# Blackfin BF533 EZ-KIT Control

## Putting the O into I/O
(JITK – Just In Time Knowledge)

**Activating a FLASH memory "output line"**
**Part 2**

**The ROW and RAW ideas are the same as in Lab. 0, Assignment 1, Lab. 2, Lab. 3 and Lab. 4**

## Agenda

- **Processors need to send out control signals (high / low 1 / 0 true / false)**
  - **General purpose input / output GPIO on processor chip (16)**
  - **FLASH memory chip has additional I/O ports connected to Ez-Lite KIT LED's**
- **Making the FLASH memory I/O port control the Ez-KIT LED's**
- **The new Blackfin assembly language instructions needed**



## Blackfin I/O pins -- REVIEW

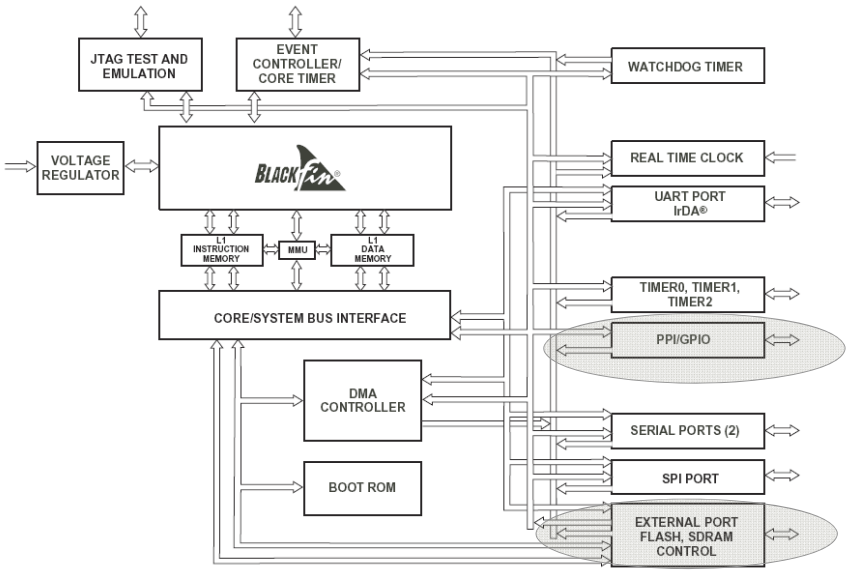



Figure 1-1. Processor Block Diagram



## Radio controlled car -- REVIEW

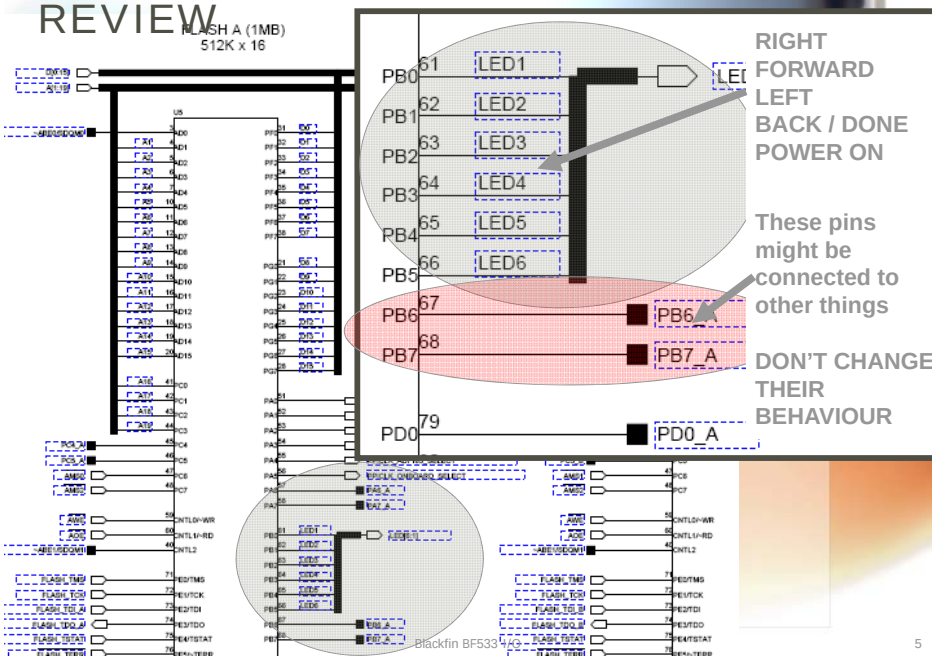
**"IN PRINCIPLE", we could**

- **Connect LED1 control signal to turn right signal line of radio transmitter**
- **Connect LED2 control signal to forward signal line of radio transmitter**
- **Connect LED3 control signal to left signal line of radio transmitter**

**"IN PRINCIPLE" means – we might start off this way while we initially explore ideas to control the car.**
**However we may (or may not) finish the project a different way.**

