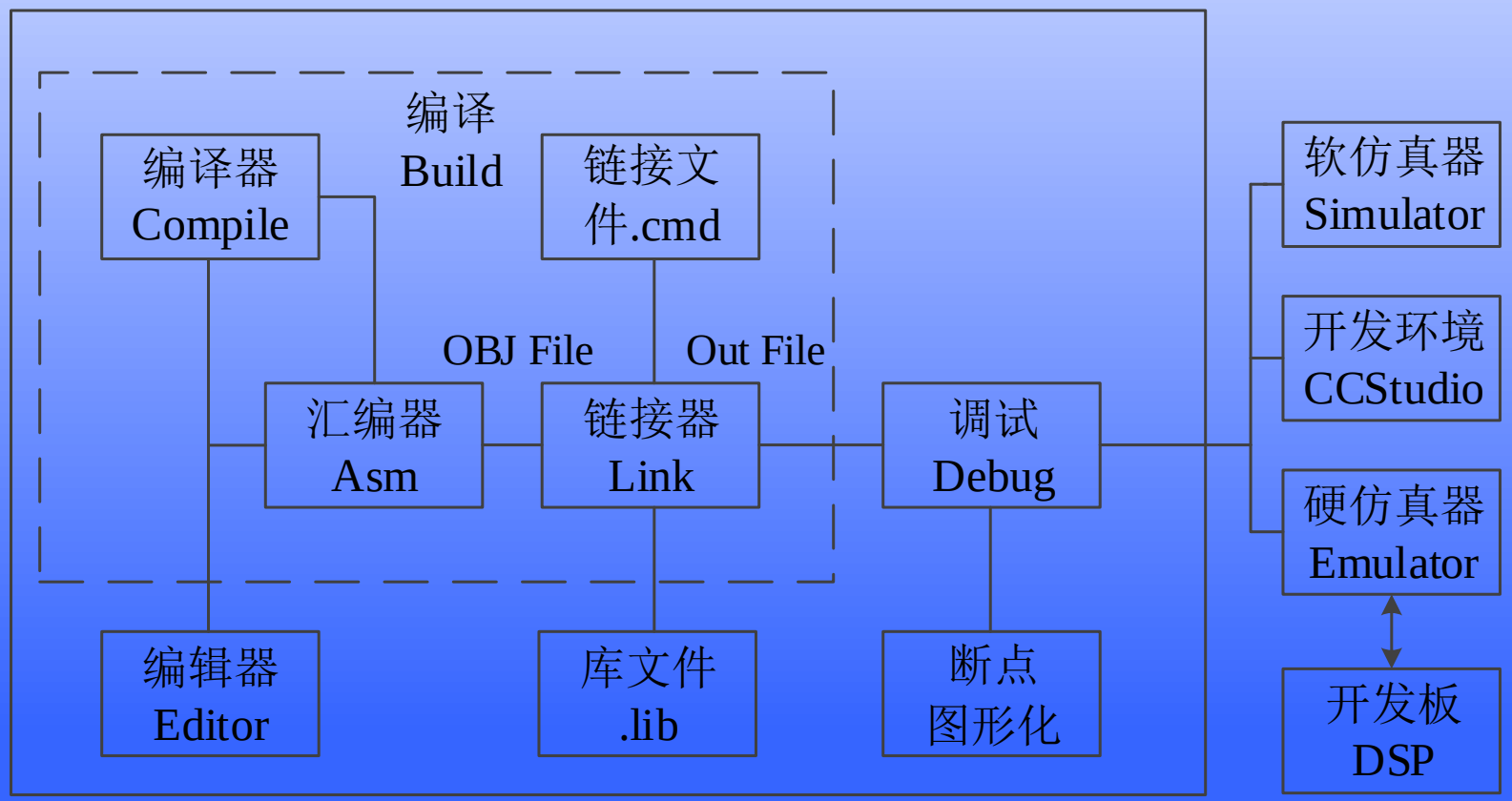
2　软件开发平台与编程方法

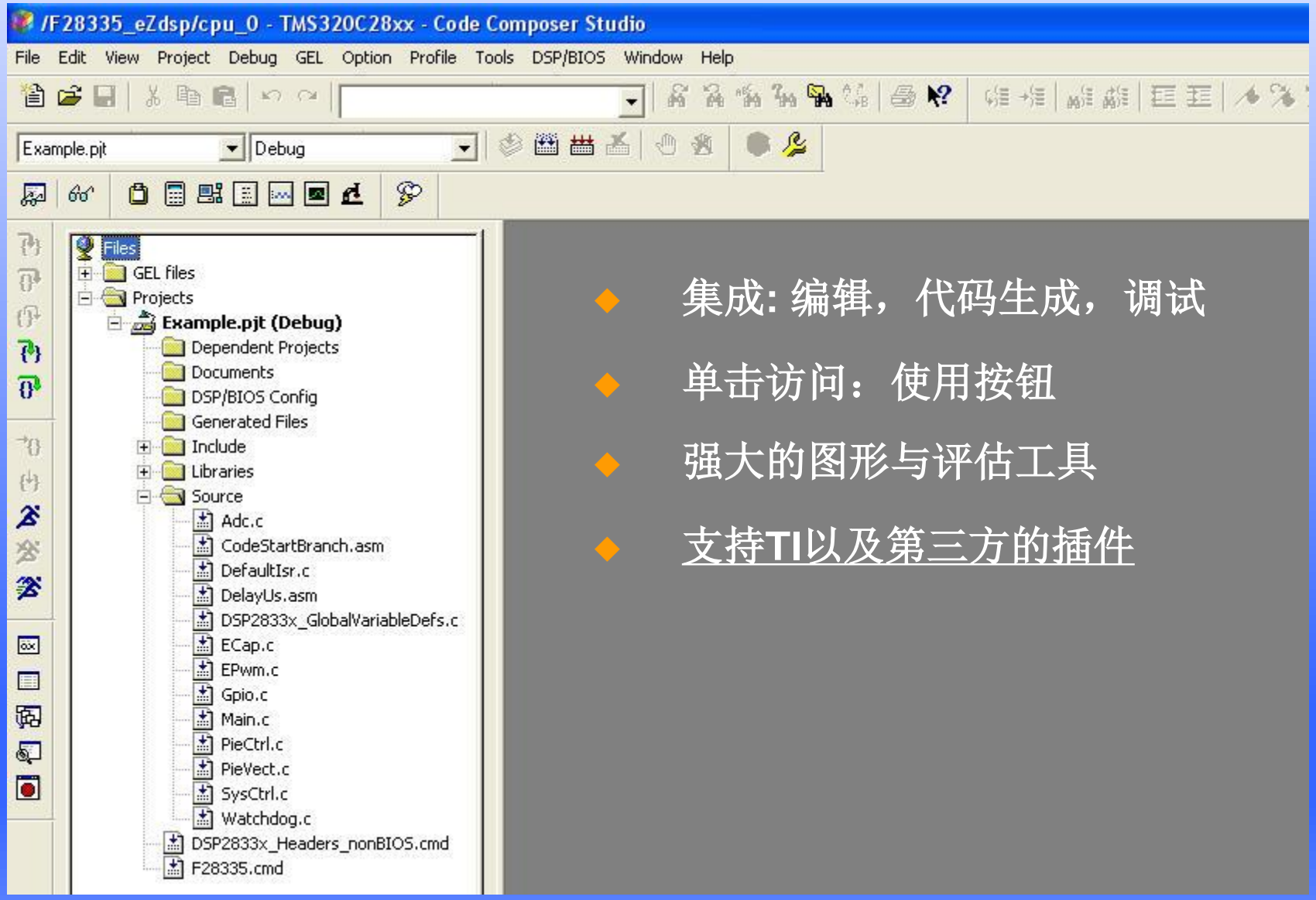
学习目标

- Code Composer Studio软件的基本使用方法
- 如何创建链接命令文件cmd
- 理解外设寄存器的头文件

CCS开发环境的基本框架

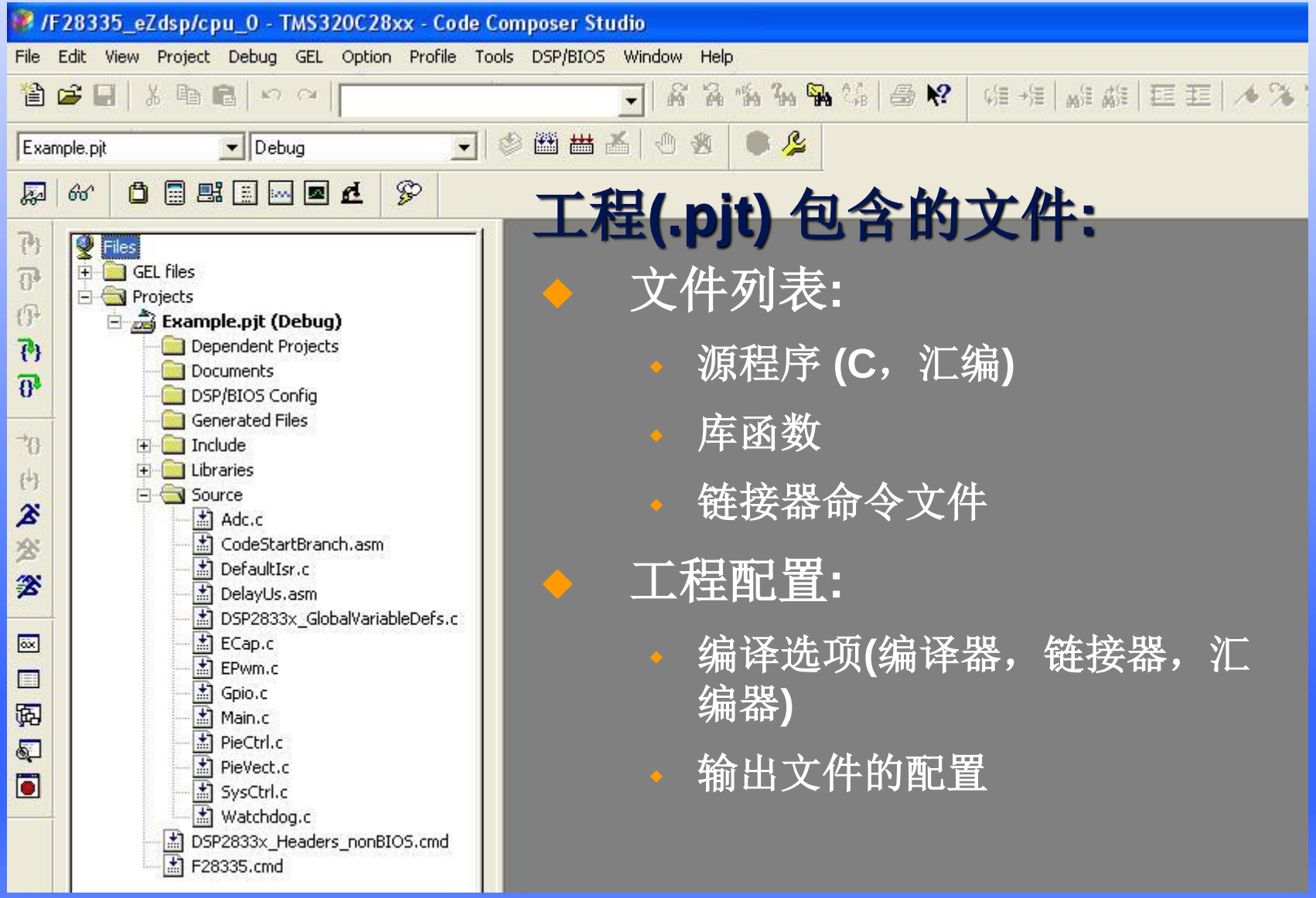


Code Composer Studio: IDE



- 集成: 编辑，代码生成，调试
- 单击访问：使用按钮
- 强大的图形与评估工具
- 支持TI以及第三方的插件

CCS的工程结构

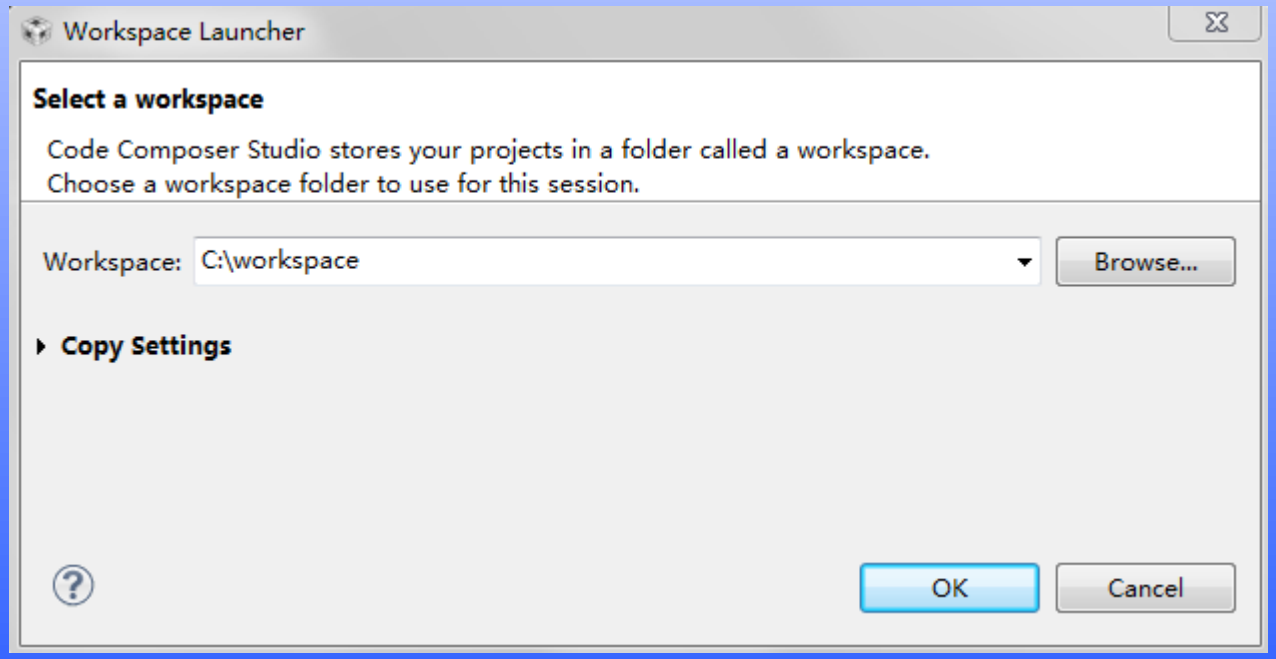


工程(.pjt) 包含的文件:

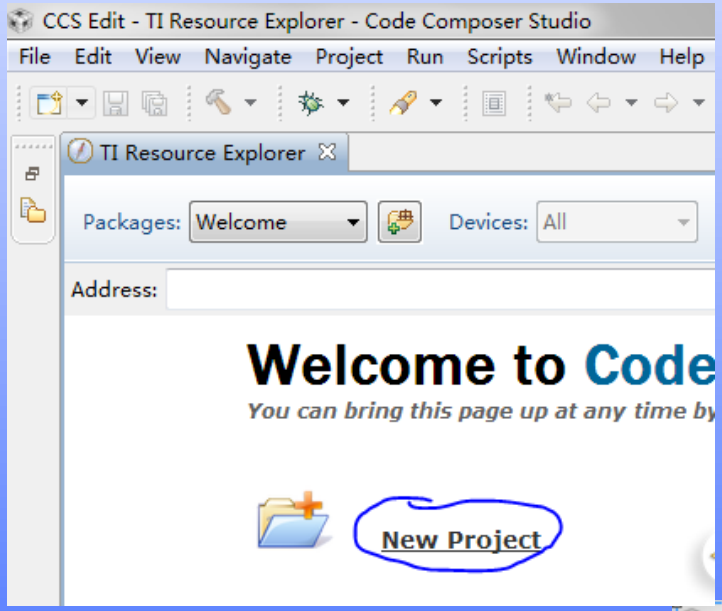
- 文件列表:
  - 源程序 (C，汇编)
  - 库函数
  - 链接器命令文件
- 工程配置:
  - 编译选项(编译器，链接器，汇编器)
  - 输出文件的配置

