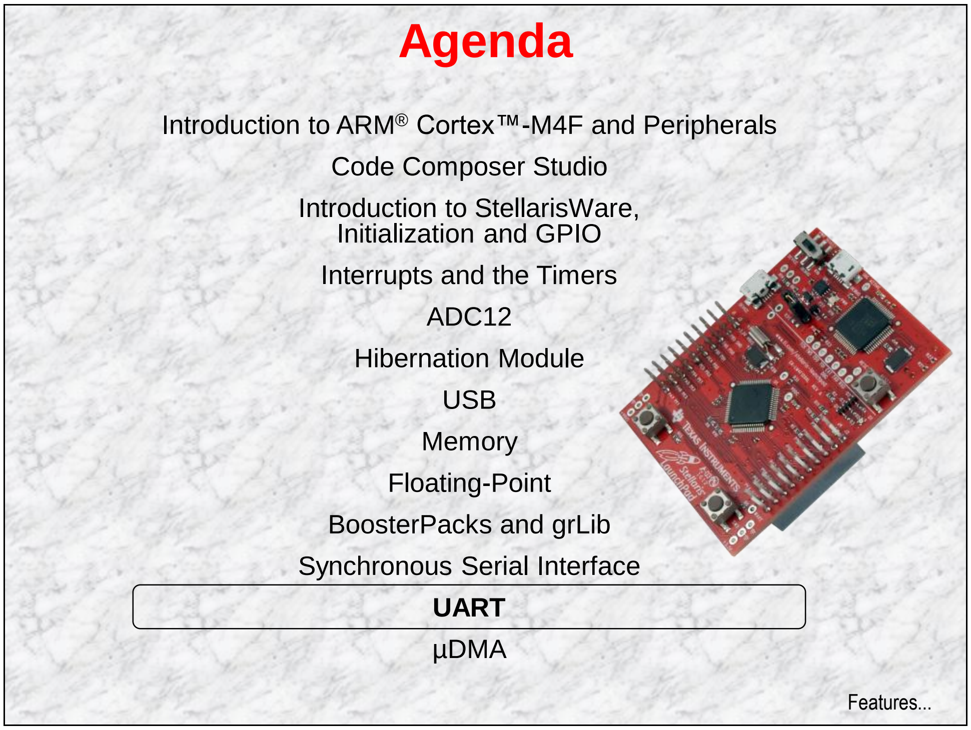
UART

Introduction

This chapter will introduce you to the capabilities of the Universal Asynchronous Receiver/Transmitter (UART). The lab uses the LaunchPad board and the Stellaris Virtual Serial Port running over the debug USB port.



Agenda

Introduction to ARM® Cortex™-M4F and Peripherals

Code Composer Studio

Introduction to StellarisWare,
Initialization and GPIO

Interrupts and the Timers

ADC12

Hibernation Module

USB

Memory

Floating-Point

BoosterPacks and grLib

Synchronous Serial Interface

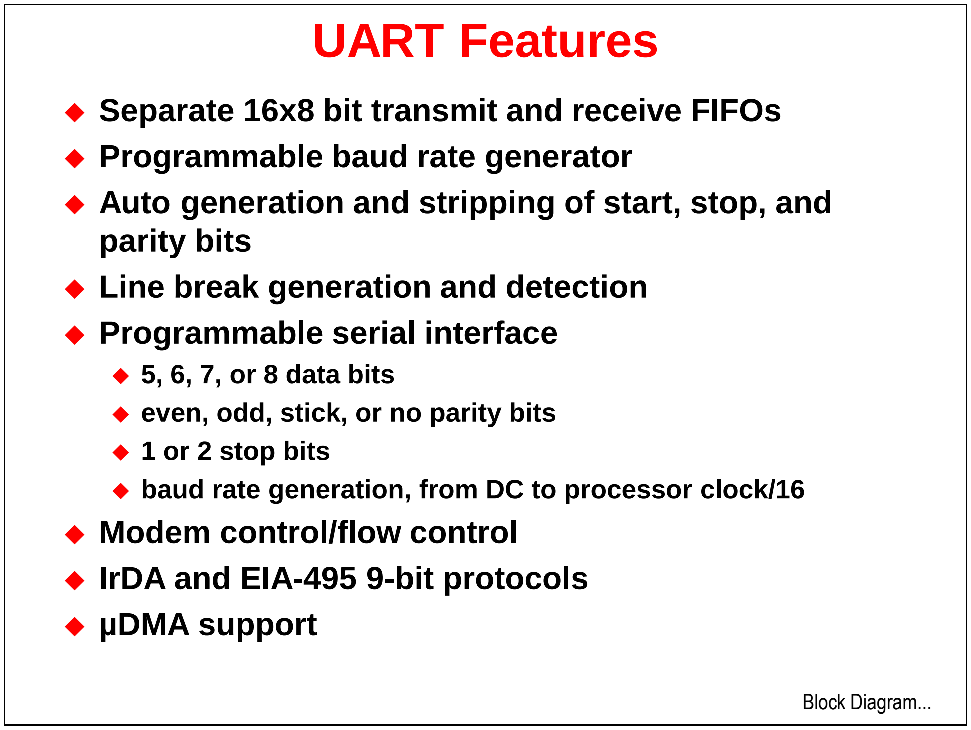
UART

µDMA

Features...

Chapter Topics

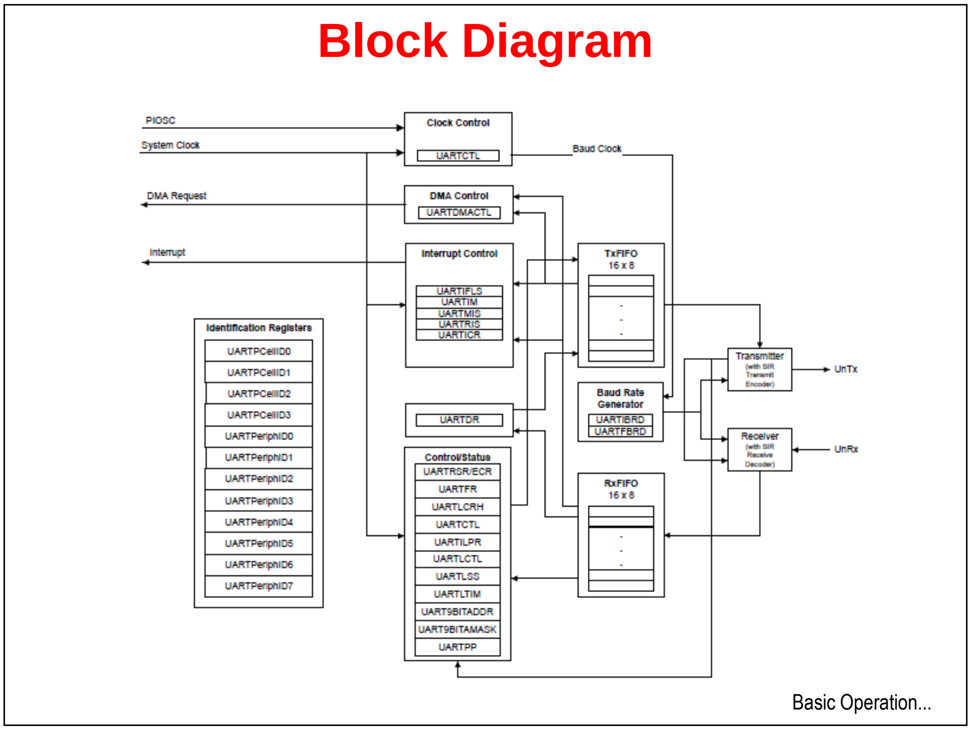
UART Features and Block Diagram



UART Features

- Separate 16x8 bit transmit and receive FIFOs
- Programmable baud rate generator
- Auto generation and stripping of start, stop, and parity bits
- Line break generation and detection
- Programmable serial interface
  - 5, 6, 7, or 8 data bits
  - even, odd, stick, or no parity bits
  - 1 or 2 stop bits
  - baud rate generation, from DC to processor clock/16
- Modem control/flow control
- IrDA and EIA-495 9-bit protocols
- µDMA support