- **In actually fact we will use both PF1, PF5, PF6, PF7 as output to control car during the labs. IN PRINCIPLE – During Lab 4 we could use SPI interface so we can control car and put out messages to operator on LCD screen. (Same SPI as used during TV flashing ship lab.)**

# LEDs connected to memory port REVIEW






# Activating LEDs -- REVIEW

- Get the FLASH to work correctly
  - **Performed by *InitFlash_CPP( ) function***
- Get the Port to work correctly as output for pins PB5 → PB0, leaving other pins unchanged in behaviour
  - **Performed by *InitFlashPort_CPP( ) function***
- Write the value we want to LEDs
  - *WriteFlashLED_ASM(int value) or*
  - *WriteFlashLED_CPP( int value) or both*
- Read back the value the LEDs show
  - *int ReadFlashLED_ASM(void) or*
  - *int ReadFlashLED_CPP(void) or both*

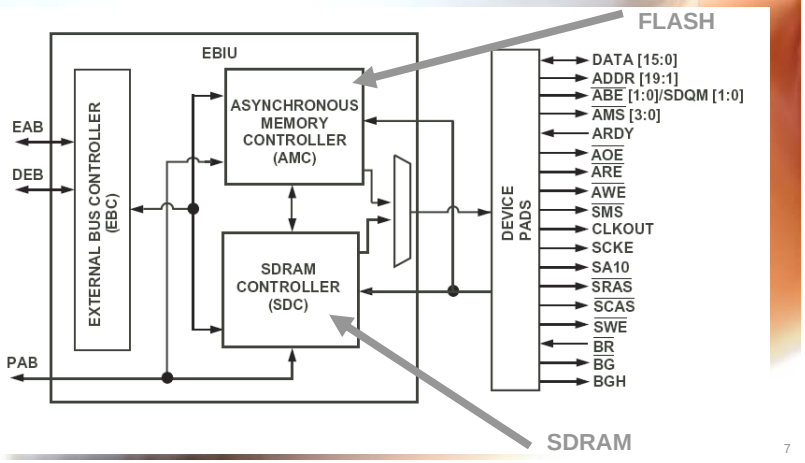
CHANGE INTERFACING FROM ASM TO CPP CODE



# "EBIU" External Bus Interface Unit -- REVIEW

**How does EBIU "know" whether to execute your code by writing the data to FLASH (LEDs live there) or SDRAM memory (Large arrays live there)?**

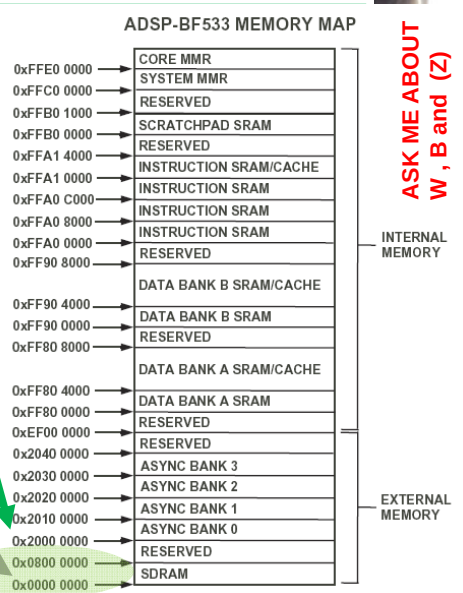
- **J.I.T.K .-- Just-In-Time-Knowledge – Need to W.A.I.N. rather than W.A.I.L.**






# ANSWER -- Blackfin Memory Map

- **McVASH and COFFEE control logic ideas again!**
- **LDF file controlled**
- **If P0 (pointer register) is set to address 0x20001000 then**
  **R0 = W[P0] (Z);**
  **reads a 32-bit value from FLASH BANK 0**
- If R0 is 6 and P0 is 0x0000 1000 then
  B[P0] = R0;
  places an 8-bit value into SDRAM memory



# FLASH registers -- REVIEW

## How does Blackfin "match" itself for fastest FLASH operation

- Depends on which FLASH is used in the EZ-Lite KIT from a specific manufacturer!

### EBIU Programming Model

This section describes the programming model of the EBIU. This model is based on system memory-mapped registers used to program the EBIU.

There are six control registers and one status register in the EBIU. They are:

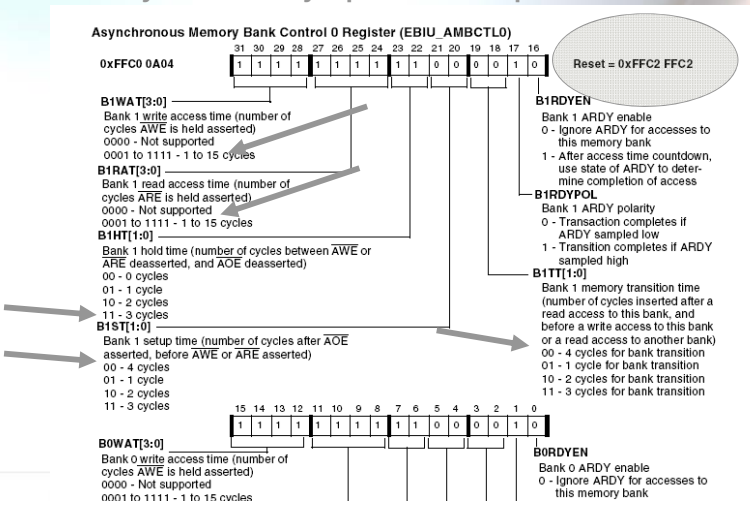
- Asynchronous Memory Global Control register (EBIU_AMGCTL)
- Asynchronous Memory Bank Control 0 register (EBIU_AMBCTL0)
- Asynchronous Memory Bank Control 1 register (EBIU_AMBCTL1)
- SDRAM Memory Global Control register (EBIU_SDGCTL)