CCS 4.x/5.x/6.x软件的使用

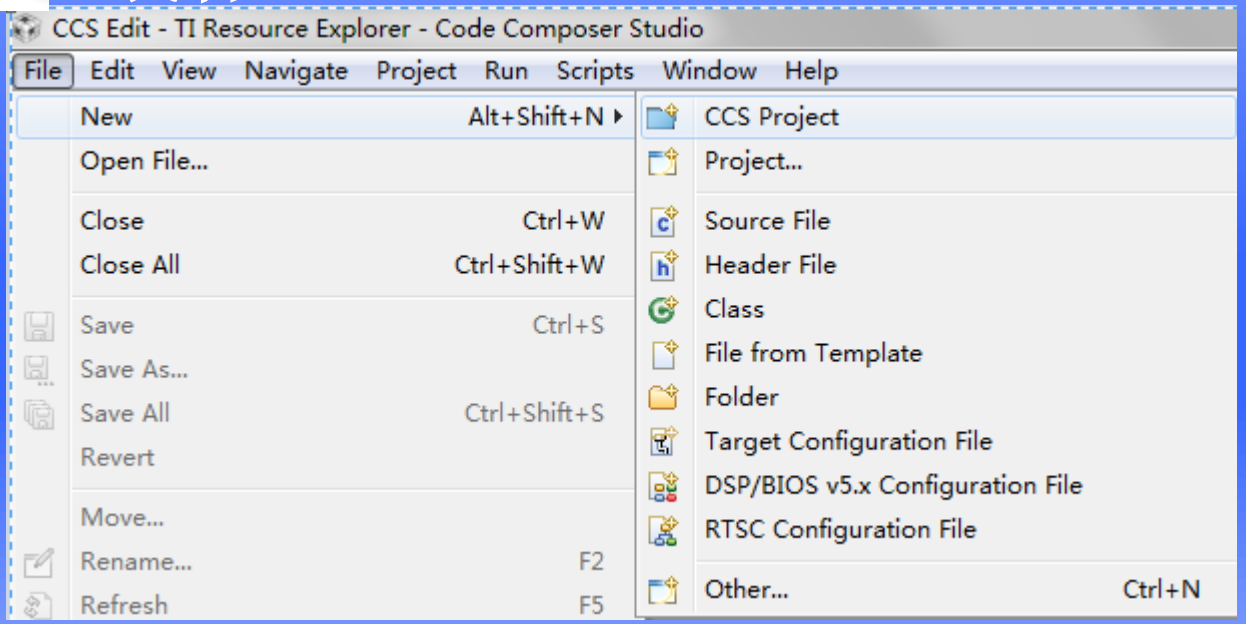
CCS 4.x/5.x/6.x的基本使用-创建工作空间



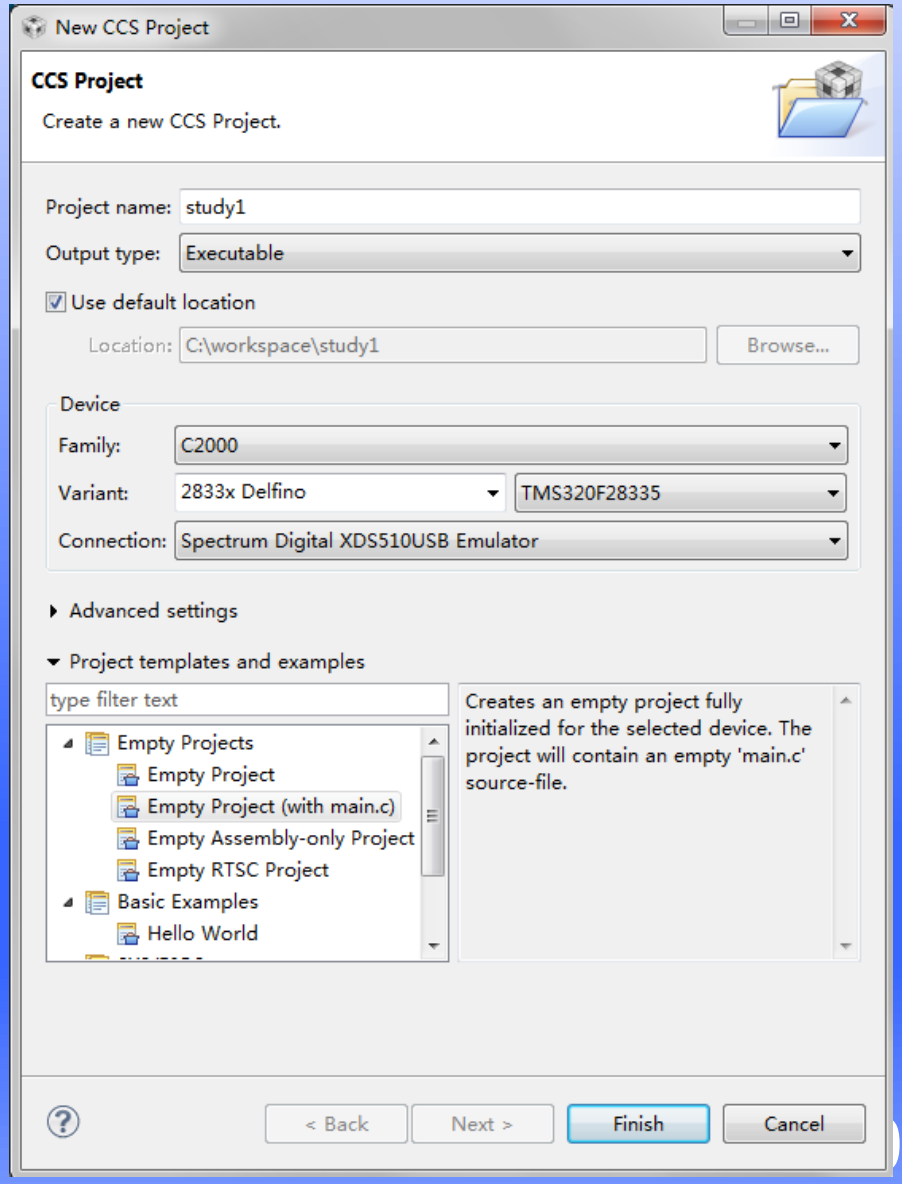
CCS 4.x/5.x/6.x的基本使用-新建工程



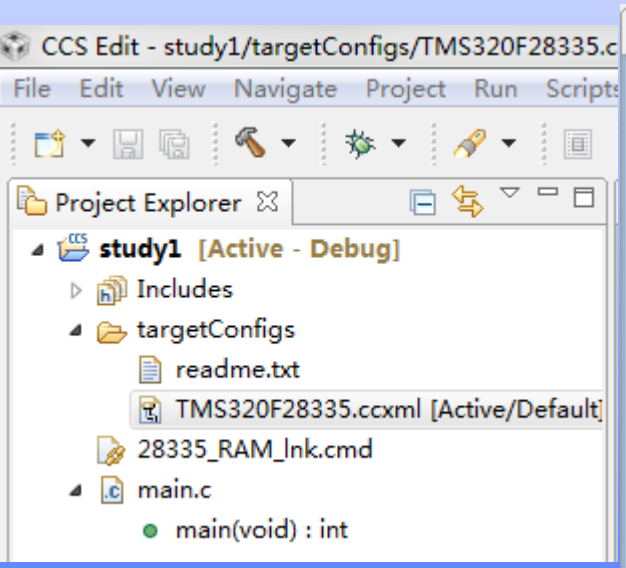
或者

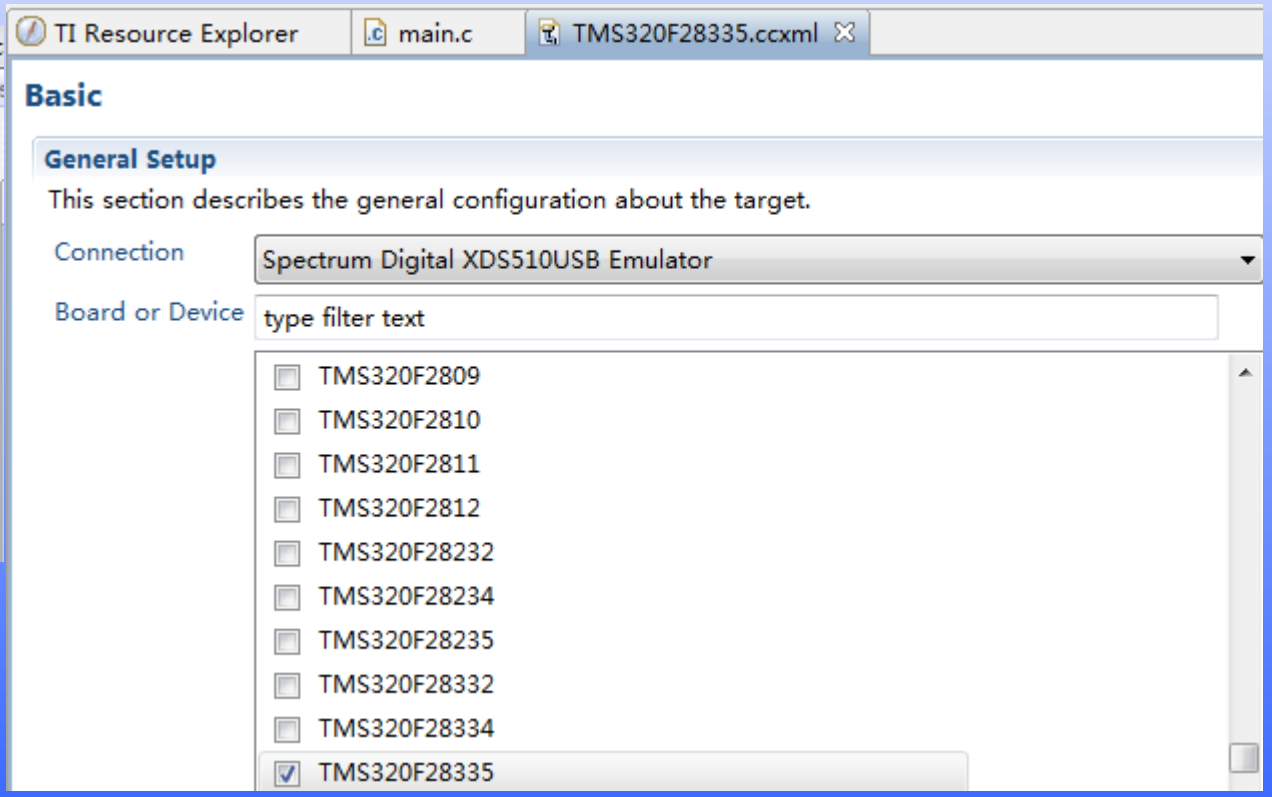


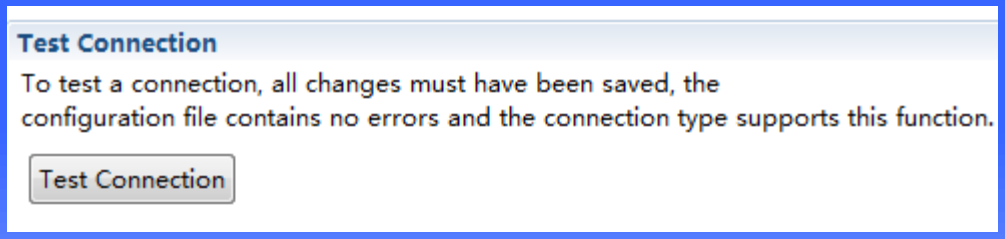
CCS 4.x/5.x/6.x的基本使用-选择器件



