EE 3171 Lecture 7

Introduction to TivaWare

Lecture 7 Topics

- A General Overview of TivaWare
- How to Create Projects using TivaWare
- Accessing Registers
- Accessing GPIO (General Purpose I/O)
  - Other TivaWare functionality will be discussed as we talk about the hardware.

Why TivaWare?

- TI distributes TivaWare because: *Programming embedded systems is hard.*
- TivaWare:
  - Simplifies the task a bit for you
  - Provides a consistent interface to all peripherals
  - Demonstrates what TI considers to be best practices for embedded programming

TivaWare Preliminaries

- There are two main folders of important stuff in the TivaWare library:
  - `driverlib/`
  - `inc/`
- The `driverlib` files are source code for interacting with hardware peripherals.
  - For the most part, these are written and you don't need to do anything with them.
- The `inc` files are just definitions for register names, variables and so on.
  - These make our job of programming easier.

Accessing Registers

- Two Different Methods:
  - Direct Register Access (The Traditional Way)
  - Software Driver Access (The Easy Way)
- Macros are stored in part-specific header files contained in the `inc/` directory; the header file for the TM4C123GH6PM microcontroller is `inc/tm4c123gh6pm.h`).
- Including that file makes it:
  - Easy to access registers that exist on the device you're using
  - Impossible to access registers that don't exist

Direct Register Access

- Rules for Direct Register Access are as follows:
- Values that end in `_R` are used to access the value of a register.
  - `SSI0_CR0_R` is used to access the `CR0` register in the SSI0 module.
- All register name macros start with the module name and instance number (for example, `SSI0` for the first SSI module) and are followed by the name of the register as it appears in the data sheet.
  - The `CR0` register in the data sheet is `SSI0_CR0_R`.
- All register bit fields start with the module name, followed by the register name, and then followed by the bit field name as it appears in the data sheet.
  - `SSI_CR0_SPH` is a single bit in the `CR0` register (in the documentation as the `SPH` bit).

It's not at all important that you know what the SPH bit does.

Direct Register Access

- Given these definitions, the **CR0** register can be programmed as follows:
```
SSI0_CR0_R = ((5 << SSI_CR0_SCR_S) |
SSI_CR0_SPH | SSI_CR0_SPO | SSI_CR0_FRF_MOTO
| SSI_CR0_DSS_8);
```
- Alternatively, the following has the same effect:
```
SSI0_CR0_R = 0x000005c7;
```

TI claims this is not as easy to understand, but this is how I've been programming for ~10 years.

- Extracting the value of the SCR field from the **CR0** register is as follows:
```
ulValue = (SSI0_CR0_R & SSI_CR0_SCR_M) >>
SSI0_CR0_SCR_S;
```

More DRA

- The GPIO modules have many registers that do not have bit field definitions.
- For these registers, the register bits represent the individual GPIO pins; so bit zero in these registers corresponds to the `Px0` pin on the part (where *x* is replaced by a GPIO module letter), bit one corresponds to the `Px1` pin, and so on.

DRA Pros and Cons

- Pros:
  - Fast, lean code.
  - Efficient code.
- Cons:
  - Requires in-depth knowledge of every hardware system (and its little nuances).
  - Can be downright confusing.

Software Driver Access

- TI's preferred method of accessing the hardware.

- Register names are hidden, many calculations are done for you and often a single function call will replace multiple DRA statements.

- `SSIConfigSetExpClk(SSI0_BASE, 50000000, SSI_FRF_MOTO_MODE_3, SSI_MODE_MASTER, 1000000, 8);`

  - Does exactly* the same thing as all the writes three slides ago.

* Could calculate a slightly different value for *one* field.

Not Mutually Exclusive

- Using these two approaches is not an “either/or” proposition.
- Consider:
  - Configuring a peripheral is not performance-critical. It’s *operation* is.
    - Therefore, use SDA for configuration and DRA for routine operation.
  - Some peripherals are just slow (e.g., serial communications).
    - Use SDA for those all the time.

SDA Pros and Cons

- Pros:
  - Much easier to understand
  - Abstracts some confusing details away.
- Cons:
  - Code may not be efficient or minimal.
  - Might let you do too much without understanding what you're doing.