# Bank control register -- REVIEW

## Reset value will probably work "as is" but not efficient – "slow reads"

- Efficiency not normally a problem – if op not done often






# General Control Register -- REVIEW

- **Reset value leaves "CLKOUT" disabled – is that important?**

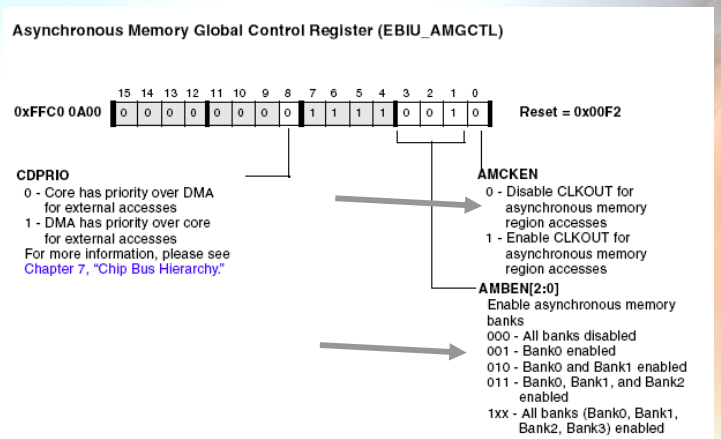



Figure 17-3. Asynchronous Memory Global Control Register



# InitFlashCPP( ) -- REVIEW

- Get the FLASH to work correctly
- May be "many" processes running on the Blackfin. All these processes may want to use InitFlashCPP( )

```
InitFlashCPP( ) {    // Design ideas by pseudo code
    If FLASH memory is already configured
      – return without re-initializing
          to avoid destroying existing code
    Else {
        configure Memory Bank control register
        THEN configure Global control
                    (turns on the FLASH)
    }
}
```

CHANGE INTERFACING FROM ASM TO CPP CODE

## I looked in EZ-Kit online documentation

- Don't start from scratch – Look for recommended settings
- These settings are specific for FLASH memory used on the EZ-Kit Lite

Table 2-4. Asynchronous Memory Control Registers Settings Example

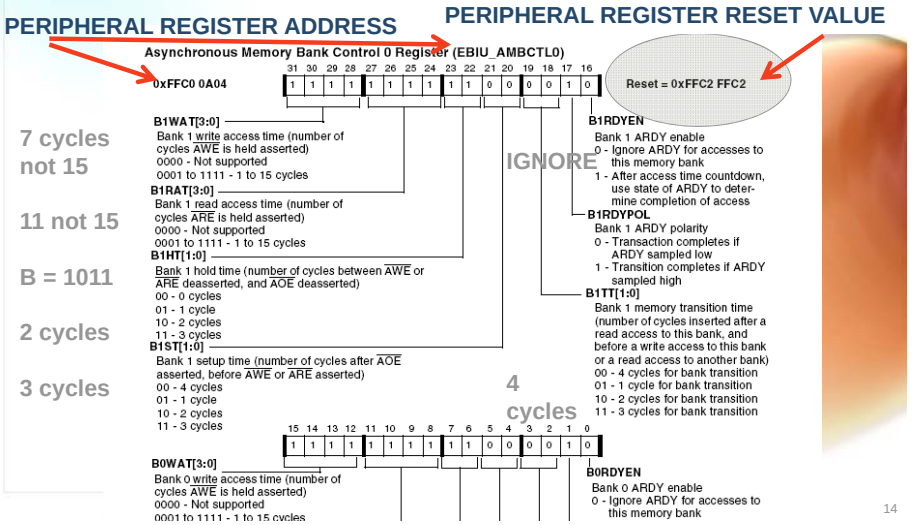
| Register | Value | Function |
|---|---|---|
| EBIU_AMBCTL0 | 0x7BB07BB0 | Timing control for Banks 1 and 0 |
| EBIU_AMBCTL1 bits 15-0 | 0x7BB0 | Timing control for Bank 2 (Bank 3 is not used) |
| EBIU_AMGCTL bits 3-0 | 0xF | Enable all banks Turns on clock |

Each Flash chip is initially configured with the memory sectors mapped into the processor's address space as shown in Table 2-5.