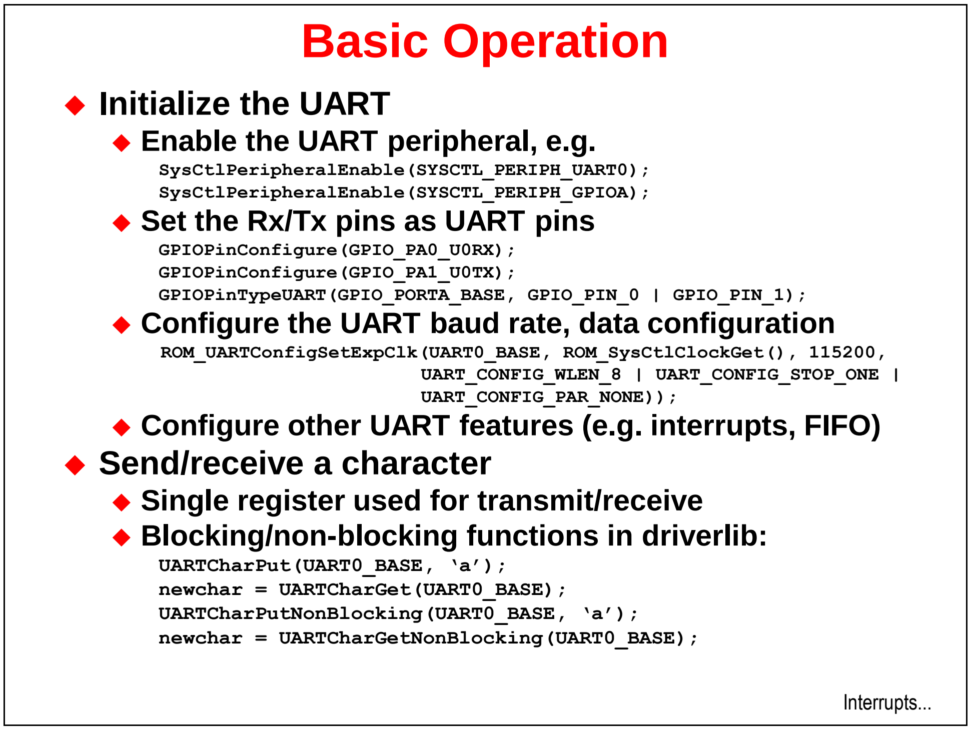
Block Diagram...



Block Diagram

Basic Operation...

Basic Operation



Basic Operation

- Initialize the UART
  - Enable the UART peripheral, e.g.

```
SysCtlPeripheralEnable(SYSCTL_PERIPH_UART0);
SysCtlPeripheralEnable(SYSCTL_PERIPH_GPIOA);
```

  - Set the Rx/Tx pins as UART pins

```
GPIOPinConfigure(GPIO_PA0_U0RX);
GPIOPinConfigure(GPIO_PA1_U0TX);
GPIOPinTypeUART(GPIO_PORTA_BASE, GPIO_PIN_0 | GPIO_PIN_1);
```

  - Configure the UART baud rate, data configuration

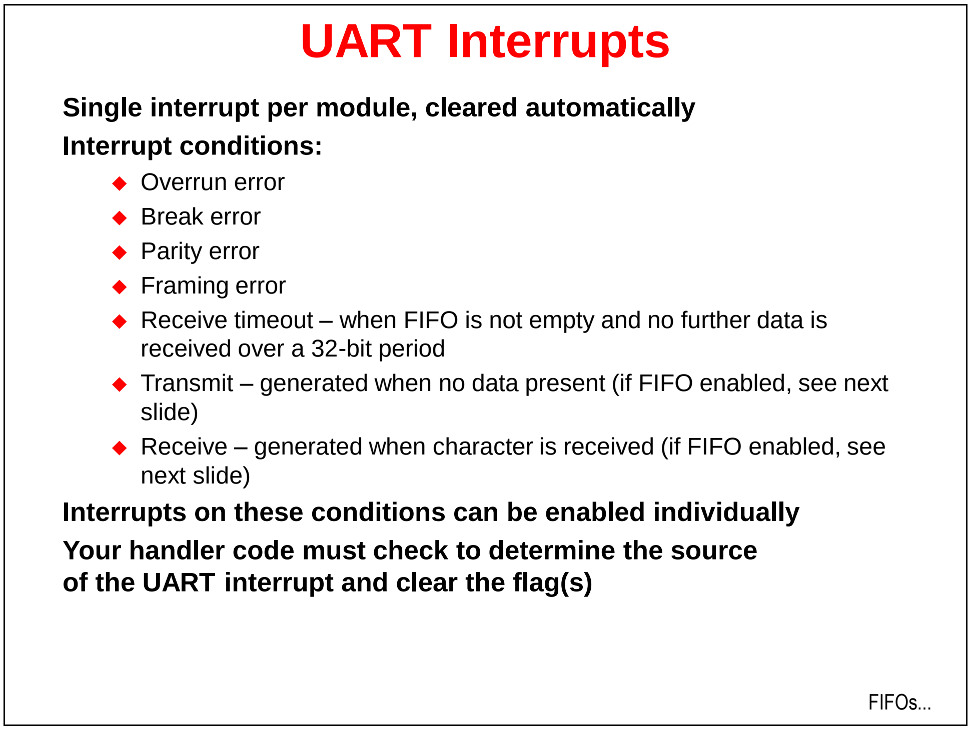
```
ROM_UARTConfigSetExpClk(UART0_BASE, ROM_SysCtlClockGet(), 115200,
                        UART_CONFIG_WLEN_8 | UART_CONFIG_STOP_ONE |
                        UART_CONFIG_PAR_NONE));
```

  - Configure other UART features (e.g. interrupts, FIFO)
- Send/receive a character
  - Single register used for transmit/receive
  - Blocking/non-blocking functions in driverlib:

```
UARTCharPut(UART0_BASE, ‘a’);
newchar = UARTCharGet(UART0_BASE);
UARTCharPutNonBlocking(UART0_BASE, ‘a’);
newchar = UARTCharGetNonBlocking(UART0_BASE);
```

Interrupts...

UART Interrupts and FIFOs



UART Interrupts

Single interrupt per module, cleared automatically

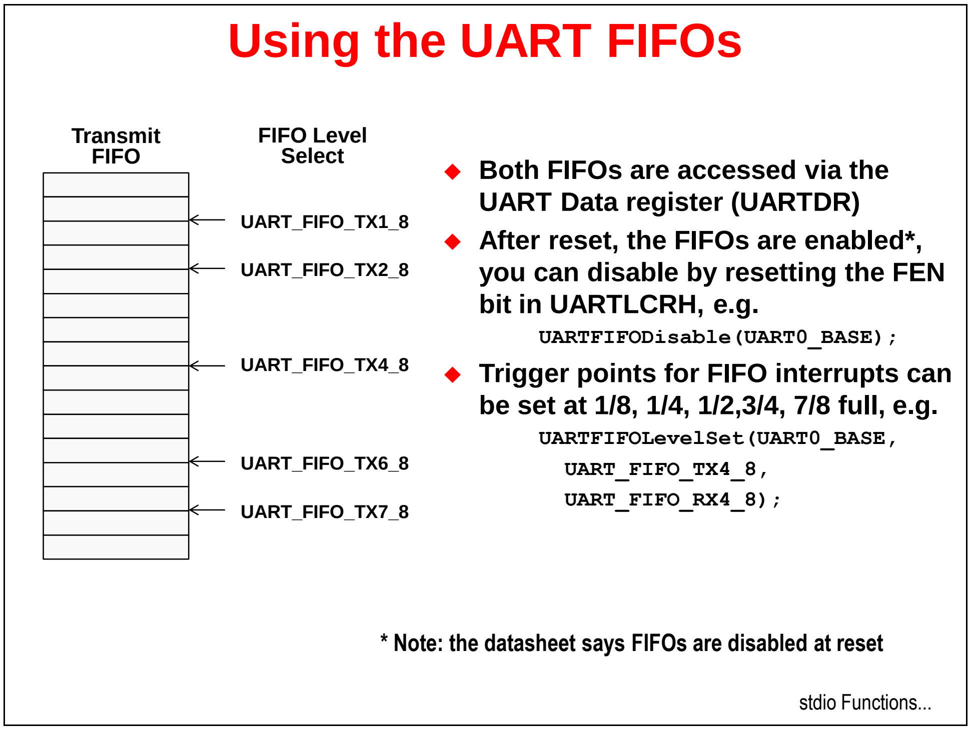
Interrupt conditions:

- Overrun error
- Break error
- Parity error
- Framing error
- Receive timeout – when FIFO is not empty and no further data is received over a 32-bit period
- Transmit – generated when no data present (if FIFO enabled, see next slide)
- Receive – generated when character is received (if FIFO enabled, see next slide)

Interrupts on these conditions can be enabled individually

Your handler code must check to determine the source of the UART interrupt and clear the flag(s)

FIFOs...