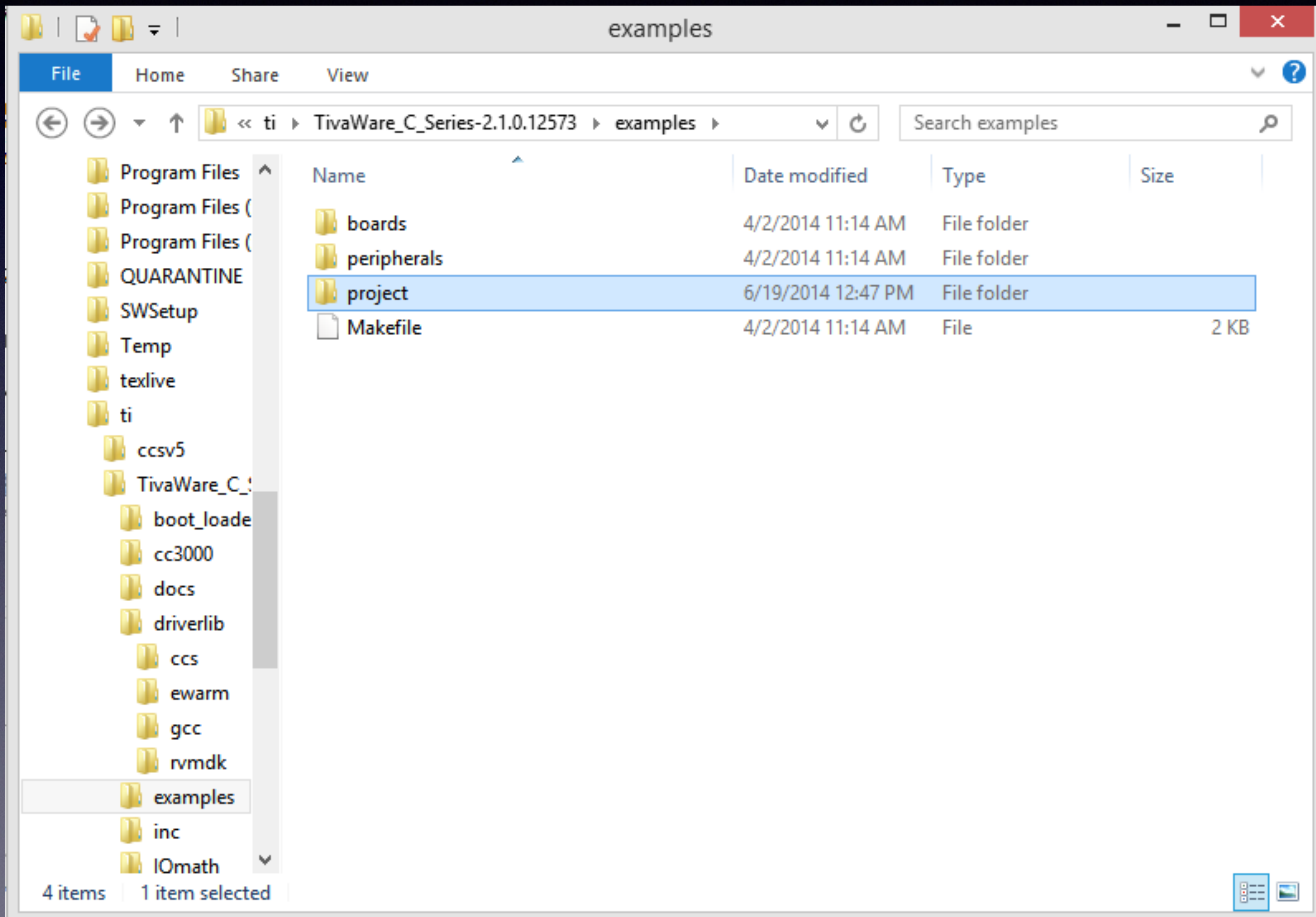
Simple Example

- Using the TivaWare libraries to make the LED blink.