## Set the Bank control register

- **Kit documentation recommends 0x7BB0. P.L1.Q -- What does this setting mean?**






## Control access speed -- REVIEW

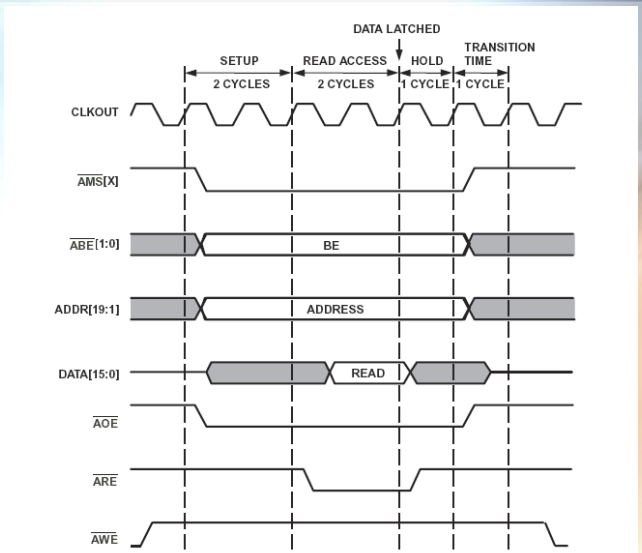



Figure 17-6. Asynchronous Read Bus Cycles



## Set General Control Register

- Documentation says set to "0x000F" for this particular FLASH chip

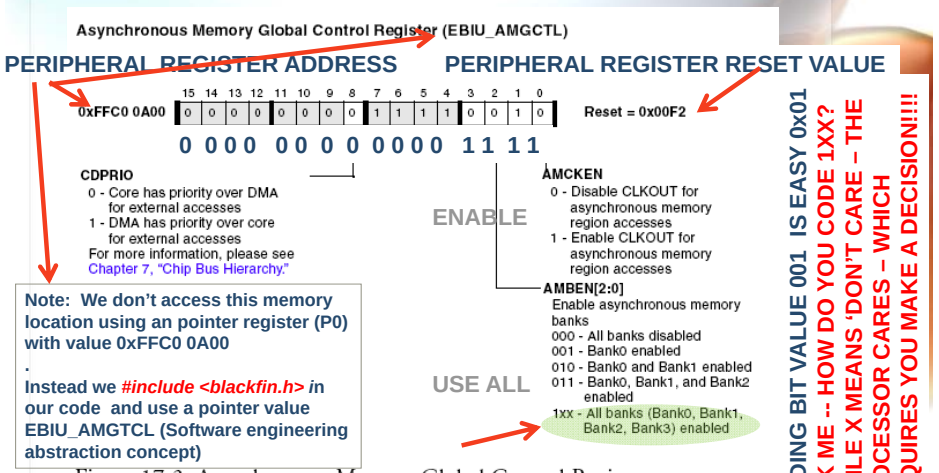



Figure 17-3. Asynchronous Memory Global Control Register

# Key issues -- REVIEW

## InitFlashCPP( )

| Register | Value | Function |
|---|---|---|
| EBIU_AMBCTL0 | 0x7BB07BB0 | Timing control for Banks 1 and 0 |
| EBIU_AMBCTL1 bits 15-0 | 0x7BB0 | Timing control for Bank 2 (Bank 3 is not used) |
| EBIU_AMGCTL bits 3-0 | 0xF | Enable all banks |

**Does not sound too big a deal** (IN PRINCIPLE)

1. Set *pointer* to *EBIU_AMBCTLO* address
2. Then set *value = 0x7BB07BB0*
3. Then store *value* at *EBIU_AMBCTLO*
   **pt = value* ***(Real C++ code or ASM design comment)***
4. Then make sure "write occurs" NOW as this processor can delay doing writes "until convenient".
   **This processor is DESIGNED to do "writes" when "it is not busy" giving highest priority to MANY read operations. This priority scheme is useful when developing processing algorithms for video or audio.**

- **Do the same for the other "32 bit" FLASH registers**

CHANGE INTERFACING FROM ASM TO CPP CODE

# Build and Test Stub -- REVIEW

```
// What we want to do -- pseudo-code
// void InitFlashASM(void) {
//          If FLASH memory already configured
//                    return without initializing
//          Else {                                  // Order is important
//                 configure Memory Bank control register
//                 THEN configure Global control
//                                 (turns on the FLASH)
//          }
//    }


                                  // void InitFlashASM(void) {
        .section program;
        .global _InitFlashASM;
_InitFlashASM:
//          If FLASH memory already configured
//                    return without initializing
//          Else {                                  // Order is important
//                 configure Memory Bank control register
//                 THEN configure Global control
//                                 (turns on the FLASH)
//          }
//    }
_InitFlashASM.END:  RTS;
```

**CHANGED TO use uTTCOS_InitLED( )**

**Show and tell – you are not actually going to code this for Lab. 1**
**Call uTTCOS utility instead --** ***uTTCOS_InitLED( );***
*Asking you about the ideas or doing some of the code makes a good quiz or exam question*

CHANGE INTERFACING FROM ASM TO CPP CODE

# When stub is tested as a stub (Link and Run) then add ASM code to learn forma

The System Synchronize (SSYNC) instruction forces all speculative, transient states in the core and system to complete before processing continues. Until SSYNC completes, no further instructions can be issued to the pipeline.