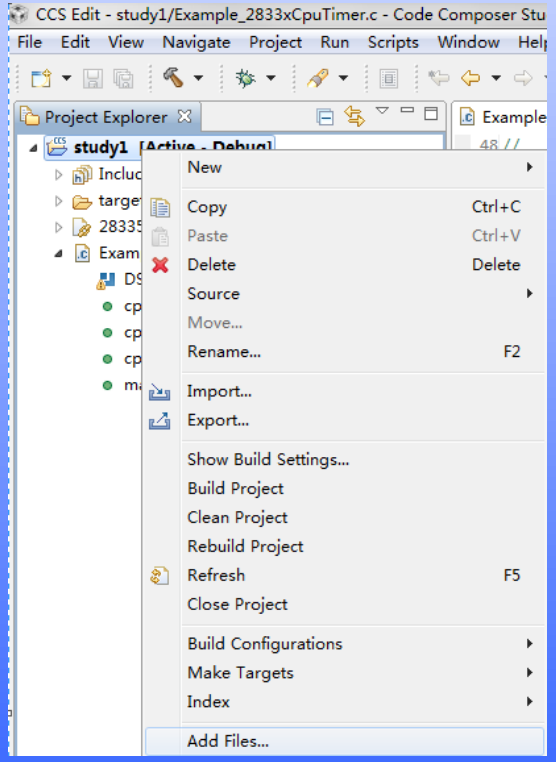
CCS 4.x/5.x/6.x的基本使用-测试硬件连接





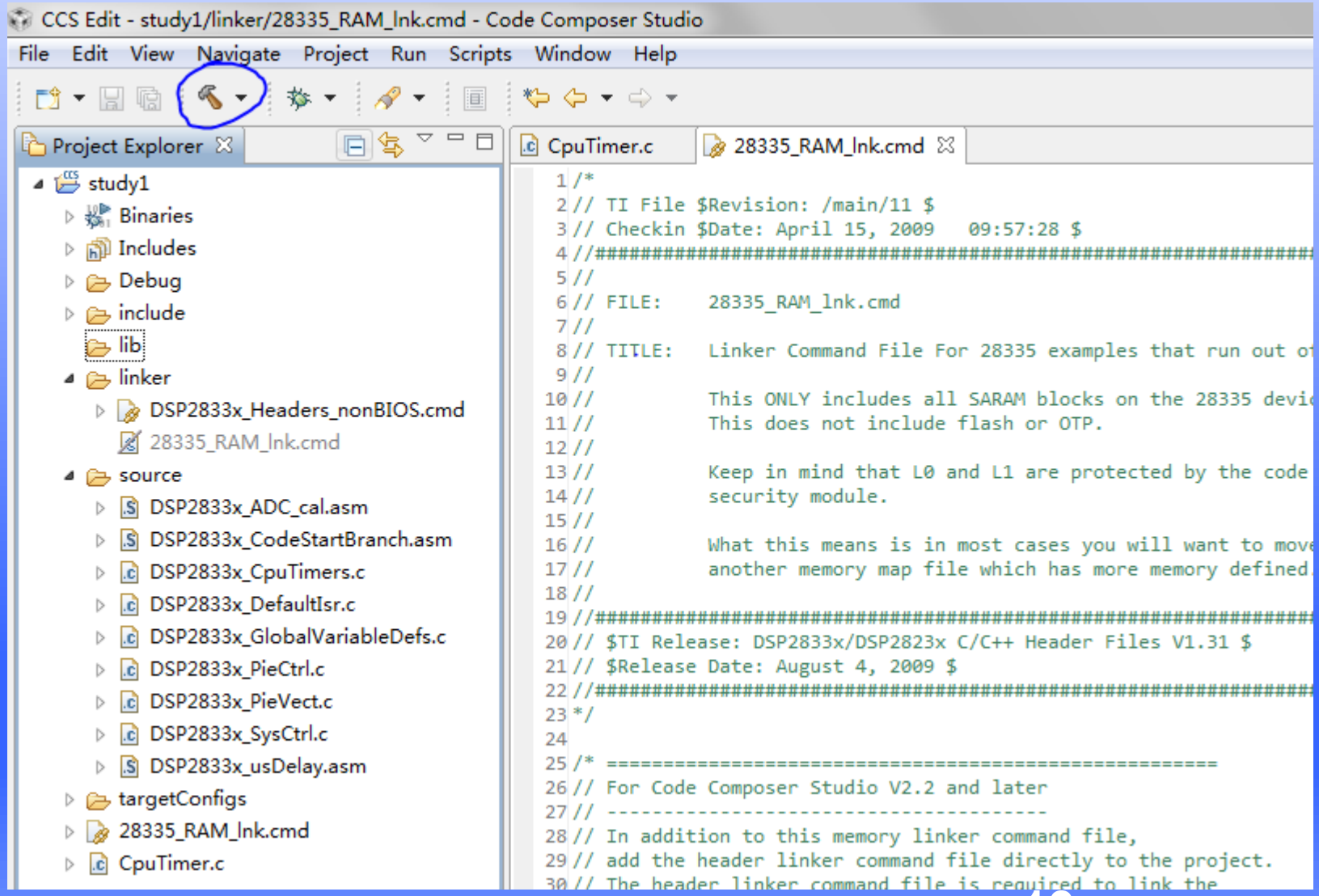


CCS 4.x/5.x/6.x的基本使用-添加文件

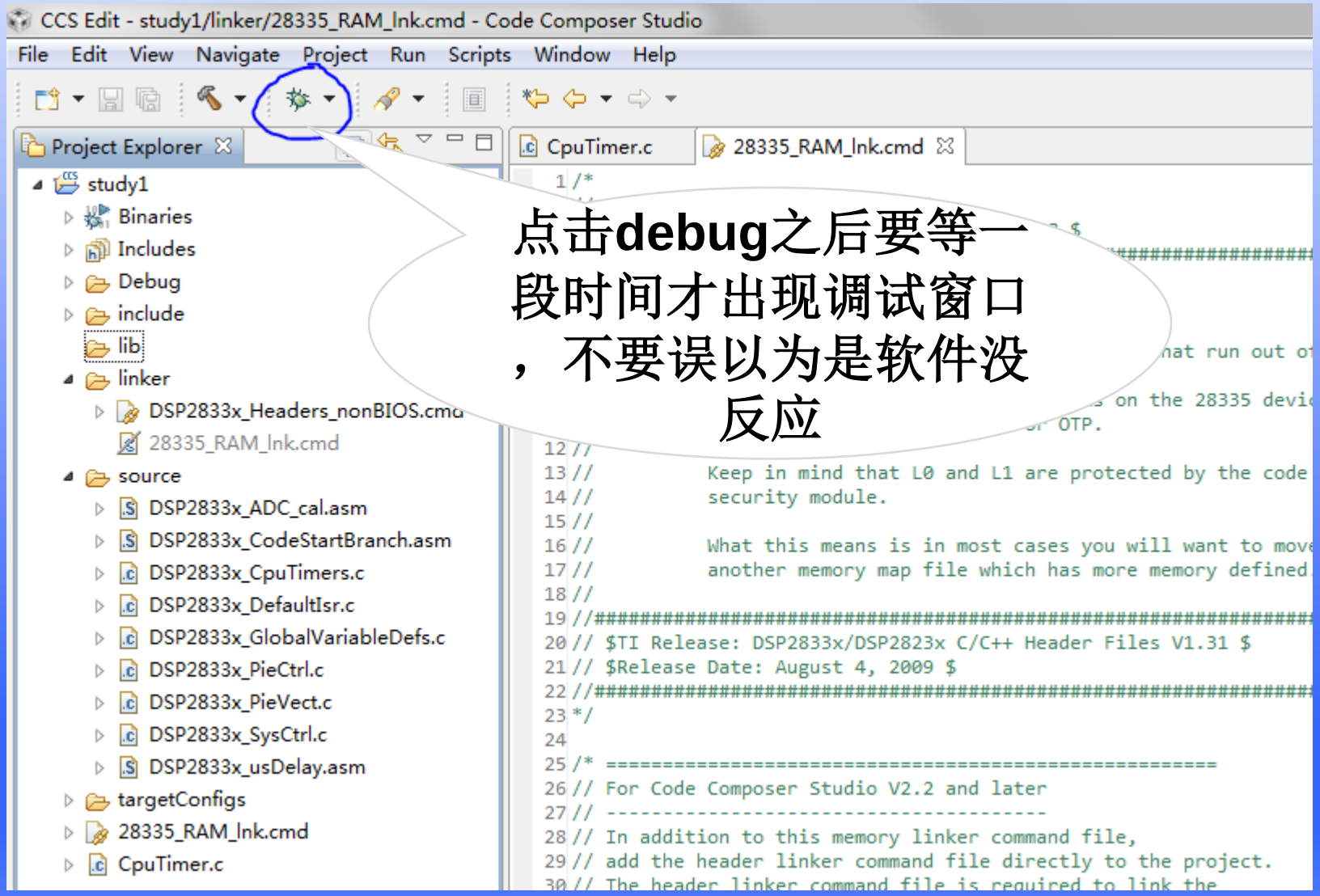


添加几个文件

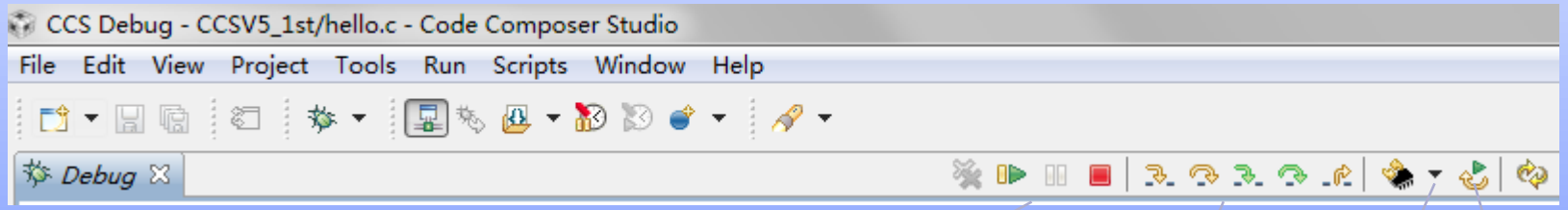
CCS 4.x/5.x6.x的基本使用-编译工程



CCS 4.x/5.x6.x的基本使用-调试工程