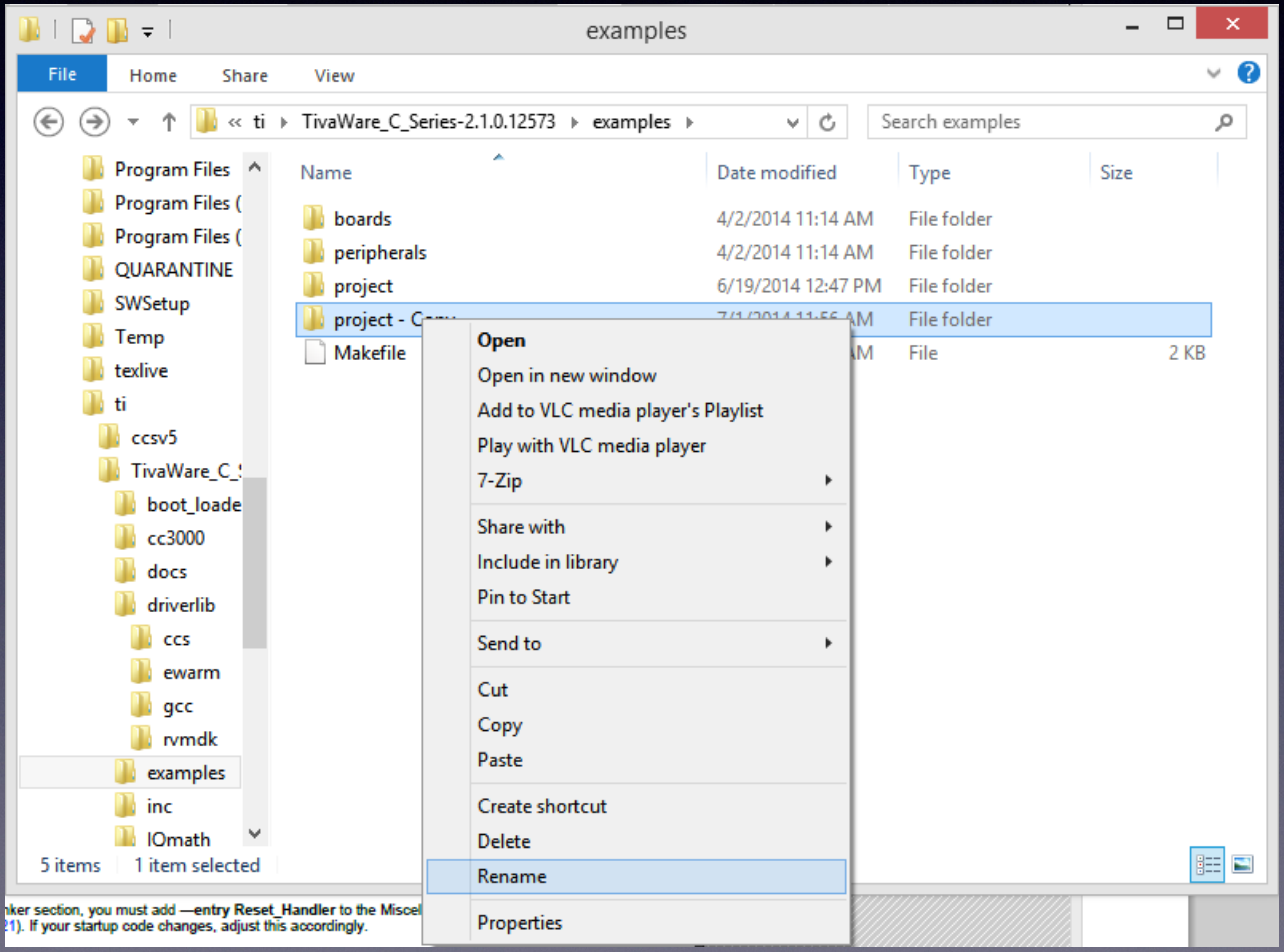
The Easy Way

- TI provides a project we can copy and modify for our own purposes with all of the hooks done for you.