The SSYNC instruction performs the same function as Core Synchronize (CSYNC). In addition, SSYNC flushes any write buffers (between the L1 memory and the system interface) and generates a Synch request signal to the external system. The operation requires an acknowledgement Synch_Ack signal by the system before completing the instruction.

**If I asked in quiz – Circle and explain the defects already in code? Are they compiler, linker, loader or run defects?**

```
                                  // void InitFlashASM(void) {
        .section program;
        .global _InitFlashASM;
_InitFlashASM:
//          If FLASH memory already configured
//                    return without initializing
//          Else {                                  // Order is important
//                 configure Memory Bank control register

// Set P0 to point to EBIU_AMBCTLO
   P0 = BIU_AMBCTLO;

// Then R0 = 0x7BB07BB0
   R0 = 0x7BB07BB0;

// Then [P0] = R0
   [P0] = R0;

// Then make sure write occurs NOW
// as this processor can delay doing writes "until convenient"
   SSYNC;          // SSYNC Programming manual page 16.8
```

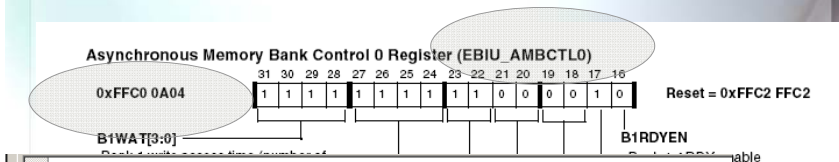
**ERROR WHEN WRITING ASM CODE**
**AVOID SAME PROBLEM IN C++**

NEW VIP BLACKFIN INSTRUCTION *SSYNC*;
Finish all pipelined operations before continuing



# Obvious problem – value needed EBIU_AMBCTL0 = ?

- **LOOK IN THE MANUAL – CHAPTER 17**




```
                                  // void InitFlashASM(void) {
        .section program;
        .global _InitFlashASM;
_InitFlashASM:
//          If FLASH memory already configured
//                    return without initializing
//          Else {                                  // Order is important
//                 configure Memory Bank control register

// Set P0 to point to EBIU_AMBCTLO
#define EBIU_AMBCTLO =0xFFC0 0A04
   P0 = BIU_AMBCTLO;

// Then R0 = 0x7BB07BB0
   R0 = 0x7BB07BB0;

// Then [P0] = R0
   [P0] = R0;

// Then make sure write occurs NOW
// as this processor can delay doing writes "until convenient"
   SSYNC;          // SSYNC Programming manual page 16.8
```

**Is the following the equivalent define to use in C++**

**#define pBIU_AMBCTL0 = (int *) 0xFFC0 0A04**
**(If use #include**

**QUIZ QUESTION**

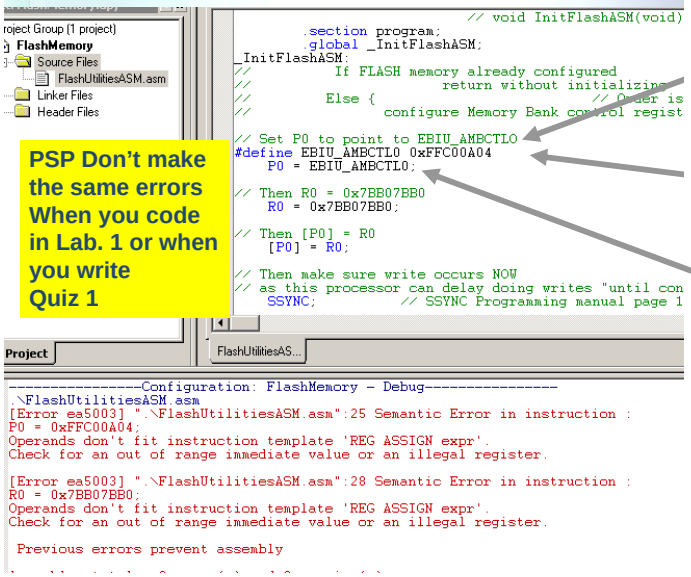
**Code review**

**2 more obvious errors**

**FIND AND EXPLAIN THEM**

CHANGE INTERFACING FROM ASM TO CPP CODE

# Corrected code – still fails (Get equivalent errors in C++)




**PSP Don't make the same errors When you code in Lab. 1 or when you write Quiz 1**

No "=" in a define statement

No "spaces" in number

Spell check

"0" not "O"