CCS 4.x/5.x6.x的基本使用-调试工程



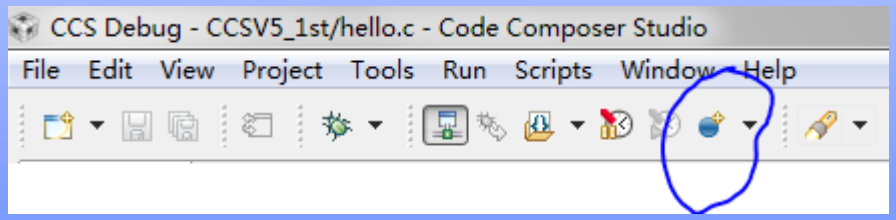
运行、暂停、终止

单步调试相关

Reset CPU

重新开始

CCS 4.x/5.x6.x的基本使用-放置断点

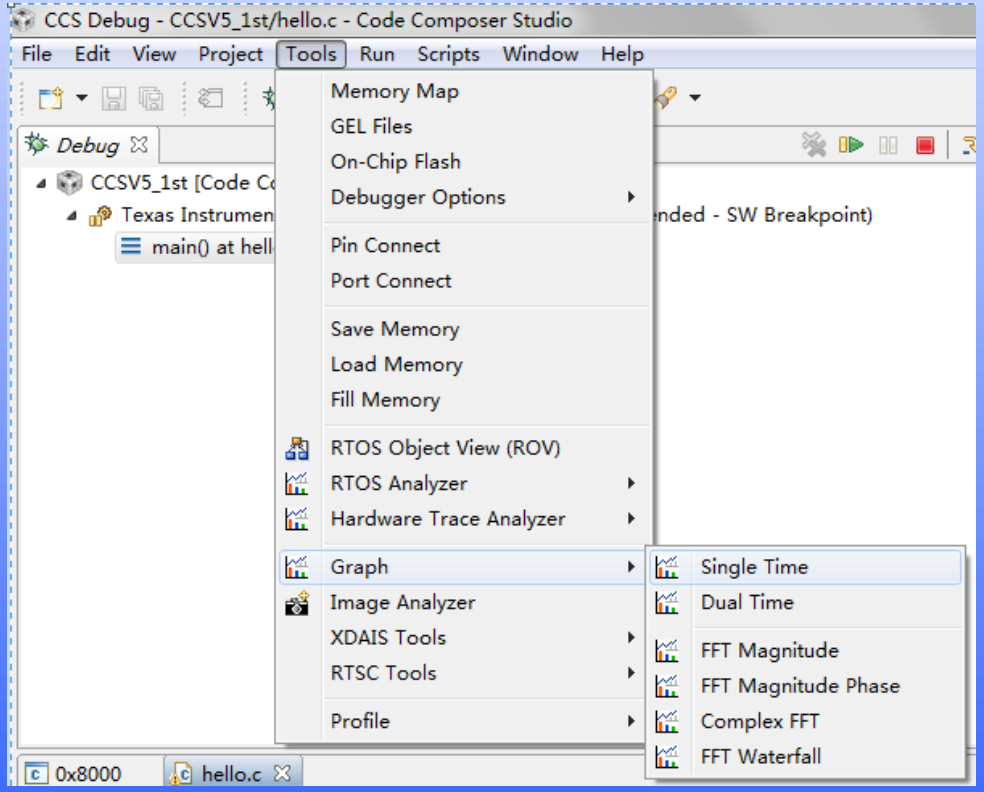


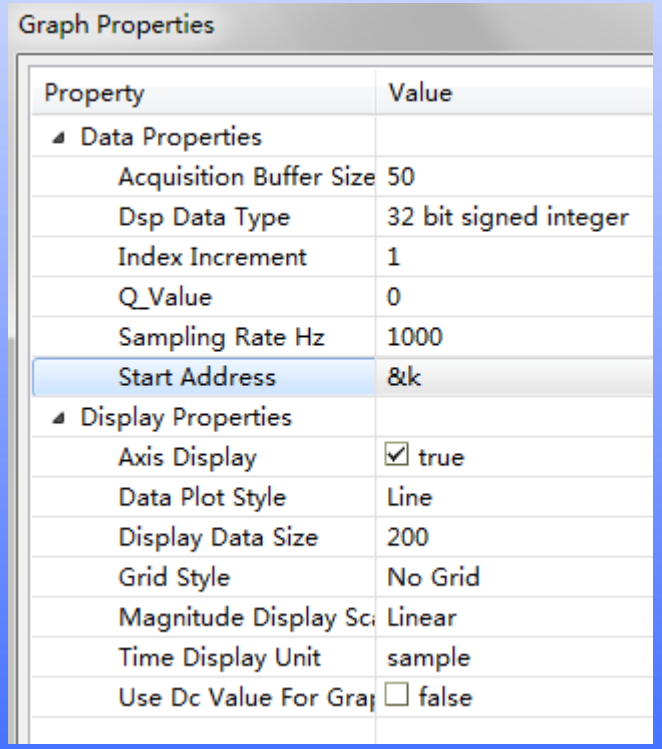
CCS 4.x/5.x6.x的基本使用-观测变量

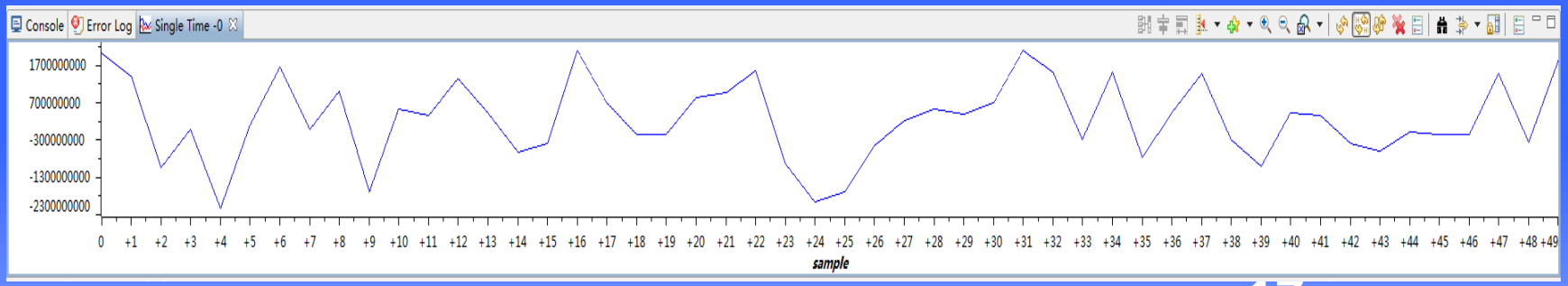
(x)= Variables | Expressions | Registers