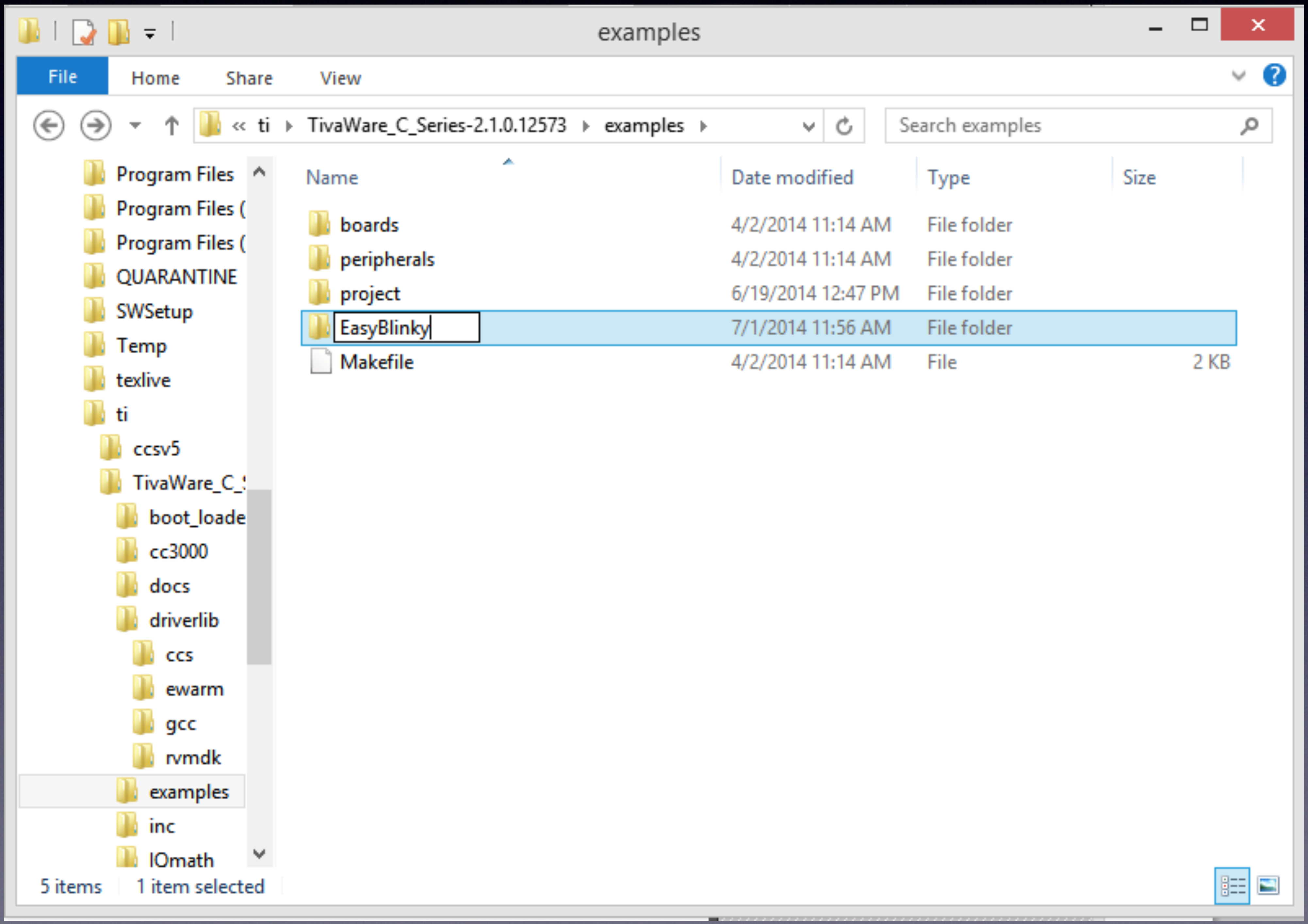
Find the Default Project



Copy and Paste, Then Rename



Renamed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boards 4/2/2014 11:14 AM File folder