Using the UART FIFOs

- **Both FIFOs are accessed via the UART Data register (UARTDR)**
- **After reset, the FIFOs are enabled*, you can disable by resetting the FEN bit in UARTLCRH, e.g.**

```
UARTFIFODisable(UART0_BASE);
```

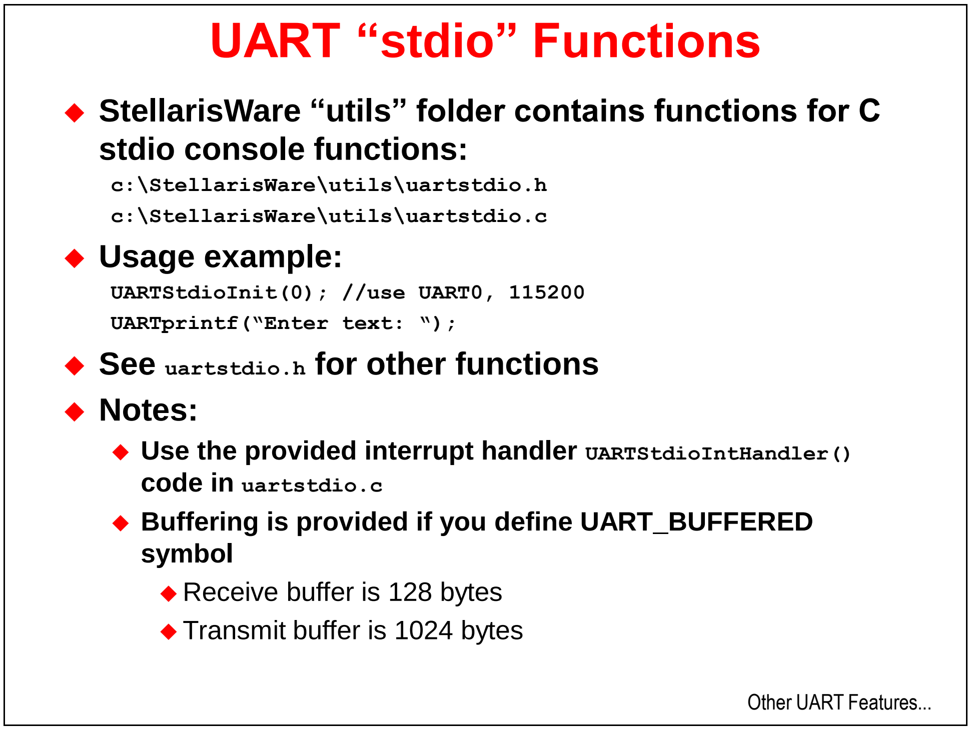
- **Trigger points for FIFO interrupts can be set at 1/8, 1/4, 1/2,3/4, 7/8 full, e.g.**

```
UARTFIFOLevelSet(UART0_BASE,
  UART_FIFO_TX4_8,
  UART_FIFO_RX4_8);
```

*** Note: the datasheet says FIFOs are disabled at reset**

stdio Functions...

UART “stdio” Functions and Other Features



UART “stdio” Functions

- **StellarisWare “utils” folder contains functions for C stdio console functions:**

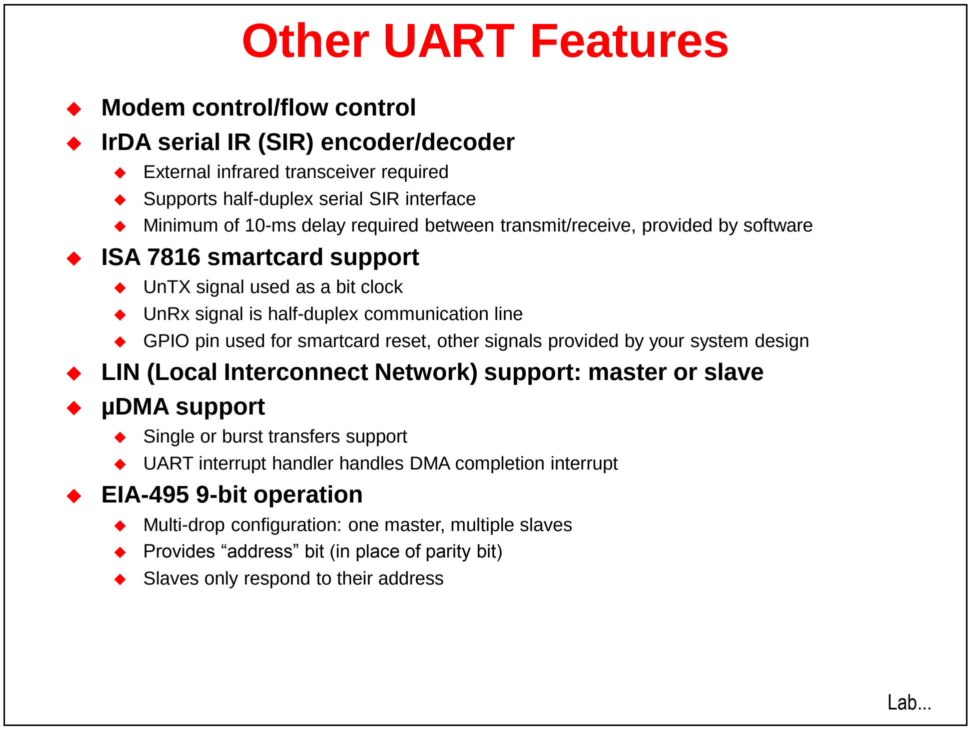
```
c:\StellarisWare\utils\uartstdio.h
c:\StellarisWare\utils\uartstdio.c
```

- **Usage example:**

```
UARTStdioInit(0); //use UART0, 115200
UARTprintf(“Enter text: “);
```

- **See `uartstdio.h` for other functions**
- **Notes:**
  - **Use the provided interrupt handler `UARTStdioIntHandler()` code in `uartstdio.c`**
  - **Buffering is provided if you define UART_BUFFERED symbol**
    - Receive buffer is 128 bytes
    - Transmit buffer is 1024 bytes

Other UART Features...



Other UART Features

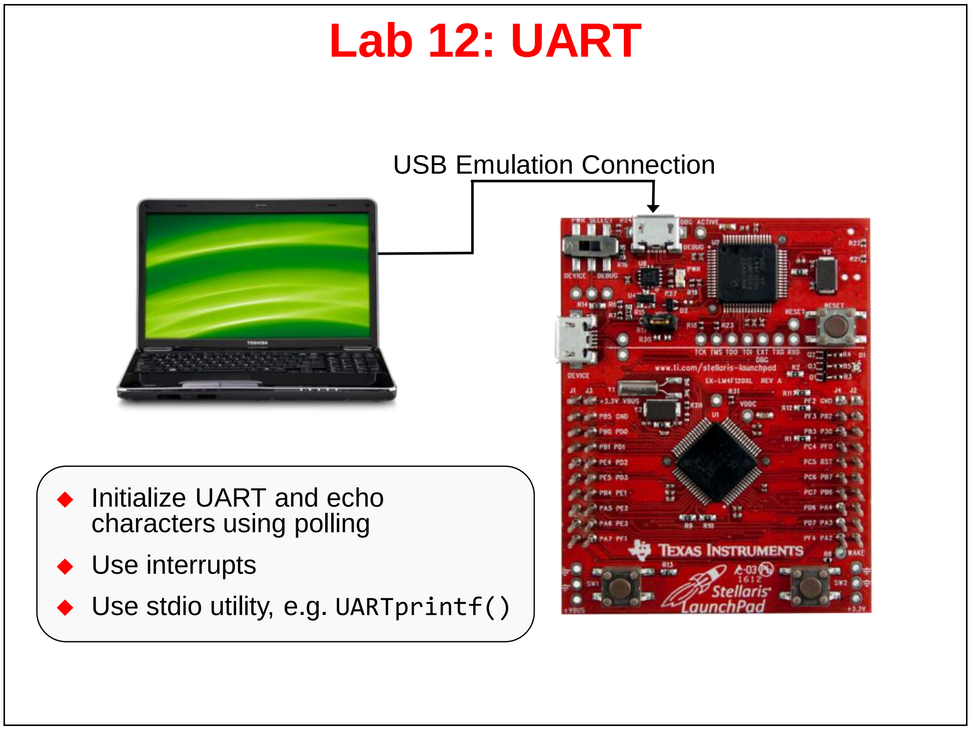
- **Modem control/flow control**
- **IrDA serial IR (SIR) encoder/decoder**
  - External infrared transceiver required
  - Supports half-duplex serial SIR interface
  - Minimum of 10-ms delay required between transmit/receive, provided by software
- **ISA 7816 smartcard support**
  - UnTX signal used as a bit clock
  - UnRx signal is half-duplex communication line
  - GPIO pin used for smartcard reset, other signals provided by your system design
- **LIN (Local Interconnect Network) support: master or slave**
- **µDMA support**
  - Single or burst transfers support
  - UART interrupt handler handles DMA completion interrupt
- **EIA-495 9-bit operation**
  - Multi-drop configuration: one master, multiple slaves
  - Provides “address” bit (in place of parity bit)
  - Slaves only respond to their address