Name	Type	Value	Location
(x)= a	int	0	0x00000403@Data
(x)= b	int	-32702	0x00000402@Data
(x)= c	int	0	0x00000401@Data
(x)= d	int	0	0x00000400@Data
(x)= e	int	6226	0x000003FF@Data
(x)= f	int	-15921	0x000003FE@Data
(x)= g	int	-11890	0x000003FD@Data
(x)= h	int	21548	0x000003FC@Data
(x)= i	int	-4602	0x000003FB@Data
(x)= j	int	30993	0x000003FA@Data
(x)= k	int	-31570	0x000003F9@Data

CCS 4.x/5.x6.x的基本使用-图形显示

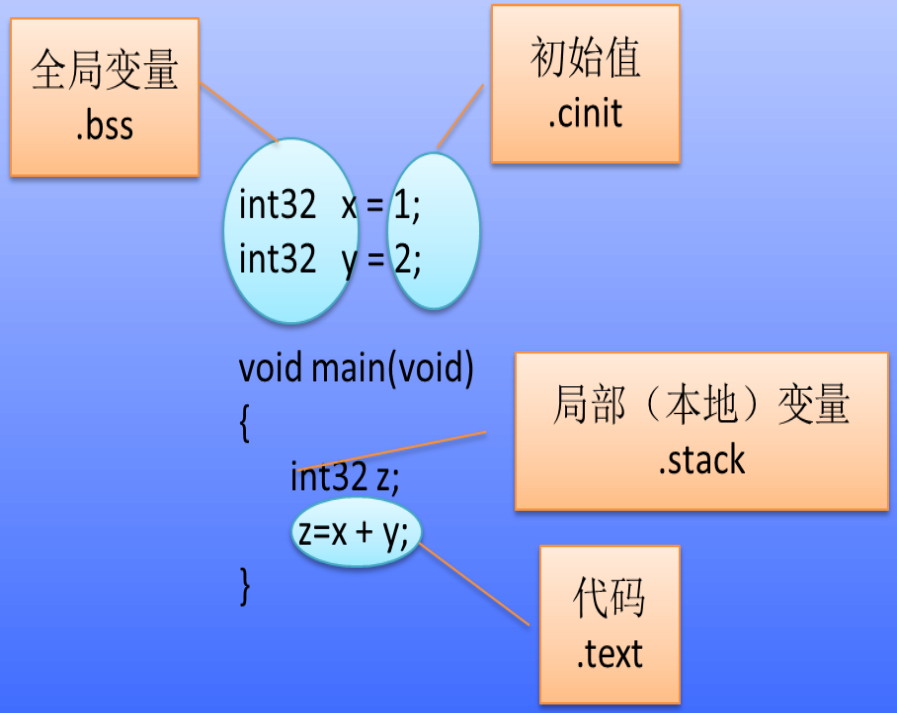






链接命令文件.cmd

段Sections

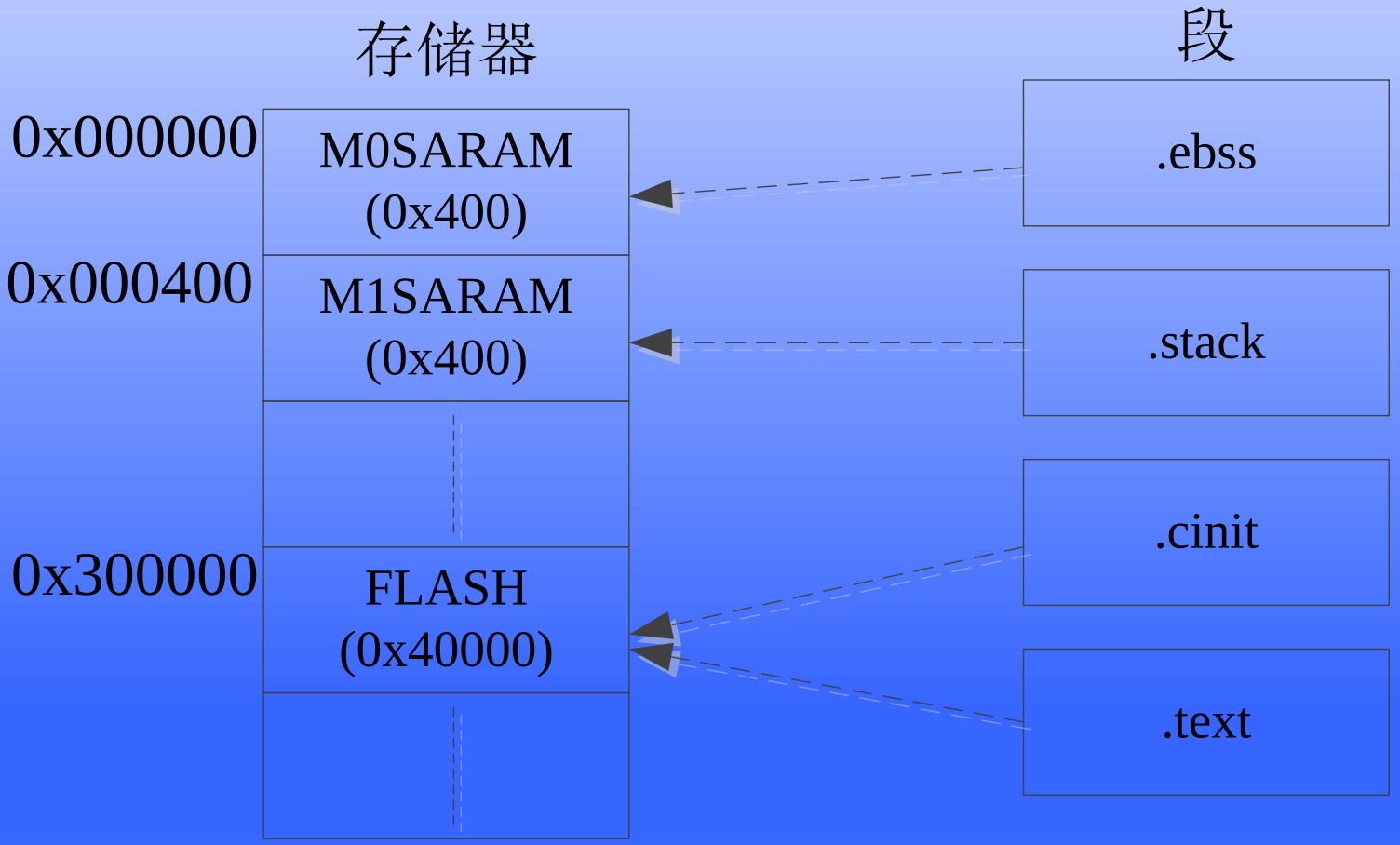


- 代码按照不同的类型保存，即‘段’
- 每个段都以“.”开头
- 段有默认的名字

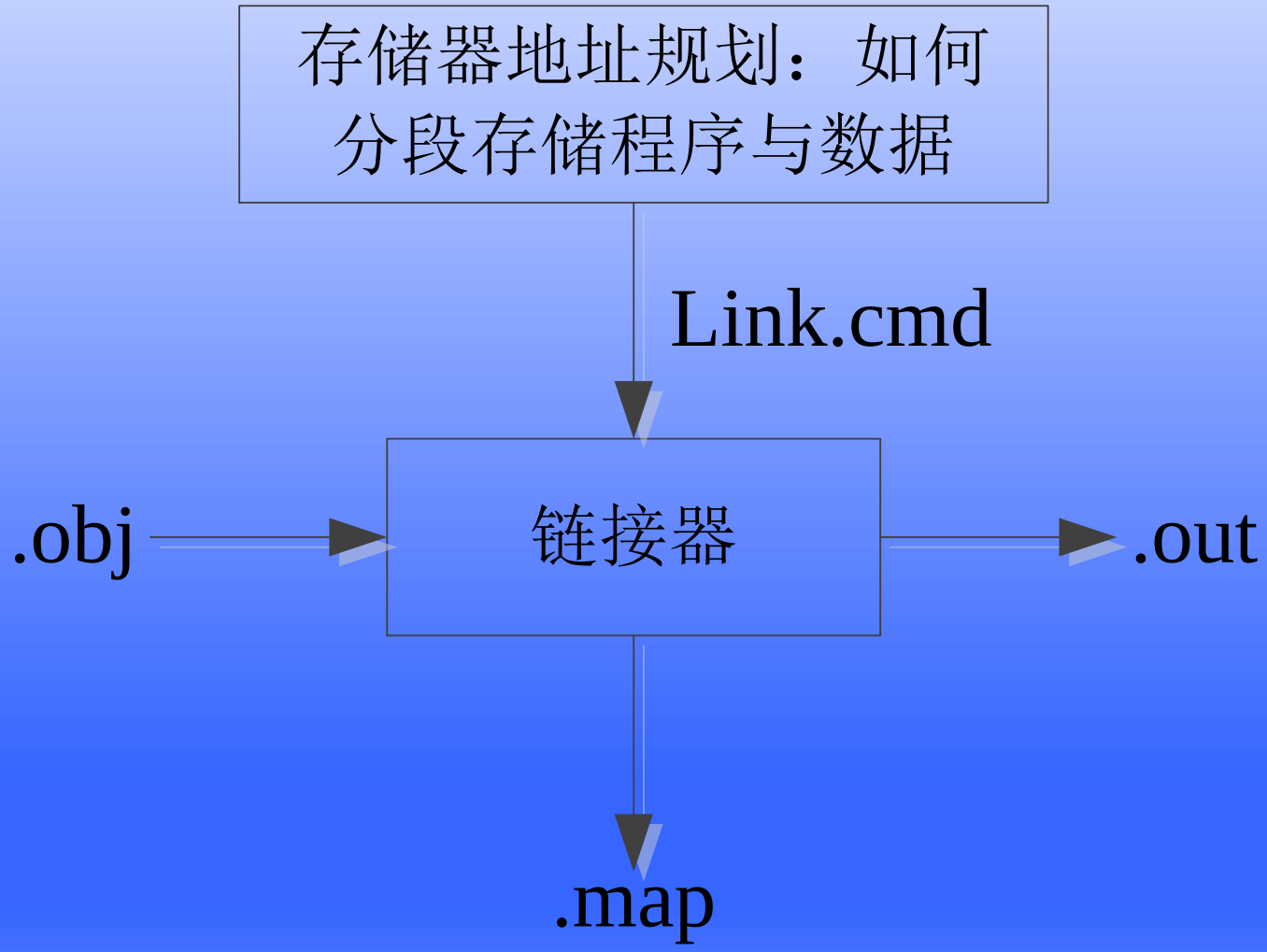
cmd文件中各个段的含义

初始化的段		
名字	描述	链接位置
.text	代码	FLASH
.cinit	全局与静态变量的初始值	FLASH
.econst	常数	FLASH
.switch	Switch表达式的表格	FLASH
.pinit	全局构造函数表（C++里面的constructor）	FLASH
未初始化的段		
名字	描述	链接位置
.ebss	全局与静态变量	RAM
.stack	堆栈空间	低64K字的RAM
.esysmem	Far malloc函数的存储空间	RAM