DEFECTS in code process

Pair programming cost if not caught by partner

3 * $5

# MIPS and Blackfin behave same when putting 32 bit numbers into 32 bit registers

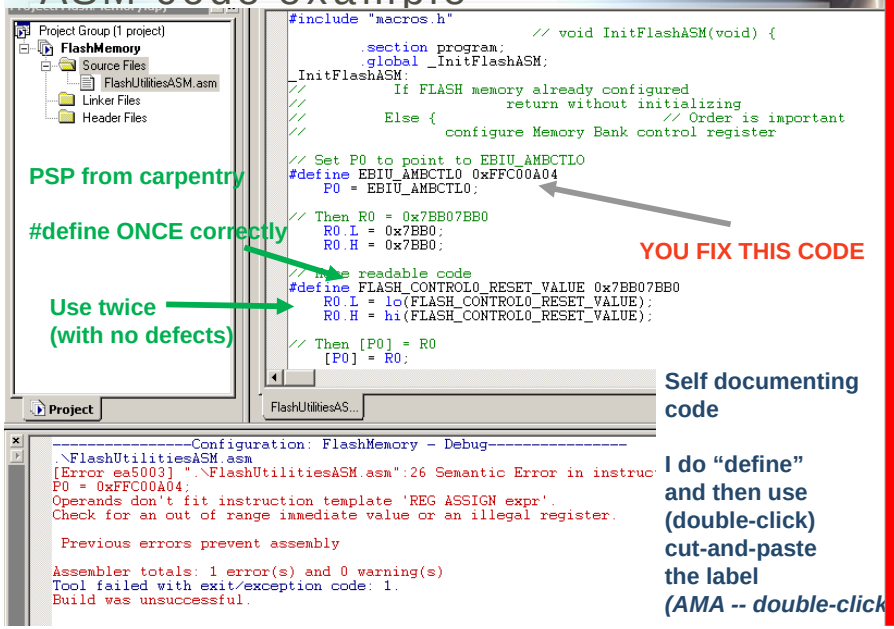
- You can't load a 32-bit register with a 32-bit immediate value using one instruction
- WRONG R0 = 0x7BB07BB0;
- Must load low 16-bit of data register
  R0.L = 0x7BB0;
- Then load high 16-bits of data register
  R0.H = 0x7B00;
- **You must load addresses into pointer register P0 the same way. YOU write the code to replace P0 = 0xFFC00A04**

In C++ code, a similar error is coding
*unsigned int value (32 bits)*
when you meant to use *unsigned short value (16 bits)*

CHANGE INTERFACING FROM ASM TO CPP CODE



# More readable and reliable ASM code example




**PSP from carpentry**

**#define ONCE correctly**

**Use twice (with no defects)**

**YOU FIX THIS CODE**

**Self documenting code**

**I do "define" and then use (double-click) cut-and-paste the label *(AMA -- double-click*

CHANGE INTERFACING FROM ASM TO CPP CODE

# What to look for in the following slides

**Detailed look at the *WriteLED( )* and *ReadLED( )* code you will USE (rather than write) during the familiarization laboratory and Lab. 1**

- Look at how the Blackfin assembly language syntax is used.
- KEY ELEMENT TO USE IN LABS AND QUIZZES.
  - Must do our coding without destroying the operation of existing code functionality.
  - When using hardware, this normally means the extensive use of bitwise AND and OR operations. Those RAW's and ROW's again

## WriteFlashLEDASM(long inValue)

**USER CASE STUDY – TASK -- Write '1' (on) or '0' (off) to the Port to activate LEDs connected to pins PB5 → PB0, leaving other pins unchanged.**

PROGRAMMED IN ASSEMBLY CODE

Table 2-9. Flash A Port B Controls

| Bit # | User IO | Bit Value |
|---|---|---|
| 5 | LED9 | 0= LED OFF; 1= LED ON |
| 4 | LED8 | 0= LED OFF; 1= LED ON |
| 3 | LED7 | 0= LED OFF; 1= LED ON |
| 2 | LED6 | 0= LED OFF; 1= LED ON |
| 1 | LED5 | 0= LED OFF; 1= LED ON |
| 0 | LED4 | 0= LED OFF; 1= LED ON |

## WriteFlashLEDASM(long in_Value)

1. Read "8-bit LED data register" into 32-bit processor data register R1 (makes a copy)
2. Keep "top" 2 bits (AND operation on bits 7 and 6) of the copied value in R1 as they have been made 1 or 0 for a reason
3. Keep "bottom" 6 bits of "in-par" 32-bit in_value (R0)
4. OR the two processor data registers
5. Write "modified copy" back into 8-bit "LED data register"

- PROBLEM "byte" read and writes – how do we do those?