peripherals 4/2/2014 11:14 AM File folder
project 6/19/2014 12:47 PM File folder
EasyBlinky 7/1/2014 11:56 AM File folder
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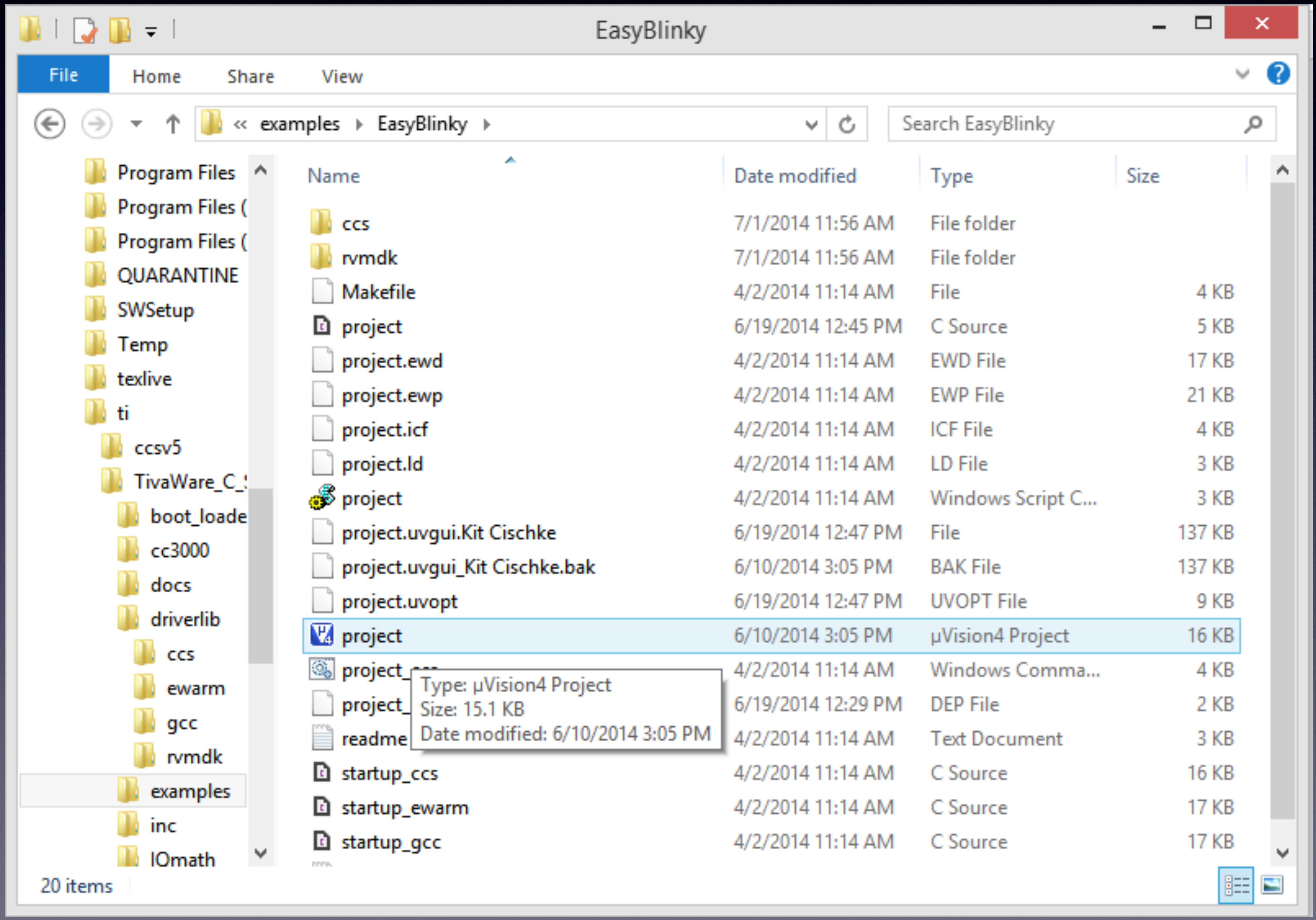
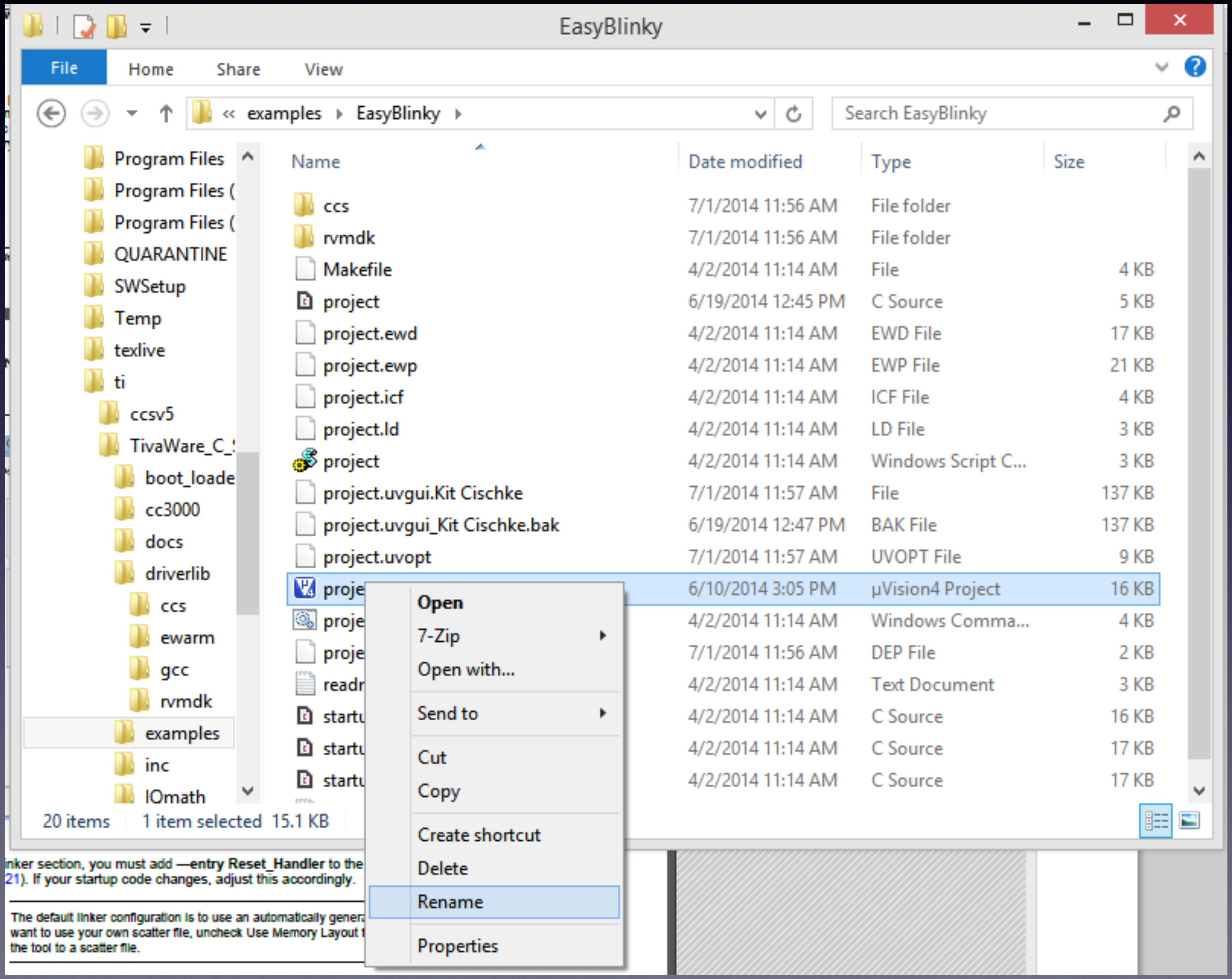
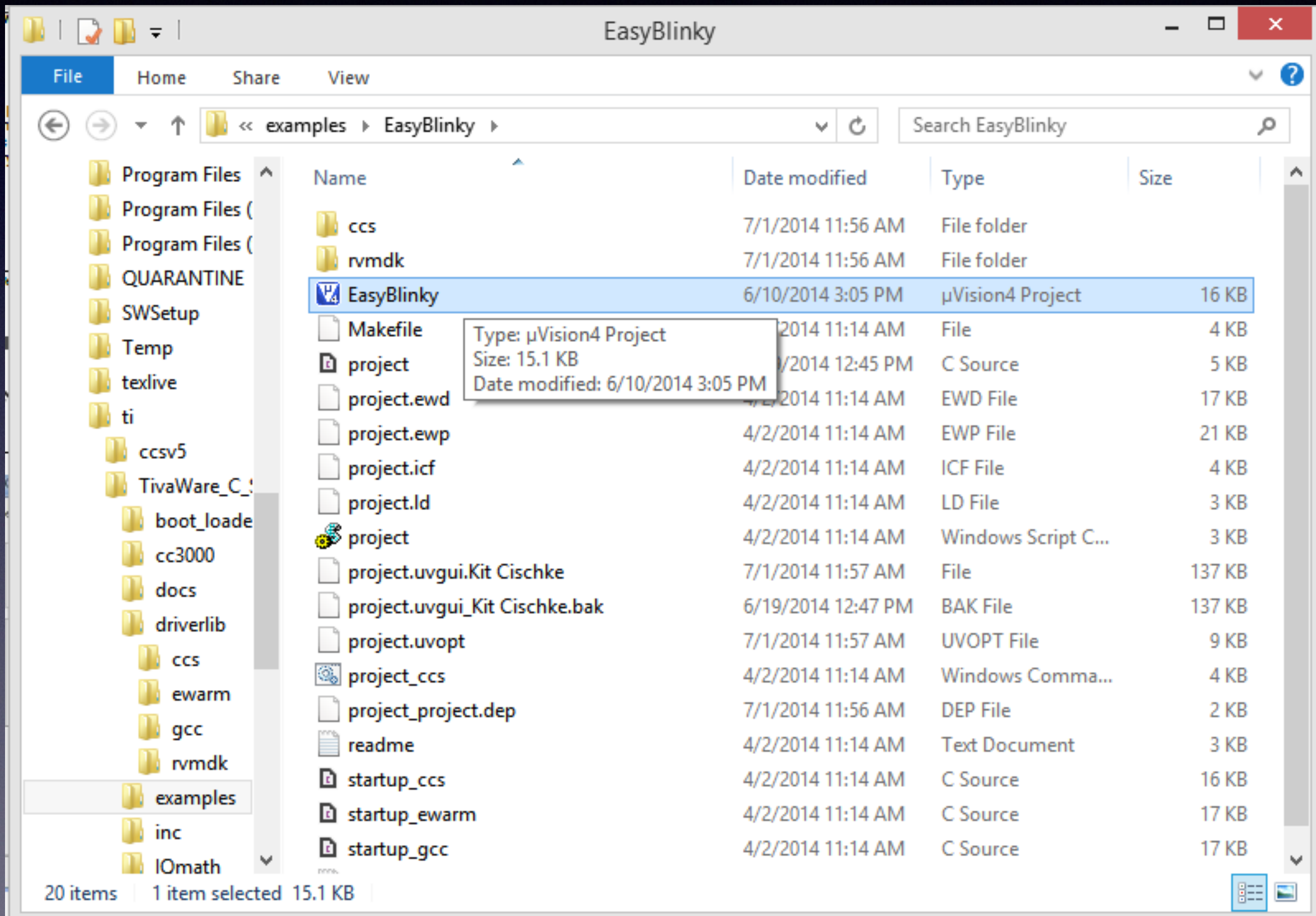
Rename the Project