链接代码与存储单元


存储器
段
0x000000
M0SARAM
(0x400)
0x000400
M1SARAM
(0x400)
0x300000
FLASH
(0x40000)
.ebss
.stack
.cinit
.text

链接的示意图



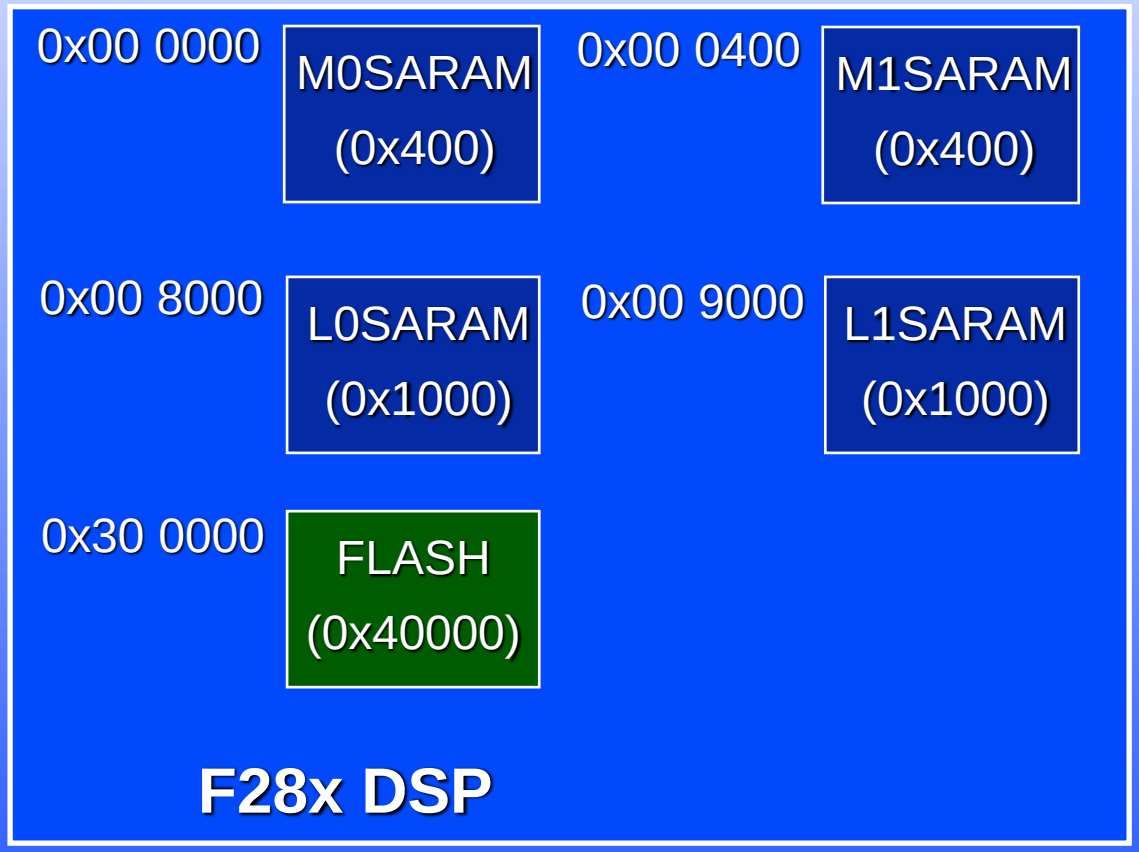
cmd文件的格式

```
MEMORY
{
   PAGE 0:           /* Program Memory */
    FLASH:    origin = 0x300000, length = 0x40000

   PAGE 1:           /* Data Memory */
    M0SARAM: origin = 0x000000, length = 0x400
    M1SARAM: origin = 0x000400, length = 0x400
}
```

完整的cmd文件

```
MEMORY
{
   PAGE 0:          /* Program Memory */
    FLASH:    origin = 0x300000, length = 0x40000

   PAGE 1:          /* Data Memory */
    M0SARAM: origin = 0x000000, length = 0x400
    M1SARAM: origin = 0x000400, length = 0x400
}
SECTIONS
{
    .text:>         FLASH       PAGE = 0
    .ebss:>         M0SARAM     PAGE = 1
    .cinit:>        FLASH       PAGE = 0
    .stack:>        M1SARAM     PAGE = 1
}
```

练习1



*把段分配到上面的**RAM**中*

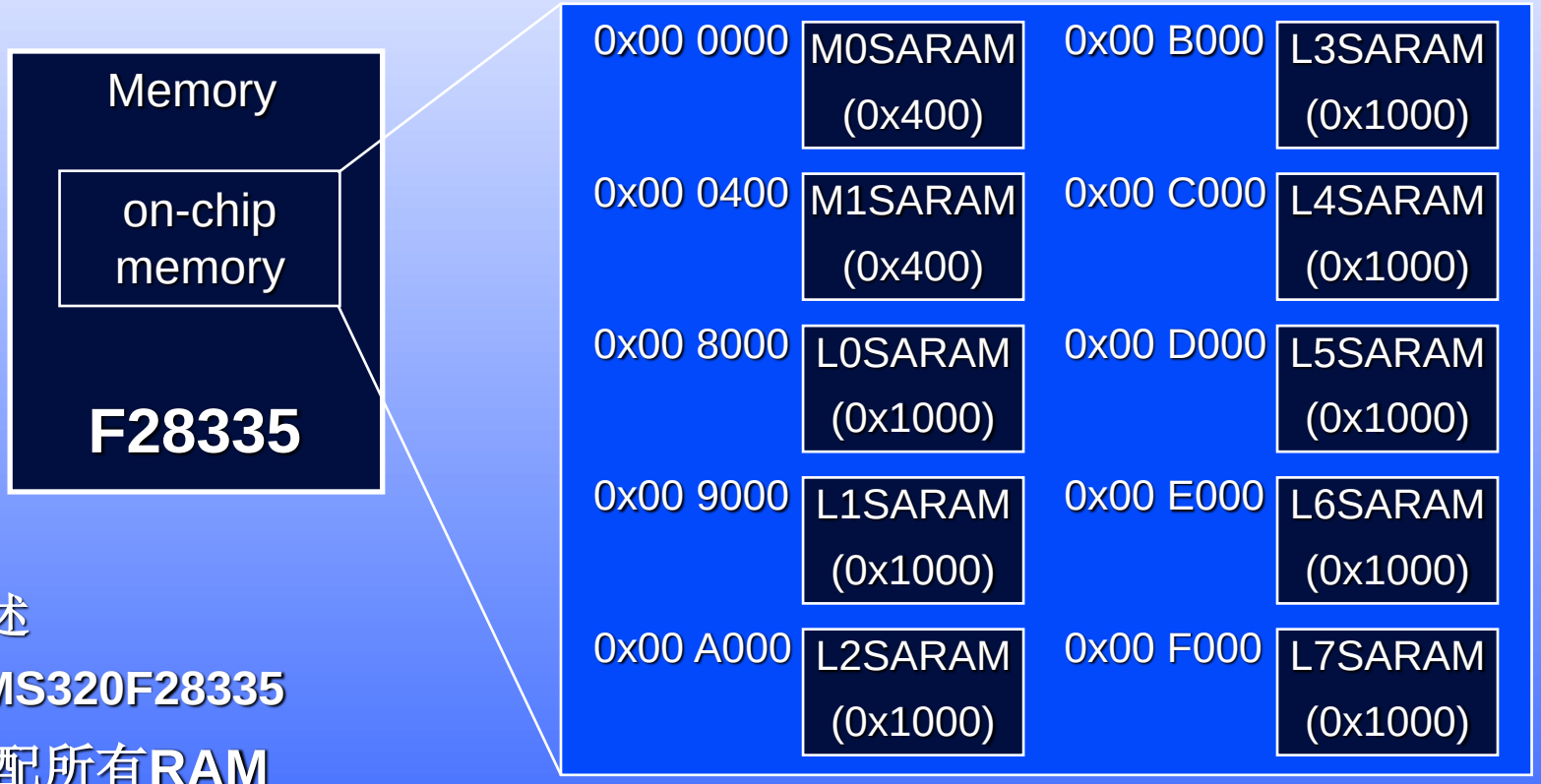
练习1

```
MEMORY
{
   PAGE__:           /* Program Memory */
    _____:      origin = _______,    length = ______
   ______:           /* Data Memory */
    _______:    origin =  ______,    length = _____
    _______:    origin = _______,    length = _____
    _______:    origin = _______,    length = _____
    _______:    origin = _______,    length = _____
}
SECTIONS
{
    .text:    >    FLASH        PAGE = 0
    .ebss:    >    M0SARAM      PAGE = 1
    .cinit:   >    FLASH        PAGE = 0
    .stack:   >    M1SARAM      PAGE = 1
}
```

练习1-结果

```
MEMORY
{
   PAGE 0:          /* Program Memory */
    FLASH:      origin = 0x300000,   length = 0x40000
   PAGE 1:          /* Data Memory */
    M0SARAM:    origin = 0x000000,   length = 0x400
    M1SARAM:    origin = 0x000400,   length = 0x400
    L0SARAM:    origin = 0x008000,   length = 0x1000
    L1SARAM:    origin = 0x009000,   length = 0x1000
}
SECTIONS
{
    .text:    >   FLASH        PAGE = 0
    .ebss:    >   M0SARAM      PAGE = 1
    .cinit:   >   FLASH        PAGE = 0
    .stack:   >   M1SARAM      PAGE = 1
}
```

练习2 cmd文件的示例



- 描述
- **TMS320F28335**
- 分配所有**RAM**

段的分配方案:

- **.text保存到RAM的L0123SARAM，位于PAGE 0 (程序空间)**
- **.cinit保存到RAM的L0123SARAM，位于PAGE 0 (程序空间)**
- **.ebss保存到RAM的L4SARAM，位于PAGE 1 (数据空间)**
- **.stack保存到RAM的M1SARAM，位于PAGE 1 (数据空间)**

练习2 cmd分配的结果

```
MEMORY
{
   PAGE 0:              /* Program Memory */
    L0123SARAM:   origin = 0x008000,  length = 0x4000
   PAGE 1:              /* Data Memory */
    M0SARAM:      origin = 0x000000,  length = 0x0400
    M1SARAM:      origin = 0x000400,  length = 0x0400
    L4SARAM:      origin = 0x00C000,  length = 0x1000
    L5SARAM:      origin = 0x00D000,  length = 0x1000
    L6SARAM:      origin = 0x00E000,  length = 0x1000
    L7SARAM:      origin = 0x00F000,  length = 0x1000
}

SECTIONS
{
    .text:       >  L0123SARAM    PAGE = 0
    .ebss:       >  L4SARAM       PAGE = 1
    .cinit:      >  L0123SARAM    PAGE = 0
    .stack:      >  M1SARAM       PAGE = 1
    .reset:      >  L0123SARAM    PAGE = 0, TYPE = DSECT
}
```

外设寄存器与头文件示例

传统C代码访问寄存器的方法

```
#define ADCTRL1      (volatile unsigned  int *)0x00007100
#define ADCTRL2      (volatile unsigned  int *)0x00007101
                      ...
void main(void)
{
    *ADCTRL1 = 0x1234;              //write entire register
    *ADCTRL2 |= 0x4000;             //reset sequencer #1
}
```

