n is between 1000 and 9999
- Print as 5 characters, right justified

```
OutChar(0x20);           // space
OutChar(0x30+n/1000);    // thousand's digit
n = n%1000;
OutChar(0x30+n/100);     // hundred's digit
n = n%100;
OutChar(0x30+n/10);      // ten's digit
OutChar(0x30+n%10);      // one's digit
```

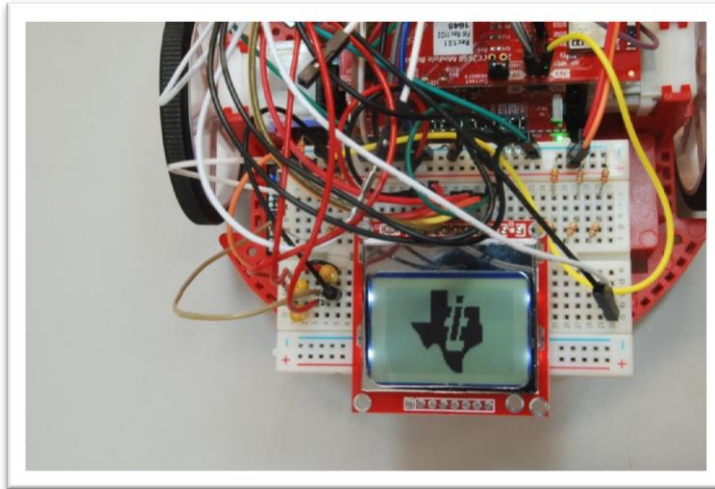


Application

LCD provides

1. Debugging information in real time as robot is moving (6 μ s/character)
2. Graphical representation of data (optional)

Minimally intrusive



```
Nokia5110_SetCursor(0,2);  
Nokia5110_OutString("D= ");  
Nokia5110_OutUDec(distance);  
Nokia5110_OutString(" mm");
```

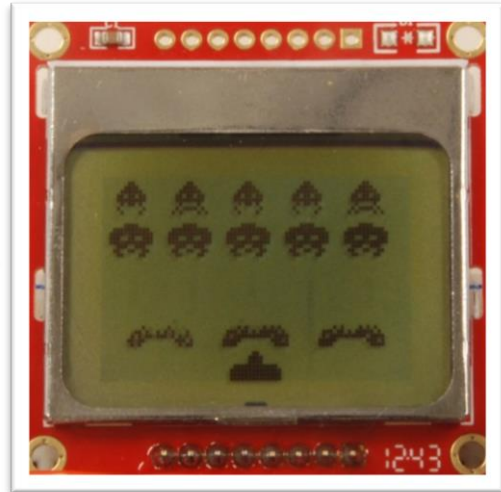
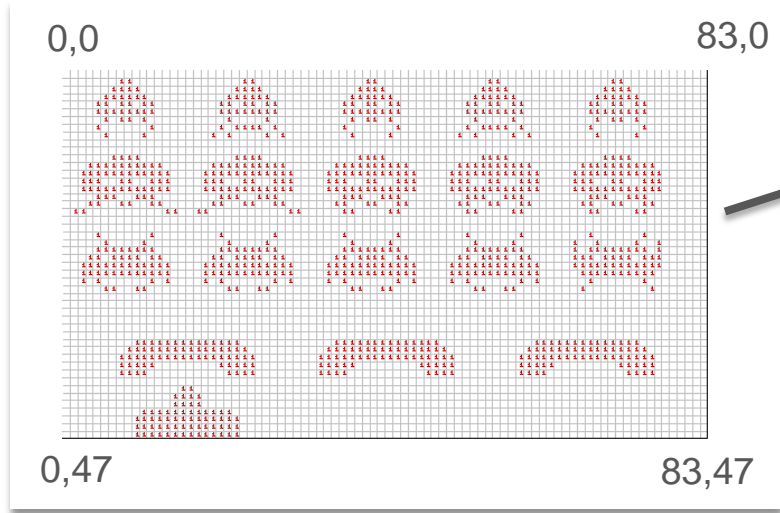
42 μ s

```
Nokia5110_SetCursor(3,2);  
Nokia5110_OutUDec(distance);
```



Summary

- Busy-wait synchronization
- Synchronous serial communication
- Graphics
- Numerical output
- Minimally intrusive debugging monitor



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