Table 2-6. Flash A Configuration Registers for port A, B

| Register Name | Port A Address | Port B Address |
|---|---|---|
| Data In (Read-only) | 0x2027 0000 | 0x2027 0001 |
| Data Out (Read-Write) | 0x2027 0004 | 0x2027 0005 |
| Direction (Read-Write) | 0x2027 0006 | 0x2027 0007 |



**The following way of writing assembly code is from my P. S. P.**

**I find it speeds coding up as I make less mistakes**



## Standard ENCM369 assembly code problem, but using different syntax

- Start with the stub and pseudo-code of user-case study
  - Use the 'real C++' as psuedo-code when we know what to. Use a description otherwise

```
    .section program;
    .global _WriteFlashLEDASM;          // void WriteFlashLEDASM(long in_value);
//                                                                ^^ in R0
_WriteFlashLEDASM:
// PROBLEM  "byte" read and writes
                                        // unsigned long ledDataCopy;

        // Read  "LED data register" into processor data register (makes a copy)
        // Convert "byte" into "unsigned long" so we can do the math
                                        // ??????

        // Keep "top" 2 bits (AND operation) of copy
                                        // #define TOP2BITS_MASKVALUE 0xC
                                        // unsigned long top2BitMask = TOP2BITS_MASKVALUE;
                                        // ledDataCopy = ledDataCopy & top2BitMask;

        // Keep "bottom" 6 bits of "in-par" 32-bit in_value
                                        // #define BOTTOM6BITS_MASKVALUE 0x3F
                                        // unsigned long bottom2BitMask = BOTTOM6BITS_MASKVALUE;
                                        // in_value = invalue & bottom2BitMask;

        // OR the two processor data registers
                                        // ledDataCopy = ledDataCopy | in_value;

        // Write "modified copy" back into "LED data register"
                                        // ?????????

_WriteFlashLEDASM.END:  RTS;
```

Typo bottom6bitmask

# Now identify the registers to use

- Input value (In_par) come in R0
- We can use R1, R2 and R3 without saving (Follows C++ / ASM coding convention)

```
    .section program;
    .global _WriteFlashLEDASM;          // void WriteFlashLEDASM(long in_value);
//                                                                  ^^ in R0
#define in_value_R0 R0

_WriteFlashLEDASM:
// PROBLEM  "byte" read and writes
                                        // unsigned long ledDataCopy;
#define ledDataCopy_R1 R1

        // Read  "LED data register" into processor data register (makes a copy)
        // Convert "byte" into "unsigned long" so we can do the math
                                        // ??????

        // Keep "top" 2 bits (AND operation) of copy
                                        // #define TOP2BITS_MASKVALUE 0xC
                                        // unsigned long top2BitMask = TOP2BITS_MASKVALUE;
#define top2BitMask_R2 R2
                                        // ledDataCopy = ledDataCopy & top2BitMask;
// R2 is now dead -- could re-use

        // Keep "bottom" 6 bits of "in-par" 32-bit in_value
                                        // #define BOTTOM6BITS_MASKVALUE 0x3F
                                        // unsigned long bottom2BitMask = BOTTOM6BITS_MASKVALUE;
#define bottom2BitMask_R3 R3
                                        // in_value = invalue & bottom2BitMask;
// R3 is now dead -- could reuse
        // OR the two processor data registers
                                        // ledDataCopy = ledDataCopy | in_value;

        // Write "modified copy" back into "LED data register"
                                        // ?????????

_WriteFlashLEDASM.END:  RTS;
```

Typo bottom6bitmask (defect if not spotted)



# Add in the code we understand

```
    .section program;
    .global _WriteFlashLEDASM;          // void WriteFlashLEDASM(long in_value);
//                                                                  ^^ in R0
#define in_value_R0 R0

_WriteFlashLEDASM:
// PROBLEM  "byte" read and writes
                                        // unsigned long ledDataCopy;
#define ledDataCopy_R1 R1

        // Read  "LED data register" into processor data register (makes a copy)
        // Convert "byte" into "unsigned long" so we can do the math
                                        // ??????

        // Keep "top" 2 bits (AND operation) of copy
                                        // #define TOP2BITS_MASKVALUE 0xC
                                        // unsigned long top2BitMask = TOP2BITS_MASKVALUE;
#define TOP2BITS_MASKVALUE 0xC
#define top2BitMask_R2 R2
    top2BitMask_R2 = TOP2BITS_MASKVALUE;
                                        // ledDataCopy = ledDataCopy & top2BitMask;
    ledDataCopy_R1 = LedDataCopy_R1 & top2BitMask_R2;
// R2 is now dead -- could re-use

        // Keep "bottom" 6 bits of "in-par" 32-bit in_value
#define BOTTOM6BITS_MASKVALUE 0x3F      // #define BOTTOM6BITS_MASKVALUE 0x3F
                                        // unsigned long bottom6BitMask = BOTTOM6BITS_MASKVALUE;
#define bottom6BitMask_R3 R3
    bottom6BitMask_R3 = BOTTOM6BITS_MASKVALUE;
                                        // in_value = invalue & bottom2BitMask;
    in_value_R0 = in_value_R0 & bottom6BitMask_R3;
// R3 is now dead -- could reuse

        // OR the two processor data registers
                                        // ledDataCopy = ledDataCopy | in_value;
    ledDataCopy_R1 = ledDataCopy_R1 || in_value_R0;

        // Write "modified copy" back into "LED data register"
                                        // ?????????

_WriteFlashLEDASM.END:  RTS;
```

Look for hidden defects where code does not match comments

Fixed typo

Still another syntax problem

# 8 bit and 32 bit writes

(Chapter 6 of instruction user manual?)