0x1234=1001000110100

0x4000=100000000000000

优点

- 简单，方便，易于输入
- 变量名与寄存器名一致，方便记忆

不足

- 无法直接操作单独的位
- 在调试时无法显示单独的位
- 效率不高

结构化的寄存器访问方法

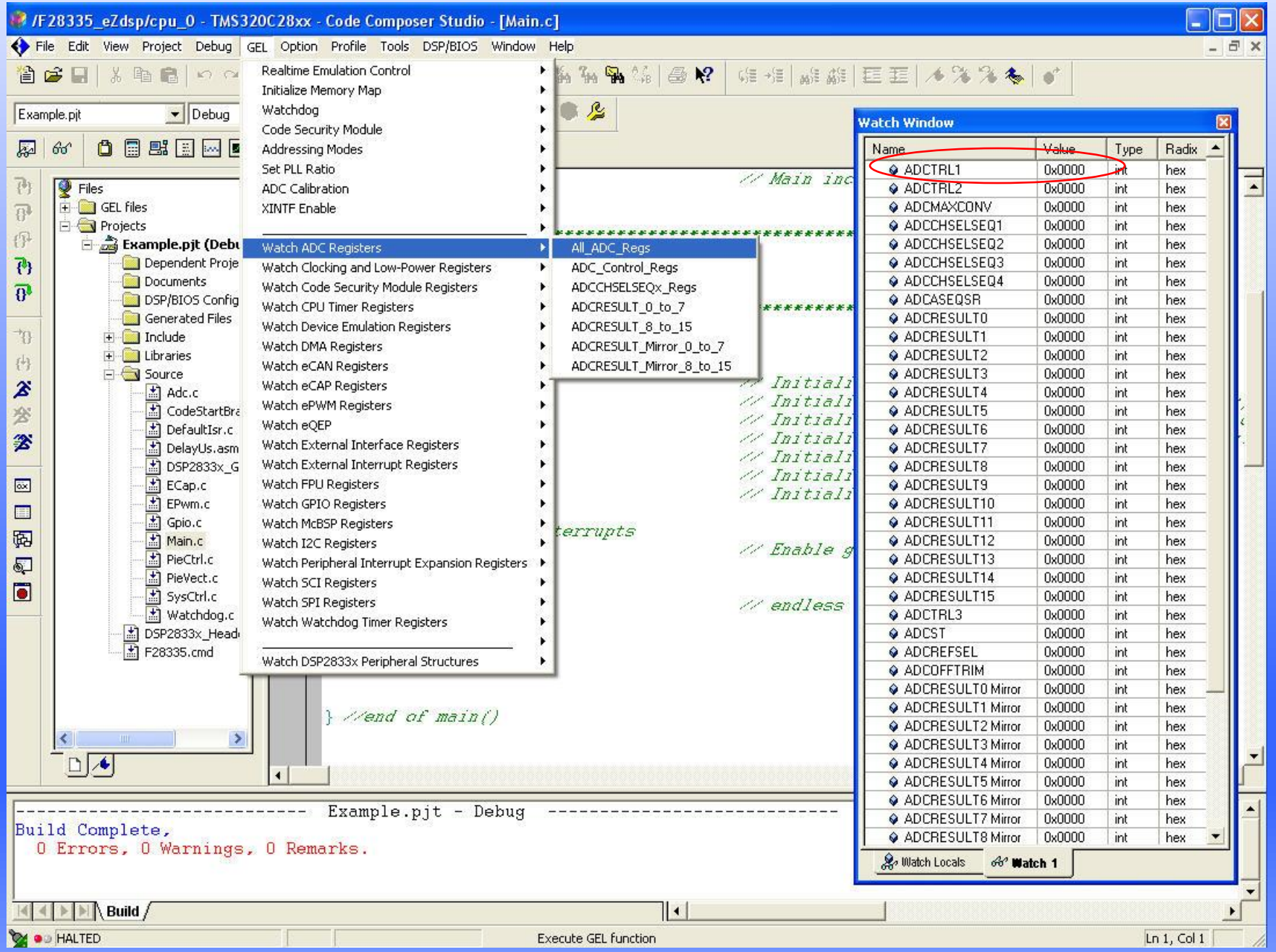
```
void main(void)
{
    AdcRegs.ADCTRL1.all = 0x1234;          //write entire register
    AdcRegs.ADCTRL2.bit.RST_SEQ1 = 1;      //reset sequencer #1
}
```

优点
- 容易操作单独的位.
- 调试功能更强大
- 可产生更高效的代码

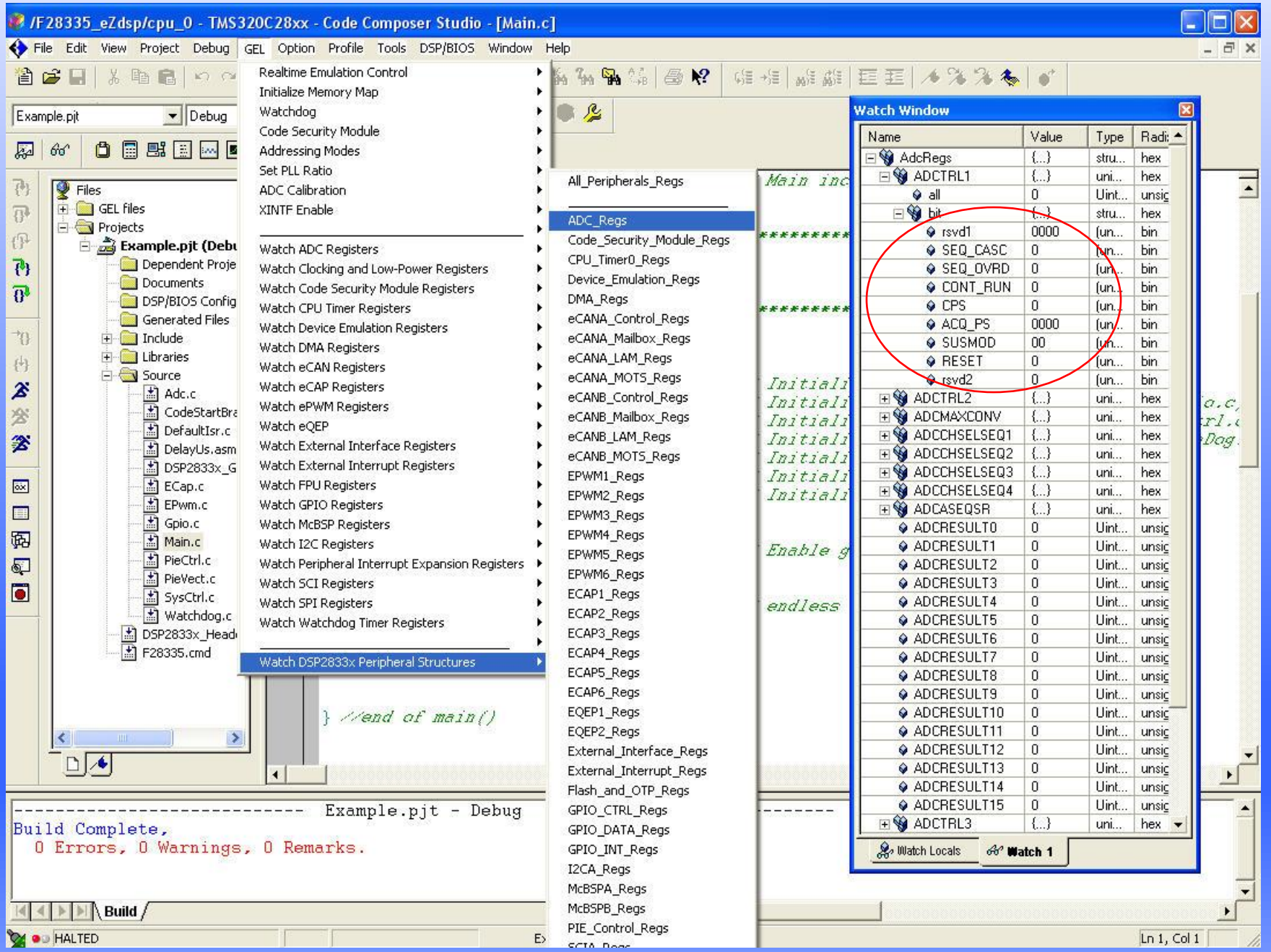
不足
- 不容易记忆
- 输入更多的字符

编译器的自动完成与提示功能可解决这些问题)

传统方法-在CCS的Watch窗口中观察寄存器



使用结构化方法观察寄存器的每个位



结构化方法是否更高效?

结构化方法可使编译器更高效地寻址并使用原子指令

C源代码

```
// Stop CPU Timer0
CpuTimer0Regs.TCR.bit.TSS = 1;

// Load new 32-bit period value
CpuTimer0Regs.PRD.all = 0x00010000;

// Start CPU Timer0
CpuTimer0Regs.TCR.bit.TSS = 0;
```

编译之后的汇编代码

```
MOVW    DP, #0030
OR      @4, #0x0010

MOVL    XAR4, #0x010000
MOVL    @2, XAR4

AND     @4, #0xFFEF
```

- 代码易读
- 位操作方便

5 words, 5个指令周期

** C28x 编译器版本v5.0.1，使用-g选项以及-o1, -o2或–o3中的任一优化级别*

传统方法编程的对比

传统方法需要大量的指针操作与随机存储器访问，也无法更高效地使用原子指令

C源代码

```
// Stop CPU Timer0
*TIMER0TCR |= 0x0010;

// Load new 32-bit period value
*TIMER0TPRD32 = 0x00010000;

// Start CPU Timer0
*TIMER0TCR &= 0xFFEF;
```

0x0010=10000

0xFFEF=1111111111101111

编译之后的汇编代码

```
MOV     @AL,*(0:0x0C04)
ORB     AL, #0x10
MOV     *(0:0x0C04), @AL

MOVL    XAR5, #0x010000
MOVL    XAR4, #0x000C0A
MOVL    *+XAR4[0], XAR5

MOV     @AL, *(0:0x0C04)
AND     @AL, #0xFFEF
MOV     *(0:0x0C04), @AL
```

- 不直观
- 对位的操作较为麻烦

9 words, 9个指令周期

** C28x 编译器版本v5.0.1，使用-g选项以及-o1, -o2或–o3中的任一优化级别*

结构化的命名规范

- DSP2833x头文件中定义了:
  - 所有的外设结构体
  - 所有的寄存器名称
  - 所有寄存器的位的含义
  - 所有的寄存器的地址

```
PeripheralName.RegisterName.all                 // Access full 16 or 32-bit register
PeripheralName.RegisterName.half.LSW            // Access low 16-bits of 32-bit register
PeripheralName.RegisterName.half.MSW            // Access high 16-bits of 32-bit register
PeripheralName.RegisterName.bit.FieldName       // Access specified bit fields of register
```

注解: [1] “PeripheralName” 外设名称(例如CpuTimer0Regs).

[2] “RegisterName” 寄存器名称(例如TCR, TIM, PRD,..).