Lab...

Lab 12

Objective

In this lab you will use the LaunchPad board, and the virtual serial port that runs over the debug USB cable.



Lab 12: UART

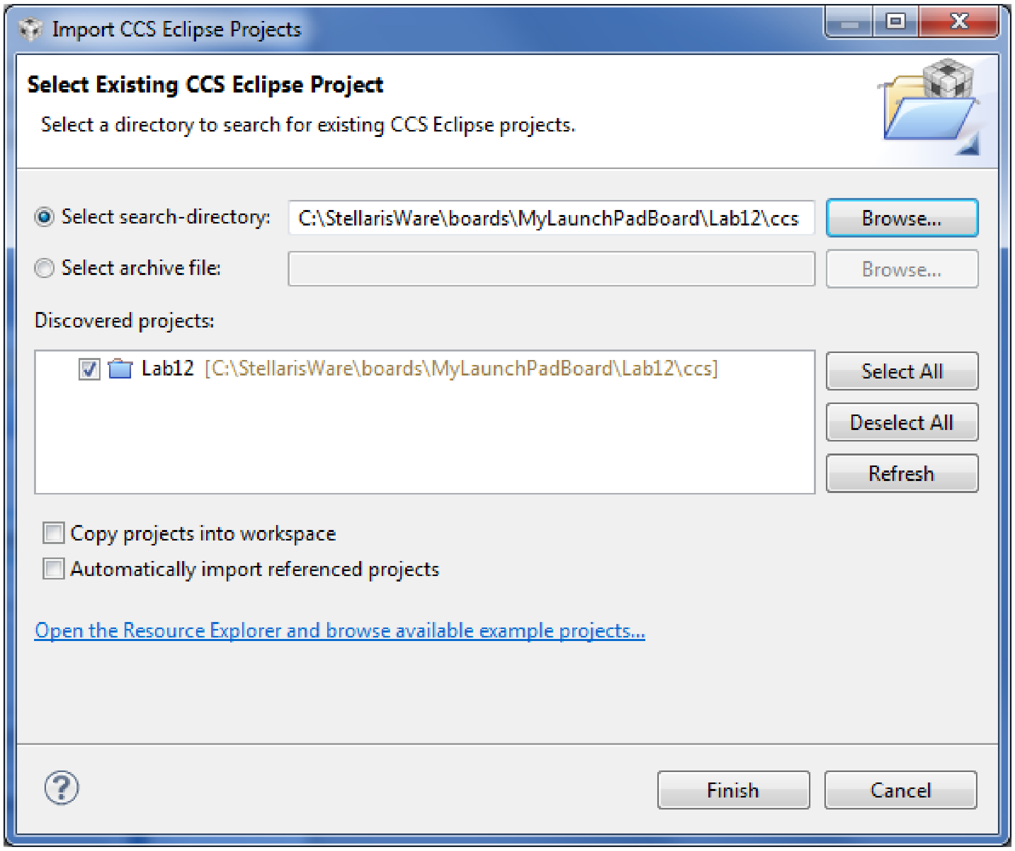
USB Emulation Connection

- Initialize UART and echo characters using polling
- Use interrupts
- Use stdio utility, e.g. `UARTprintf()`

Procedure

Import Lab12

1. We have already created the Lab12 project for you with a **`main.c`** file, a startup file, and all the necessary project and build options set. Maximize Code Composer and click Project → Import Existing CCS Eclipse Project. Make the settings shown below and click Finish. Make sure that the “Copy projects into workspace” checkbox is **unchecked**.



Import CCS Eclipse Projects

Select Existing CCS Eclipse Project

Select a directory to search for existing CCS Eclipse projects.

● Select search-directory: C:\StellarisWare\boards\MyLaunchPadBoard\Lab12\ccs

○ Select archive file:

Discovered projects:

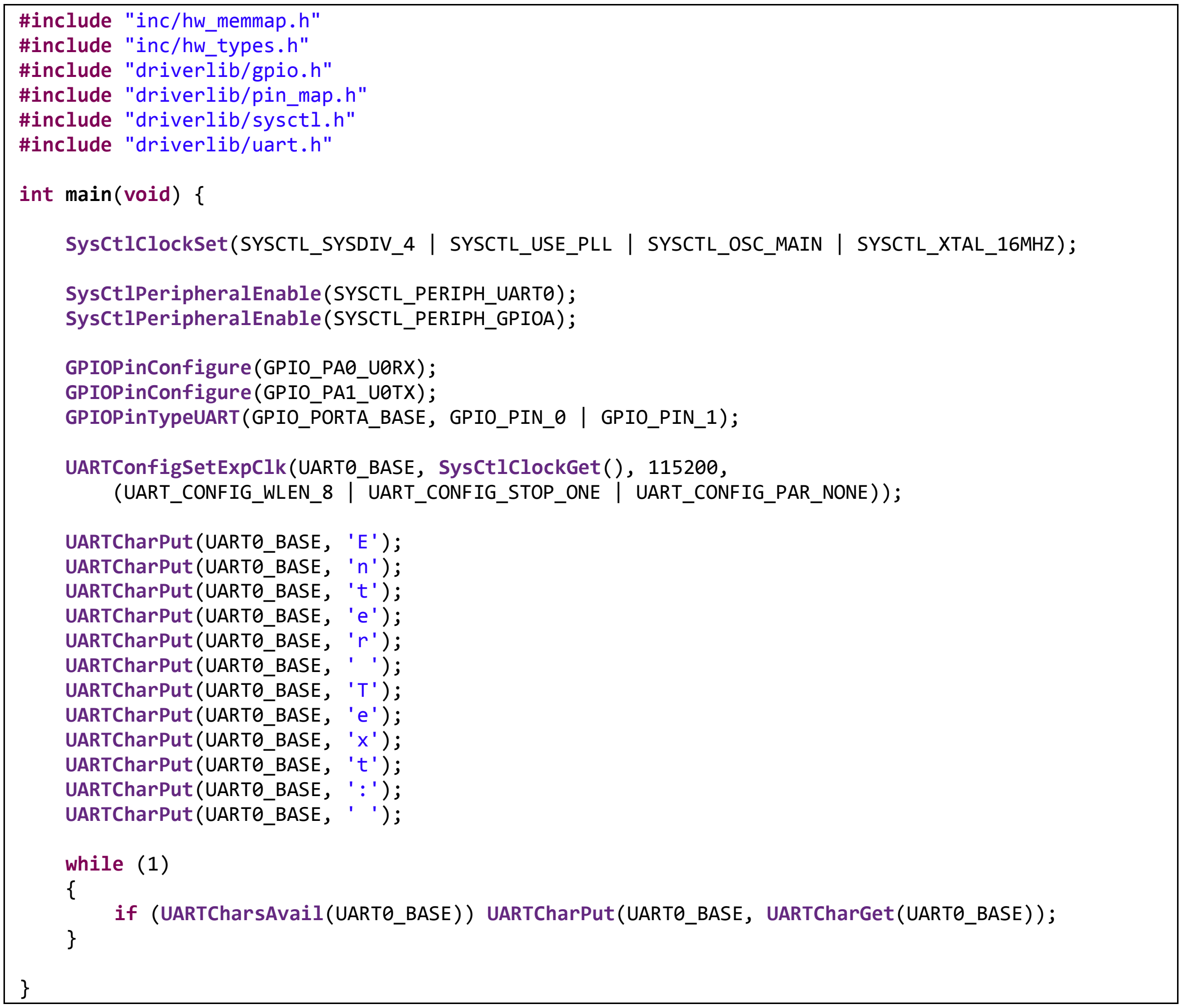
☑ Lab12 [C:\StellarisWare\boards\MyLaunchPadBoard\Lab12\ccs]

☐ Copy projects into workspace

☐ Automatically import referenced projects

Open the Resource Explorer and browse available example projects...