- [P0] = R0;  32-bit write (4 bytes)
  - Places all 32-bits of processor data register into “long word” (32 bit) address starting at memory location P0
  - If P0 = 0x1000 – then place “32-bit” value at memory location 0x1000
- B[P0] = R0;  8-bit write
  - Places “bottom” 8-bits of 32-bit processor data register into “byte” (8 bit) address starting at memory location pointed to by pointer register P0

COMMON MIS-UNDERSTANDING -- You need a 32-bit (not 8-bit) address register to write a 8 bit data value (because memory is large and so you need a large address to acces)



# 8 bit and 32 bit reads

- R0 = [P0];  32-bit read (4 bytes)
  - Places all 32-bits of “long word” (32 bit) address starting at memory location P0 into processor data register
  - If P0 = 0x1000 – then place “32-bit” value at memory location 0x1000
- R0 = B[P0] (Z);  8-bit read
  - Places “byte” (8 bit) address starting at memory location P0 into “bottom” 8-bits of processor data register and puts “0” into the “top” 24 bits of register
  - Must convert “8-bit” read operation into a “32” bit “store in register” operation

COMMON MIS-UNDERSTANDING -- You need a 32-bit (not 8-bit) address register read a 8 bit data value (because memory is large and so you need a large address to acces)

# Add byte read and write operations

```
    .section program;
    .global _WriteFlashLEDASM;          // void WriteFlashLEDASM(long in_value);
//                                                                ^^ in R0
#define in_value_R0 R0

_WriteFlashLEDASM:
// PROBLEM  "byte" read and writes
                                        // unsigned long ledDataCopy;
#define ledDataCopy_R1 R1

        // Read  "LED data register" into processor data register (makes a copy)
        // Convert "byte" into "unsigned long" so we can do the math
#define LED_DATA_REGISTER_ADDRESS 0x2027 0005
        P0.L = lo(LED_DATA_REGISTER_ADDRESS); P0.H = hi(LED_DATA_REGISTER_ADDRESS
        ledDataCopy_R1 = B[P0] (Z);

        // Keep "top" 2 bits (AND operation) of copy
                                        // #define TOP2BITS_MASKVALUE 0xC
#define TOP2BITS_MASKVALUE 0xC          // unsigned long top2BitMask = TOP2BITS_M
#define top2BitMask_R2 R2
    top2BitMask_R2 = TOP2BITS_MASKVALUE;
                                        // ledDataCopy = ledDataCopy & top2BitMas
    ledDataCopy_R1 = LedDataCopy_R1 & top2BitMask_R2;
// R2 is now dead -- could re-use

        // Keep "bottom" 6 bits of "in-par" 32-bit in_value
#define BOTTOM6BITS_MASKVALUE 0x3F      // #define BOTTOM6BITS_MASKVALUE 0x3F
                                        // unsigned long bottom6BitMask = BOTTOM6
#define bottom6BitMask_R3 R3
    bottom6BitMask_R3 = BOTTOM6BITS_MASKVALUE;
                                        // in_value = invalue & bottom2BitMask;
    in_value_R0 = in_value_R0 & bottom6BitMask_R3;
// R3 is now dead -- could reuse

        // OR the two processor data registers
                                        // ledDataCopy = ledDataCopy | in_value;
    ledDataCopy_R1 = ledDataCopy_R1 | in_value_R0;

        // Write "modified copy" back into "LED data register"
    B[P0] = ledDataCopy_R1;

_WriteFlashLEDASM.END:  RTS;
```

**DO CODE REVIEW**
**Is this correct for keeping top 2 bits of an 8-bit value?**

**"DEFECT" if not corrected ** AMW ****

**Still syntax problems "ERRORS"**

**Fix WriteASM as exercise. Test by replacing uTTCOS_WriteLED( ) in Lab code**

# My_InitLEDASM() to complete

- Set direction to 1 on lower pins leaving other direction values unchanged
  - Read "direction" byte register into processor data register (makes a copy)
  - Set another processor data register to 0x3F
  - OR the two data registers (HOW?)
  - Write "modified copy" back into "direction byte register"

Table 2-6. Flash A Configuration Registers for port A, B

| Register Name | Port A Address | Port B Address |
|---|---|---|
| Data In (Read-only) | 0x2027 0000 | 0x2027 0001 |
| Data Out (Read-Write) | 0x2027 0004 | 0x2027 0005 |
| Direction (Read-Write) | 0x2027 0006 | 0x2027 0007 |

NOW USE CPP VERSION OF THIS CODE

# Agenda

- Processors need to send out control signals (high / low 1 / 0 true / false)
  - General purpose input / output GPIO on processor chip (16)
  - FLASH memory chip has additional I/O ports connected to Ez-Lite KIT LED's
- Making the FLASH memory I/O port control the Ez-KIT LED's
- The new Blackfin assembly language instructions needed