Rename the Project



Open the Project



Modify `project.c`

```c
int
main(void)
{
    // Enable the GPIO module.
    ROM_SysCtlPeripheralEnable(SYSCTL_PERIPH_GPIOF);
    ROM_SysCtlDelay(1);

    // Configure PF3 as an output.
    ROM_GPIOPinTypeGPIOOutput(GPIO_PORTF_BASE, GPIO_PIN_3);

    // Loop forever.
    while(1)
    {
        // Set the GPIO high.
        ROM_GPIOPinWrite(GPIO_PORTF_BASE, GPIO_PIN_3, GPIO_PIN_3);

        // Delay for a while.
        ROM_SysCtlDelay(1000000);

        // Set the GPIO low.
        ROM_GPIOPinWrite(GPIO_PORTF_BASE, GPIO_PIN_3, 0);

        // Delay for a while.
        ROM_SysCtlDelay(1000000);
    }
}
```

SysCtlPeripheralEnable()

- `void SysCtlPeripheralEnable(uint32_t ui32Peripheral)`
  - Page 263, TivaWare Peripheral Driver Library Guide
- This function enables a peripheral. At power-up, all peripherals are disabled; they must be enabled in order to operate or respond to register reads/writes.
- `ui32Peripheral` can only be certain values (as defined in the documentation)

SysCtlDelay()

- `void SysCtlDelay(uint32_t ui32Count)`
- `ui32Count` is the number of delay loop iterations to perform.
- This function provides a means of generating a constant length delay. It is written in assembly to keep the delay consistent across tool chains, avoiding the need to tune the delay based on the tool chain in use.
- The loop takes 3 cycles/loop.