2. Expand the project by clicking on the + or ▷ next to Lab12 in the Project Explorer pane. Double-click on **`main.c`** to open it for review. The code looks like the next page:



```
#include "inc/hw_memmap.h"
#include "inc/hw_types.h"
#include "driverlib/gpio.h"
#include "driverlib/pin_map.h"
#include "driverlib/sysctl.h"
#include "driverlib/uart.h"

int main(void) {

    SysCtlClockSet(SYSCTL_SYSDIV_4 | SYSCTL_USE_PLL | SYSCTL_OSC_MAIN | SYSCTL_XTAL_16MHZ);

    SysCtlPeripheralEnable(SYSCTL_PERIPH_UART0);
    SysCtlPeripheralEnable(SYSCTL_PERIPH_GPIOA);

    GPIOPinConfigure(GPIO_PA0_U0RX);
    GPIOPinConfigure(GPIO_PA1_U0TX);
    GPIOPinTypeUART(GPIO_PORTA_BASE, GPIO_PIN_0 | GPIO_PIN_1);

    UARTConfigSetExpClk(UART0_BASE, SysCtlClockGet(), 115200,
        (UART_CONFIG_WLEN_8 | UART_CONFIG_STOP_ONE | UART_CONFIG_PAR_NONE));

    UARTCharPut(UART0_BASE, 'E');
    UARTCharPut(UART0_BASE, 'n');
    UARTCharPut(UART0_BASE, 't');
    UARTCharPut(UART0_BASE, 'e');
    UARTCharPut(UART0_BASE, 'r');
    UARTCharPut(UART0_BASE, ' ');
    UARTCharPut(UART0_BASE, 'T');
    UARTCharPut(UART0_BASE, 'e');
    UARTCharPut(UART0_BASE, 'x');
    UARTCharPut(UART0_BASE, 't');
    UARTCharPut(UART0_BASE, ':');
    UARTCharPut(UART0_BASE, ' ');

    while (1)
    {
        if (UARTCharsAvail(UART0_BASE)) UARTCharPut(UART0_BASE, UARTCharGet(UART0_BASE));
    }

}
```

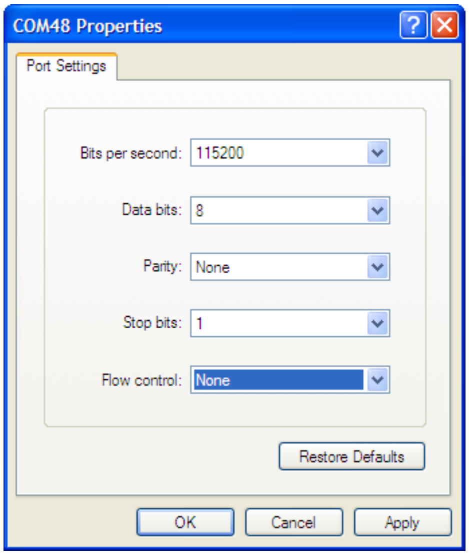
3. In **`main()`**, notice the initialization sequence for using the UART:
   - Set up the system clock
   - Enable the UART0 and GPIOA peripherals (the UART pins are on GPIO Port A)
   - Configure the pins for the receiver and transmitter using GPIOPinConfigure
   - Initialize the parameters for the UART: 115200, 8-1-N
   - Use simple "**`UARTCharPut()`**" calls to create a prompt.
   - An infinite loop. In this loop, if there is a character in the receiver, it is read, and then written to the transmitter. This echos what you type in the terminal window.

Build, Download, and Run the UART Example Code

4. Click the Debug button to build and download your program to the LM4F120H5QR memory.

5. We can communicate with the board through the UART. The UART is connected as a virtual serial port through the emulator USB connection. You can find the COM port number for this serial port back in chapter one of this workbook on page 18 or 19.

6. **In WinXP**, open HyperTerminal by clicking Start → Run…, then type `hypertrm` in the Open: box and click OK. Pick any name you like for your connection and click OK. In the next dialog box, change the Connect using: selection to COM##, where ## is the COM port number you noted earlier from Device Manager. Click OK. Make the selections shown below and click OK.



COM48 Properties

Port Settings

Bits per second: 115200

Data bits: 8

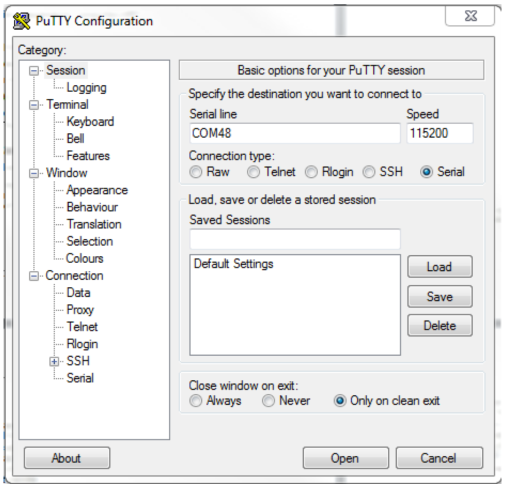
Parity: None

Stop bits: 1

Flow control: None

When the terminal window opens click the Resume button in CCS, then type some characters and you should see the characters echoed into the terminal window. Skip to step 8.

7. In **Win7**, double-click on **`putty.exe`**. Make the settings shown below and then click Open. Your COM port number will be the one you noted earlier in chapter one.



PuTTY Configuration

Basic options for your PuTTY session

Specify the destination you want to connect to

Serial line: COM48

Speed: 115200

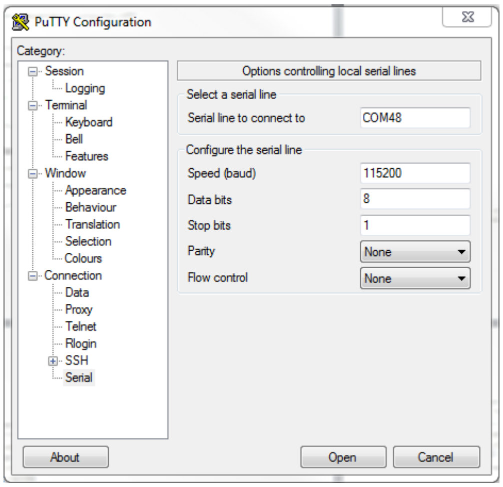
Connection type: ○ Raw ○ Telnet ○ Rlogin ○ SSH ● Serial

Load, save or delete a stored session

Saved Sessions

Default Settings

Close window on exit: ○ Always ○ Never ● Only on clean exit



PuTTY Configuration

Options controlling local serial lines

Select a serial line

Serial line to connect to: COM48

Configure the serial line

Speed (baud): 115200

Data bits: 8

Stop bits: 1

Parity: None

Flow control: None

When the terminal window opens click the Resume button in CCS, then type some characters and you should see the characters echoed into the terminal window.

Using UART Interrupts

Instead of continually polling for characters, we'll make some modifications to our code to allow the use of interrupts to receive and transmit characters. In the first part of this lab, the only indication we had that our code was running was to open the terminal window to type characters and see them echoed back. In this part of the lab, we'll add a visual indicator to show that we received and transmitted a character. So we'll need to add code similar to previous labs to blink the LED inside the interrupt handler.