[3] “FieldName” 位的名称(i.e. POL, TOG, TSS,..).

DSP2833x的外设与头文件包

(http://www.ti.com, 搜索编号SPRC530的文件包)

- 包含所有使用结构化编程方法所需的头文件和示例
- 定义了外设寄存器、位的信息和地址
- 内容包括

- \DSP2833x_headers\include → .h files
- \DSP2833x_headers\cmd → linker .cmd files
- \DSP2833x_headers\gel → .gel files for CCS
- \DSP2833x_examples → ‘2833x examples
- \DSP2823x_examples → ‘2823x examples
- \doc → documentation

外设结构的.h文件 (1)

- 包含了每个外设寄存器的位的信息。以ADC为例：

你的C代码(例如Adc.c)

```
#include  “DSP2833x_Device.h”

Void InitAdc(void)
{
    /* Reset the ADC module */
   AdcRegs.ADCTRL1.bit.RESET = 1;

   /* configure the ADC register */
   AdcRegs.ADCTRL1.all = 0x0710;
};
```

DSP2833x_Adc.h

```
/* ADC Individual Register Bit Definitions */
struct ADCTRL1_BITS {     // bits  description
   Uint16  rsvd1:4;       // 3:0 reserved
   Uint16  SEQ_CASC:1;    // 4 Cascaded sequencer mode
   Uint16  SEQ_OVRD:1     // 5 Sequencer override
   Uint16  CONT_RUN:1;    // 6 Continuous run
   Uint16  CPS:1;         // 7 ADC core clock prescaler
   Uint16  ACQ_PS:4;      // 11:8 Acquisition window size
   Uint16  SUSMOD:2;      // 13:12 Emulation suspend mode
   Uint16  RESET:1;       // 14 ADC reset
   Uint16  rsvd2:1;       // 15 reserved
};

/* Allow access to the bit fields or entire register */
union ADCTRL1_REG {
  Uint16           all;
  struct ADCTRL1_BITS  bit;
};

// ADC External References & Function Declarations:
extern volatile struct ADC_REGS AdcRegs;
```

外设结构的.h文件 (2)

- *每个外设都对应一个头文件*

DSP2833x_Device.h	DSP2833x_DevEmu.h	DSP2833x_SysCtrl.h
DSP2833x_PieCtrl.h	DSP2833x_Adc.h	DSP2833x_CpuTimers.h
DSP2833x_ECan.h	DSP2833x_ECap.h	DSP2833x_EPwm.h
DSP2833x_EQep.h	DSP2833x_Gpio.h	DSP2833x_I2c.h
DSP2833x_Sci.h	DSP2833x_Spi.h	DSP2833x_XIntrupt.h
DSP2833x_PieVect.h	DSP2833x_DefaultIsr.h	DSP2833x_DMA.h
DSP2833x_Mcbsp.h	DSP2833x_Xintf.h	

- ***DSP2833x_Device.h***
  - 主头文件(for ‘2833x and ‘2823x devices)
  - 用来引用其它所有的头文件
  - 使用方法：

```
#include “DSP2833x_Device.h”
```

全局变量定义文件
DSP2833x_GlobalVariableDefs.c

- 为每个外设建立了一个全局变量以方便使用
- 每个外设的结构体都使用**DATA_SECTION**指令来链接到**cmd**文件中的特定段

DSP2833x_GlobalVariableDefs.c

```
#include "DSP2833x_Device.h“
…
#pragma DATA_SECTION(AdcRegs,"AdcRegsFile");
volatile struct ADC_REGS AdcRegs;
…
```

- 把此文件添加到自己的工程中：

  DSP2833x_GlobalVariableDefs.c

全局变量定义文件

DSP2833x_GlobalVariableDefs.c

DSP2833x_GlobalVariableDefs.c

```
1  // TI File $Revision: /main/2 $
2  // Checkin $Date: March 5, 2007   12:20:33 $
3  //###########################################################################
4  //
5  // FILE:    DSP2833x_GlobalVariableDefs.c
6  //
7  // TITLE:   DSP2833x Global Variables and Data Section Pragmas.
8  //
9  //###########################################################################
10 // $TI Release: DSP2833x Header Files V1.01 $
11 // $Release Date: September 26, 2007 $
12 //###########################################################################
13
14 #include "DSP2833x_Device.h"     // DSP2833x Headerfile Include File
15
16 //---------------------------------------------------------------------------
17 // Define Global Peripheral Variables:
18 //
19 //---------------------------------------
20 #ifdef __cplusplus
21 #pragma DATA_SECTION("AdcRegsFile")
22 #else
23 #pragma DATA_SECTION(AdcRegs,"AdcRegsFile");
24 #endif
25 volatile struct ADC_REGS AdcRegs;
26
27 //---------------------------------------
28 #ifdef __cplusplus
29 #pragma DATA_SECTION("AdcMirrorFile")
30 #else
31 #pragma DATA_SECTION(AdcMirror,"AdcMirrorFile");
32 #endif
33 volatile struct ADC_RESULT_MIRROR_REGS AdcMirror;
34
35 //---------------------------------------
36 #ifdef __cplusplus
37 #pragma DATA_SECTION("CpuTimer0RegsFile")
38 #else
39 #pragma DATA_SECTION(CpuTimer0Regs,"CpuTimer0RegsFile");
40 #endif
41 volatile struct CPUTIMER_REGS CpuTimer0Regs;
42
43 //---------------------------------------
44 #ifdef   cplusplus
```

外设结构体与cmd文件的对应

DSP2833x_nonBIOS.cmd

DSP2833x_GlobalVariableDefs.c

```
#include "DSP2833x_Device.h“
…
#pragma DATA_SECTION(AdcRegs,"AdcRegsFile");
volatile struct ADC_REGS AdcRegs;
…
```

DSP2833x_Headers_nonBIOS.cmd

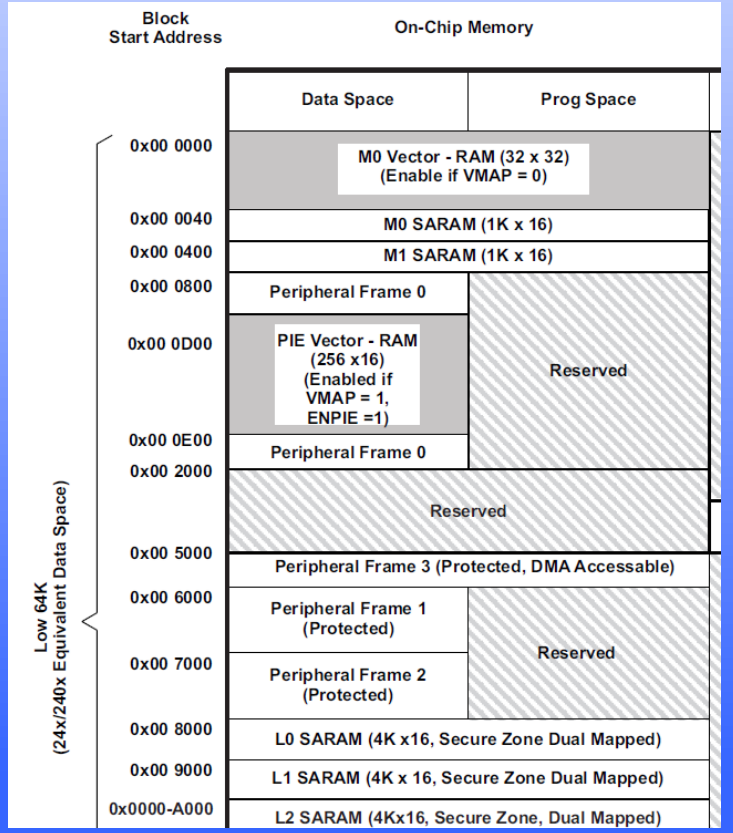
```
MEMORY
{  PAGE1:
     ADC:    origin=0x007100, length=0x000020
     ...
}
SECTIONS
{
    AdcRegsFile:    >  ADC        PAGE = 1
    ...
}
```

外设结构体与cmd文件的对应

DSP2833x_nonBIOS.cmd

```
MEMORY
{
 PAGE 0:    /* Program Memory */

 PAGE 1:    /* Data Memory */

   DEV_EMU     : origin = 0x000880, length = 0x000180     /* device emulation registers */
   FLASH_REGS  : origin = 0x000A80, length = 0x000060     /* FLASH registers */
   CSM         : origin = 0x000AE0, length = 0x000010     /* code security module registers */

   ADC_MIRROR  : origin = 0x000B00, length = 0x000010     /* ADC Results register mirror */

   XINTF       : origin = 0x000B20, length = 0x000020     /* external interface registers */

   CPU_TIMER0  : origin = 0x000C00, length = 0x000008     /* CPU Timer0 registers */
   CPU_TIMER1  : origin = 0x000C08, length = 0x000008     /* CPU Timer0 registers (CPU Timer1 & Timer
   CPU_TIMER2  : origin = 0x000C10, length = 0x000008     /* CPU Timer0 registers (CPU Timer1 & Timer

   PIE_CTRL    : origin = 0x000CE0, length = 0x000020     /* PIE control registers */
   PIE_VECT    : origin = 0x000D00, length = 0x000100     /* PIE Vector Table */

   DMA         : origin = 0x001000, length = 0x000200     /* DMA Rev 0 registers */

   MCBSPA      : origin = 0x005000, length = 0x000040     /* McBSP-A registers */
   MCBSPB      : origin = 0x005040, length = 0x000040     /* McBSP-B registers */

   ECANA       : origin = 0x006000, length = 0x000040     /* eCAN-A control and status registers */
   ECANA_LAM   : origin = 0x006040, length = 0x000040     /* eCAN-A local acceptance masks */
   ECANA_MOTS  : origin = 0x006080, length = 0x000040     /* eCAN-A message object time stamps */
   ECANA_MOTO  : origin = 0x0060C0, length = 0x000040     /* eCAN-A object time-out registers */
   ECANA_MBOX  : origin = 0x006100, length = 0x000100     /* eCAN-A mailboxes */
```

```
SECTIONS
{
   PieVectTableFile : > PIE_VECT,   PAGE = 1

/*** Peripheral Frame 0 Register Structures ***/
   DevEmuRegsFile    : > DEV_EMU,     PAGE = 1
   FlashRegsFile     : > FLASH_REGS,  PAGE = 1
   CsmRegsFile       : > CSM,         PAGE = 1
   AdcMirrorFile     : > ADC_MIRROR,  PAGE = 1
   XintfRegsFile     : > XINTF,       PAGE = 1
   CpuTimer0RegsFile : > CPU_TIMER0,  PAGE = 1
   CpuTimer1RegsFile : > CPU_TIMER1,  PAGE = 1
   CpuTimer2RegsFile : > CPU_TIMER2,  PAGE = 1
   PieCtrlRegsFile   : > PIE_CTRL,    PAGE = 1
   DmaRegsFile       : > DMA,         PAGE = 1

/*** Peripheral Frame 3 Register Structures ***/
   McbspaRegsFile    : > MCBSPA,      PAGE = 1
   McbspbRegsFile    : > MCBSPB,      PAGE = 1
```



教材25页

每个外设都有专门的示例