Modify `project.c`

```c
int
main(void)
{
    // Enable the GPIO module.
    ROM_SysCtlPeripheralEnable(SYSCTL_PERIPH_GPIOF);
    ROM_SysCtlDelay(1);

    // Configure PF3 as an output.
    ROM_GPIOPinTypeGPIOOutput(GPIO_PORTF_BASE, GPIO_PIN_3);

    // Loop forever.
    while(1)
    {
        // Set the GPIO high.
        ROM_GPIOPinWrite(GPIO_PORTF_BASE, GPIO_PIN_3, GPIO_PIN_3);

        // Delay for a while.
        ROM_SysCtlDelay(1000000);

        // Set the GPIO low.
        ROM_GPIOPinWrite(GPIO_PORTF_BASE, GPIO_PIN_3, 0);

        // Delay for a while.
        ROM_SysCtlDelay(1000000);
    }
}
```

Enable Port F and then the required delay (so the peripheral responds).

GPIOPinTypeGPIOOutput()

- `GPIOPinTypeGPIOOutput(uint32_t ui32Port, uint8_t ui8Pins)`
- Configures pin(s) for use as GPIO outputs.
- **`ui32Port`** is the base address of the GPIO port. **`ui8Pins`** is the special constant describing which pin(s).
- The GPIO pins must be properly configured in order to function correctly as GPIO outputs. This function provides the proper configuration for those pin(s).

Modify `project.c`

```c
int
main(void)
{
    // Enable the GPIO module.
    ROM_SysCtlPeripheralEnable(SYSCTL_PERIPH_GPIOF);
    ROM_SysCtlDelay(1);

    // Configure PF3 as an output.
    ROM_GPIOPinTypeGPIOOutput(GPIO_PORTF_BASE, GPIO_PIN_3);

    // Loop forever.
    while(1)
    {
        // Set the GPIO high.
        ROM_GPIOPinWrite(GPIO_POR                          N_3);

        // Delay for a while.
        ROM_SysCtlDelay(1000000);

        // Set the GPIO low.
        ROM_GPIOPinWrite(GPIO_PORTF_BASE, GPIO_PIN_3, 0);

        // Delay for a while.
        ROM_SysCtlDelay(1000000);
    }
}
```

Configure pin 3 of Port F to be an output, because it's hooked to the LED.

GPIOPinWrite()

- Writes a value to the specified pin(s).
- `void GPIOPinWrite(uint32_t ui32Port, uint8_t ui8Pins, uint8_t ui8Val)`
- `ui32Port` is the base address of the GPIO port. `ui8Pins` is the special representation of the pin(s). `ui8Val` is the value to write to the pin(s).
- Writes the corresponding bit values to the output pin(s) specified by `ui8Pins`. Writing to a pin configured as an input pin has no effect.

Modify `project.c`

```c
int
main(void)
{
    // Enable the GPIO module.
    ROM_SysCtlPeripheralEnable(SYSCTL_PERIPH_GPIOF);
    ROM_SysCtlDelay(1);

    // Configure PF3 as an output.
    ROM_GPIOPinTypeGPIOOutput(GPIO_PORTF_BASE, GPIO_PIN_3);

    // Loop forever.
    while(1)
    {
        // Set the GPIO high.
        ROM_GPIOPinWrite(GPIO_PORTF_BASE, GPIO_PIN_3, GPIO_PIN_3);

        // Delay for a
        ROM_SysCtlDela

        // Set the GPI
        ROM_GPIOPinWri                                  3, 0);

        // Delay for a
        ROM_SysCtlDelay(1000000);
    }
}
```

Writes a 1 to pin 3 of Port F to turn on the LED.

Modify `project.c`

```c
int
main(void)
{
    // Enable the GPIO module.
    ROM_SysCtlPeripheralEnable(SYSCTL_PERIPH_GPIOF);
    ROM_SysCtlDelay(1);

    // Configure PF3 as an output.
    ROM_GPIOPinTypeGPIOOutput(GPIO_PORTF_BASE, GPIO_PIN_3);

    // Loop forever.
    while(1)
    {
        // Set the GPIO high.
        ROM_GPIOPinWrite(GPIO_PORTF_BASE, GPIO_PIN_3, GPIO_PIN_3);

        // Delay for a while.
        ROM_SysCtlDelay(1000000);

        // Set the GPIO low.
        ROM_GPIOPinWrite(GPIO_PORTF_BASE, GPIO_PIN_3, 0);

        // Delay for a whil
        ROM_SysCtlDelay(100
    }
}
```

Writes a 0 to pin 3 of Port F to turn off the LED.

TivaWare

- The TivaWare libraries are extensive for all of the I/O devices, which we'll talk about when we talk about each device.