8. First, let's add the code in **`main()`** to enable the UART interrupts we want to handle. Click on the Terminate button to return to the CCS Edit perspective. We need to add two additional header files at the top of the file:

```
#include "inc/hw_ints.h"
#include "driverlib/interrupt.h"
```

9. Now we need to add the code to enable processor interrupts, then enable the UART interrupt, and then select which individual UART interrupts to enable. We will select receiver interrupts (RX) and receiver timeout interrupts (RT). The receiver interrupt is generated when a single character has been received (when FIFO is disabled) or when the specified FIFO level has been reached (when FIFO is enabled). The receiver timeout interrupt is generated when a character has been received, and a second character has not been received within a 32-bit period. Add the following code just below the **`UARTConfigSetExpClk()`** function call:

```
IntMasterEnable();
IntEnable(INT_UART0);
UARTIntEnable(UART0_BASE, UART_INT_RX | UART_INT_RT);
```

10. We also need to initialize the GPIO peripheral and pin for the LED. Just before the function **`UARTConfigSetExpClk()`** is called, add these two lines:

```
SysCtlPeripheralEnable(SYSCTL_PERIPH_GPIOF);
GPIOPinTypeGPIOOutput(GPIO_PORTF_BASE, GPIO_PIN_2);
```

11. Finally, we can create an empty **`while(1)`** loop at the end of main by commenting out the line of code that's already there:

```
    while (1)
    {
//     if (UARTCharsAvail(UART0_BASE)) UARTCharPut(UART0_BASE,UARTCharGet(UART0_BASE));
    }
```

12. Save the changes you made to `main.c` (but leave it open for making additional edits).

13. Now we need to write the UART interrupt handler. The interrupt handler needs to read the UART interrupt status register to know which specific interrupt event(s) just occurred. This value is then used to clear the interrupt status bits (we only enabled RX and RT interrupts, so those are the only possible sources for the interrupt). The next step is to receive and transmit all the characters that have been received. After each character is "echoed" to the terminal, the LED is blinked for about 1 millisecond. Insert this code below the include statements and above **main()**:

```
void UARTIntHandler(void)
{
    unsigned long ulStatus;

    ulStatus = UARTIntStatus(UART0_BASE, true); //get interrupt status

    UARTIntClear(UART0_BASE, ulStatus); //clear the asserted interrupts

    while(UARTCharsAvail(UART0_BASE)) //loop while there are chars
    {
        UARTCharPutNonBlocking(UART0_BASE, UARTCharGetNonBlocking(UART0_BASE));
                  //echo character
        GPIOPinWrite(GPIO_PORTF_BASE, GPIO_PIN_2, GPIO_PIN_2); //blink LED
        SysCtlDelay(SysCtlClockGet() / (1000 * 3)); //delay ~1 msec
        GPIOPinWrite(GPIO_PORTF_BASE, GPIO_PIN_2, 0); //turn off LED
    }
}
```

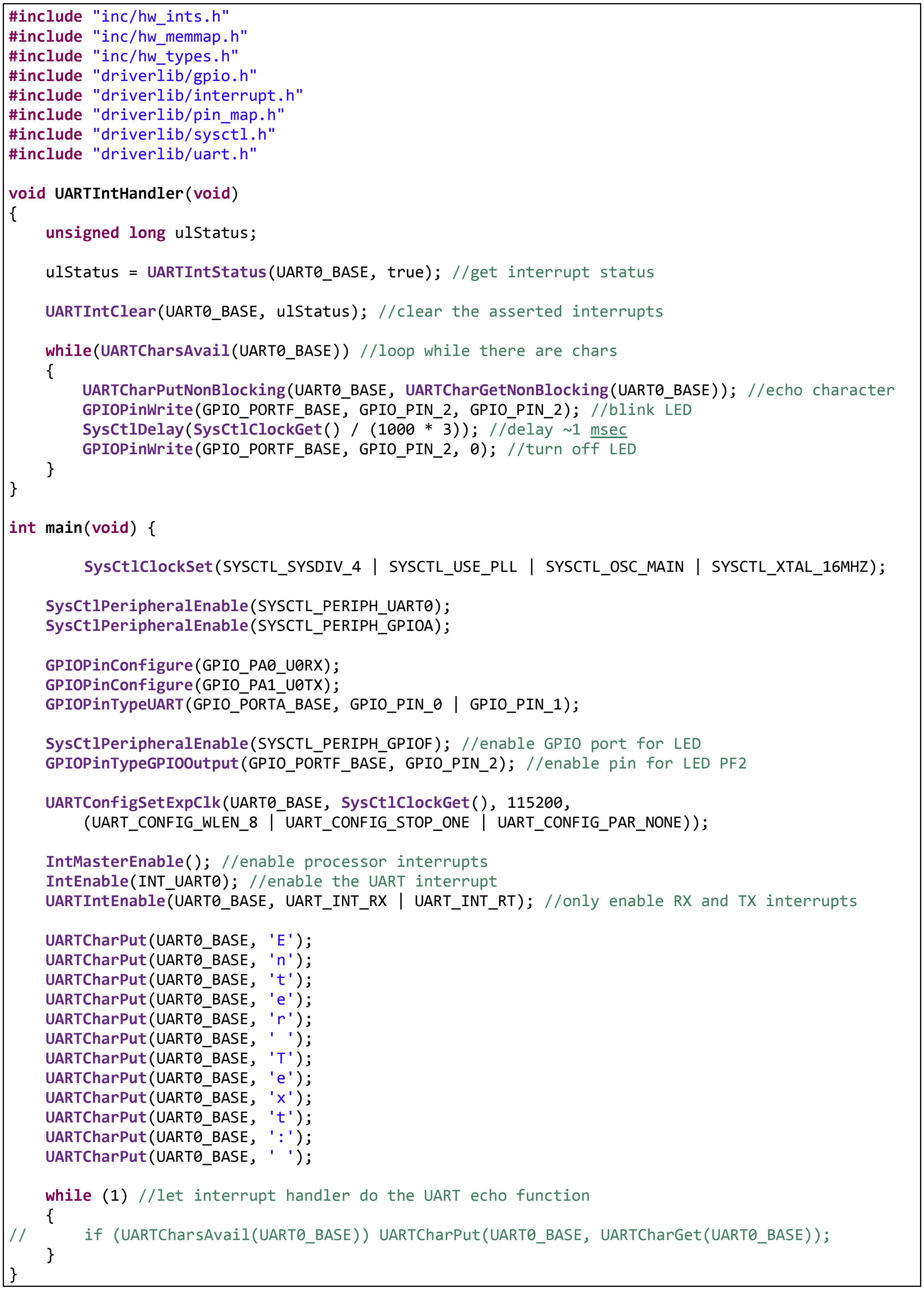
14. We're almost done. We've added all the code we need. The final step is to insert the address of the UART interrupt handler into the interrupt vector table. To do this, open up the **startup_ccs.c** file. Just below the prototype for `_c_int00(void)`, add the UART interrupt handler prototype:

```
extern void UARTIntHandler(void);
```

15. On about line 68, you'll find the interrupt vector table entry for "UART0 Rx and Tx". It's just below the entry for "GPIO Port E". The default interrupt handler is named `IntDefaultHandler`. All we need to do is replace this name with `UARTIntHandler` so the line looks like:

```
UARTIntHandler,                        // UART0 Rx and Tx
```

16. Save your work. Your **main.c** code should look like this.



```
#include "inc/hw_ints.h"
#include "inc/hw_memmap.h"
#include "inc/hw_types.h"
#include "driverlib/gpio.h"
#include "driverlib/interrupt.h"
#include "driverlib/pin_map.h"
#include "driverlib/sysctl.h"
#include "driverlib/uart.h"

void UARTIntHandler(void)
{
    unsigned long ulStatus;

    ulStatus = UARTIntStatus(UART0_BASE, true); //get interrupt status

    UARTIntClear(UART0_BASE, ulStatus); //clear the asserted interrupts

    while(UARTCharsAvail(UART0_BASE)) //loop while there are chars
    {
        UARTCharPutNonBlocking(UART0_BASE, UARTCharGetNonBlocking(UART0_BASE)); //echo character
        GPIOPinWrite(GPIO_PORTF_BASE, GPIO_PIN_2, GPIO_PIN_2); //blink LED
        SysCtlDelay(SysCtlClockGet() / (1000 * 3)); //delay ~1 msec
        GPIOPinWrite(GPIO_PORTF_BASE, GPIO_PIN_2, 0); //turn off LED
    }
}

int main(void) {

        SysCtlClockSet(SYSCTL_SYSDIV_4 | SYSCTL_USE_PLL | SYSCTL_OSC_MAIN | SYSCTL_XTAL_16MHZ);

    SysCtlPeripheralEnable(SYSCTL_PERIPH_UART0);
    SysCtlPeripheralEnable(SYSCTL_PERIPH_GPIOA);

    GPIOPinConfigure(GPIO_PA0_U0RX);
    GPIOPinConfigure(GPIO_PA1_U0TX);
    GPIOPinTypeUART(GPIO_PORTA_BASE, GPIO_PIN_0 | GPIO_PIN_1);

    SysCtlPeripheralEnable(SYSCTL_PERIPH_GPIOF); //enable GPIO port for LED
    GPIOPinTypeGPIOOutput(GPIO_PORTF_BASE, GPIO_PIN_2); //enable pin for LED PF2

    UARTConfigSetExpClk(UART0_BASE, SysCtlClockGet(), 115200,
        (UART_CONFIG_WLEN_8 | UART_CONFIG_STOP_ONE | UART_CONFIG_PAR_NONE));

    IntMasterEnable(); //enable processor interrupts
    IntEnable(INT_UART0); //enable the UART interrupt
    UARTIntEnable(UART0_BASE, UART_INT_RX | UART_INT_RT); //only enable RX and TX interrupts

    UARTCharPut(UART0_BASE, 'E');
    UARTCharPut(UART0_BASE, 'n');
    UARTCharPut(UART0_BASE, 't');
    UARTCharPut(UART0_BASE, 'e');
    UARTCharPut(UART0_BASE, 'r');
    UARTCharPut(UART0_BASE, ' ');
    UARTCharPut(UART0_BASE, 'T');
    UARTCharPut(UART0_BASE, 'e');
    UARTCharPut(UART0_BASE, 'x');
    UARTCharPut(UART0_BASE, 't');
    UARTCharPut(UART0_BASE, ':');
    UARTCharPut(UART0_BASE, ' ');

    while (1) //let interrupt handler do the UART echo function
    {
//      if (UARTCharsAvail(UART0_BASE)) UARTCharPut(UART0_BASE, UARTCharGet(UART0_BASE));
    }
}
```

17. Click the Debug button to build and download your program to the LM4F120H5QR memory.
18. If you've closed it, open Hyperterminal or puTTY, and configure it as before.
19. Click the Resume button. Type some characters and you should see the characters echoed into the terminal window. Note the LED.

Add Formatting, Enable FIFOs, use UARTprintf

20. In these final steps, we'll add some formatting to make our terminal window a little better behaved. When a "CR" carriage return character is received (Enter key), we can detect that and also echo a "LF" line feed character. CR is character 13 decimal, LF is 10 decimal. To do this we can't simply echo the character in the interrupt handler. We need to read the character into a variable, echo it, then test to see if it was "CR" and issue the "LF". Click the Terminate button to return to the CCS Edit perspective. In `main.c` , look in the `UARTIntHandler`, and replace the single line that calls `UARTCharPutNonBlocking()` with these lines of code:

```
received_character = UARTCharGet(UART0_BASE);
UARTCharPutNonBlocking(UART0_BASE, received_character); //echo character
if (received_character == 13) UARTCharPutNonBlocking(UART0_BASE, 10);
```

21. The variable **`received_character`** must be defined as well. Just below the variable declaration for **`ulStatus`**, insert this line:

```
unsigned char received_character;
```

22. To enable the FIFOs, add these lines in **`main()`** just after the call to `UARTConfigSetExpClk()`:

```
UARTFIFOLevelSet(UART0_BASE, UART_FIFO_TX4_8, UART_FIFO_RX4_8); // FIFO 8 chars
UARTFIFOEnable(UART0_BASE); //enable FIFOs
```

23. The final step is to experiment with `UARTprintf()`. There are some stdio console functions defined in the StellarisWare /utils folder. To create the "Enter Text: " prompt we can use a simple function call to `UARTprintf()`. We can also clean up the formatting within the terminal window using ANSI escape sequences. We'll use two of these, one to erase the screen, the other to return the cursor to the (0,0) upper left corner of the screen. For more information on ANSI escape sequences, go to *http://ascii-table.com/.* We need a header file, so add the following line:

```
#include "utils/uartstdio.h"
```

24. We can replace the simple prompt created in the previous code. Remove all 12 calls to `UARTCharPut()`. Then add these two lines of code in their place:

```
UARTStdioInit(0); //tells uartstdio functions to use UART0
UARTprintf("\033[2J\033[HEnter Text: "); //erase screen, cursor at (0,0)
```

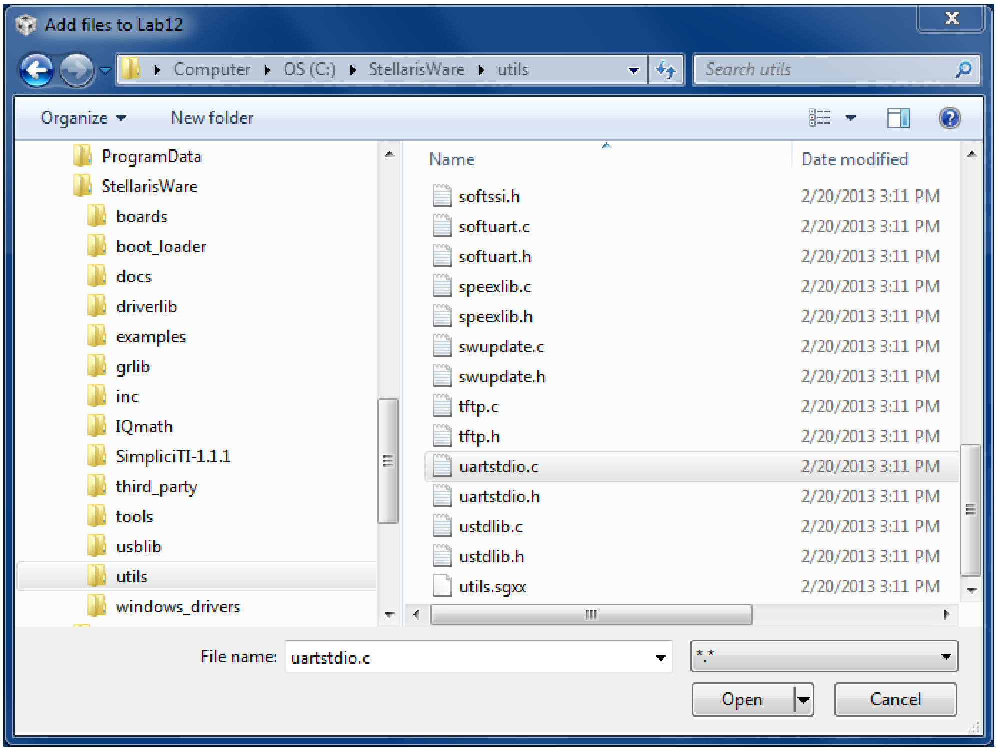
Note: When using UARTStdio functions, please see the the `uartstdio.c` file to understand how the buffers work, whether or not FIFOs are enabled, and especially notice that there is a UART interrupt handler provided there that works differently than the one we're using in this example. The two function calls we used here seem to work o.k. but other functions may not work as documented unless you define the proper symbols, e.g. UART_BUFFERED, and provide the proper interrupt vector

---

25. Save your work. Your code should look like this.

```
#include "inc/hw_ints.h"
#include "inc/hw_memmap.h"
#include "inc/hw_types.h"
#include "driverlib/gpio.h"
#include "driverlib/interrupt.h"
#include "driverlib/pin_map.h"
#include "driverlib/sysctl.h"
#include "driverlib/uart.h"
#include "utils/uartstdio.h"

void UARTIntHandler(void)
{
    unsigned long ulStatus;
    unsigned char received_character;

    ulStatus = UARTIntStatus(UART0_BASE, true); //get interrupt status

    UARTIntClear(UART0_BASE, ulStatus); //clear the asserted interrupts

    while(UARTCharsAvail(UART0_BASE)) //loop while there are characters in the receive FIFO
    {
        received_character = UARTCharGet(UART0_BASE);
        UARTCharPutNonBlocking(UART0_BASE, received_character); //echo character
        if (received_character == 13) UARTCharPutNonBlocking(UART0_BASE, 10); //if CR received,
issue LF as well

        GPIOPinWrite(GPIO_PORTF_BASE, GPIO_PIN_2, GPIO_PIN_2); //blink LED
        SysCtlDelay(SysCtlClockGet() / (1000 * 3)); //delay ~1 msec
        GPIOPinWrite(GPIO_PORTF_BASE, GPIO_PIN_2, 0); //turn off LED
    }
}

int main(void) {

        SysCtlClockSet(SYSCTL_SYSDIV_4 | SYSCTL_USE_PLL | SYSCTL_OSC_MAIN | SYSCTL_XTAL_16MHZ);

    SysCtlPeripheralEnable(SYSCTL_PERIPH_UART0);
    SysCtlPeripheralEnable(SYSCTL_PERIPH_GPIOA);

    GPIOPinConfigure(GPIO_PA0_U0RX);
    GPIOPinConfigure(GPIO_PA1_U0TX);
    GPIOPinTypeUART(GPIO_PORTA_BASE, GPIO_PIN_0 | GPIO_PIN_1);

    SysCtlPeripheralEnable(SYSCTL_PERIPH_GPIOF); //enable GPIO port for LED
    GPIOPinTypeGPIOOutput(GPIO_PORTF_BASE, GPIO_PIN_2); //enable pin for LED PF2

    UARTConfigSetExpClk(UART0_BASE, SysCtlClockGet(), 115200,
        (UART_CONFIG_WLEN_8 | UART_CONFIG_STOP_ONE | UART_CONFIG_PAR_NONE));

    UARTFIFOLevelSet(UART0_BASE, UART_FIFO_TX4_8, UART_FIFO_RX4_8); //set FIFO level to 8 charac-
ters
    UARTFIFOEnable(UART0_BASE); //enable FIFOs

    IntMasterEnable(); //enable processor interrupts
    IntEnable(INT_UART0); //enable the UART interrupt

    UARTIntEnable(UART0_BASE, UART_INT_RX | UART_INT_RT); //enable Receiver interrupts

    UARTStdioInit(0); //tells uartstdio functions to use UART0
    UARTprintf("\033[2J\033[HEnter Text: "); // erase screen, put cursor at home position (0,0),
prompt

    while (1) //let interrupt handler do the UART echo function
    {
//      if (UARTCharsAvail(UART0_BASE)) UARTCharPut(UART0_BASE, UARTCharGet(UART0_BASE));
    }

}
```

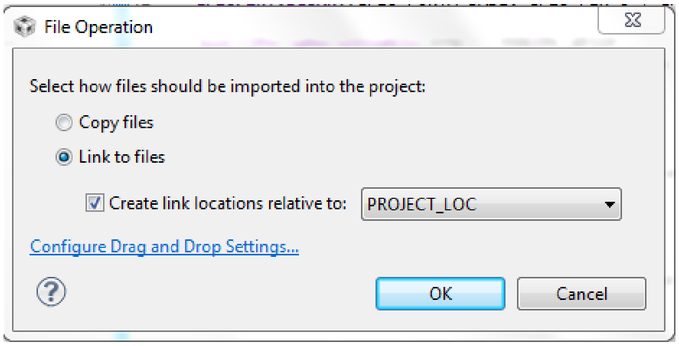
26. Before we can compile/build this example, we need to add the `uartstdio.c` file from the /utils folder into our project. Click on Project → Add files…. Then navigate to c:\StellarisWare\utils and select uartstdio.c. Then click Open.



Name	Date modified
softssi.h	2/20/2013 3:11 PM
softuart.c	2/20/2013 3:11 PM
softuart.h	2/20/2013 3:11 PM
speexlib.c	2/20/2013 3:11 PM
speexlib.h	2/20/2013 3:11 PM
swupdate.c	2/20/2013 3:11 PM
swupdate.h	2/20/2013 3:11 PM
tftp.c	2/20/2013 3:11 PM
tftp.h	2/20/2013 3:11 PM
uartstdio.c	2/20/2013 3:11 PM
uartstdio.h	2/20/2013 3:11 PM
ustdlib.c	2/20/2013 3:11 PM
ustdlib.h	2/20/2013 3:11 PM
utils.sgxx	2/20/2013 3:11 PM

File name: uartstdio.c   *.*

When you are asked how to import the file, make the selections below and click OK.



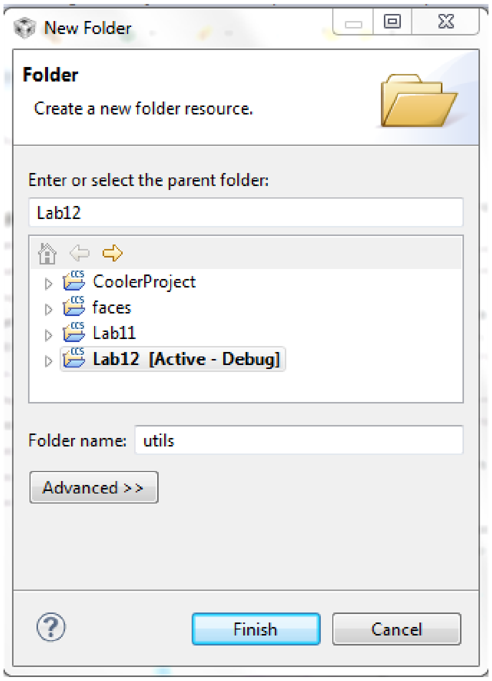
Select how files should be imported into the project:

○ Copy files

● Link to files

☑ Create link locations relative to: PROJECT_LOC

27. You can create folders within your project to organize the added files and make things easier to understand. Right-click on Lab12 and select New → Folder. Name the folder utils and click Finish. You can then drag **`uartstdio.c`** to the utils folder in your Project Explorer.



New Folder

Folder

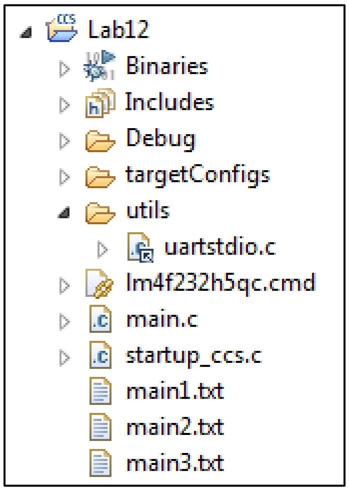
Create a new folder resource.

Enter or select the parent folder:

Lab12

- CoolerProject
- faces
- Lab11
- **Lab12 [Active - Debug]**

Folder name: utils



```
Lab12
  Binaries
  Includes
  Debug
  targetConfigs
  utils
    uartstdio.c
  lm4f232h5qc.cmd
  main.c
  startup_ccs.c
  main1.txt
  main2.txt
  main3.txt
```

28. Click the Debug button to build and download your program to the LM4F120H5QR memory.

29. If you've closed it, open Hyperterminal or puTTY, and set it up as before.

30. Click the Resume button. You should now see the prompt to enter some text at the top left corner of the terminal window. Type some characters and you should see the characters echoed into the terminal window. When you press the "Enter" key (carriage return), you should now see the line feed character issues as well.

31. At this point you may be wondering why you don't see any effects of turning on the FIFOs. It appears that the characters are still being received and transmitted one at a time. In fact, we're still getting RT (receiver timeout) interrupts because we're just entering characters from the terminal very slowly, compared to a continuous stream of characters. If you want to experiment with the FIFO, you could try a couple of additional things. First, don't enable RT interrupts, only enable RX interrupts. If you have the FIFO level set to 8 characters as we did in our code, you will need to enter 8 characters before they are all echoed back to you. The interrupt occurs after at least 8 characters have been received in the FIFO. You could also experiment with setting the FIFO levels to 2 characters, 4 characters, 12 characters, 14 characters. Have fun.

32. Close puTTY or HyperTerminal. Click the Terminate button to return to the CCS Edit perspective. Close the Lab12 project and minimize Code Composer Studio.

You're done.