11034 MPL

Modular Coding Techniques using MPLINK™ Linker

Class Objective

- **When you finish this class you will:**
  - Understand what relocatable code is
  - Know advantages of relocatable code over absolutely located code
  - Combine code from 2 or more files to create a relocatable project
  - Create libraries using good coding practices and MPLIB™ object librarian

Agenda

- **Absolute and Relocatable Code**
  - Lab 1 - Migrating from absolute assembly
- **Creating Relocatable Assembly using MPLINK™ Linker**
- **Good Practices**
- **Common Errors**
  - Lab 2 - Creating a multi-file project
- **Creating and Using Libraries**
  - Lab 3 - Creating and Using Libraries

Absolute and Relocatable Code

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Absolute Code

- All code and data addresses must be explicitly defined.
- Projects consist of one "root" assembly source file
- All other assembly source files must be `#include`'d into root file
- Only root file can use END

Example of Absolute Code

modified 18F4620TEMP.ASM

```
        CBLOCK 0x080
        WREG_TEMP                   ; Context saving variable
        STATUS_TEMP                 ; Context saving variable
        BSR_TEMP                    ; Context saving variable
        ENDC

EXAMPLE EQU  0x000                  ; Define a variable

;*****************************************************************
        ORG    0x0018
        movff  STATUS,STATUS_TEMP           ; save STATUS
        movff  WREG,WREG_TEMP               ; Save WREG
        ...
        movff  WREG_TEMP,WREG               ; restore WREG
        movff  STATUS_TEMP,STATUS           ; restore STATUS
        retfie
```

Absolute Code

- Use **ORG** directives to specify starting location of program code in memory
- Use **EQU** statements to assign addresses

  Drawbacks

  - Must specify ***exact*** addresses for code and variables
  - Cannot be used with C18
  - Cannot be used with third-party libraries

Relocatable Code

- Organize program code and data into sections
- Reserve space with `RES`, `DB`, `DW` directives
- Memory allocation is handled by MPLINK™ Linker

Advantage

  - Flexible use of memory resources

Example of Relocatable Code

modified 18F4620TMPO.ASM

```
    UDATA
WREG_TEMP     RES 1          ;variable used for context saving
STATUS_TEMP   RES 1          ;variable used for context saving
BSR_TEMP      RES 1          ;variable used for context saving

    UDATA_ACS
EXAMPLE       RES 1          ;example of a variable in access RAM

;*****************************************************************
       CODE   0x0018
       goto   LowInt                  ;go to low priority ISR

PROGRAM_CODE  CODE
LowInt:
       movff  STATUS,STATUS_TEMP      ;save STATUS register
       movff  WREG,WREG_TEMP          ;save working register
       movff  BSR,BSR_TEMP            ;save BSR register
       …
```

Advantages of Relocatable Code

- Modularity
- Able to use third-party libraries
- Integrates with the MPLAB® C18 compiler
- Don’t need to specify addresses of variables or code
- For large, multi-file projects, Build Process can be significantly faster (USB, TCP/IP, MiWi™ protocol and Zigbee™ technology stacks)

Disadvantages

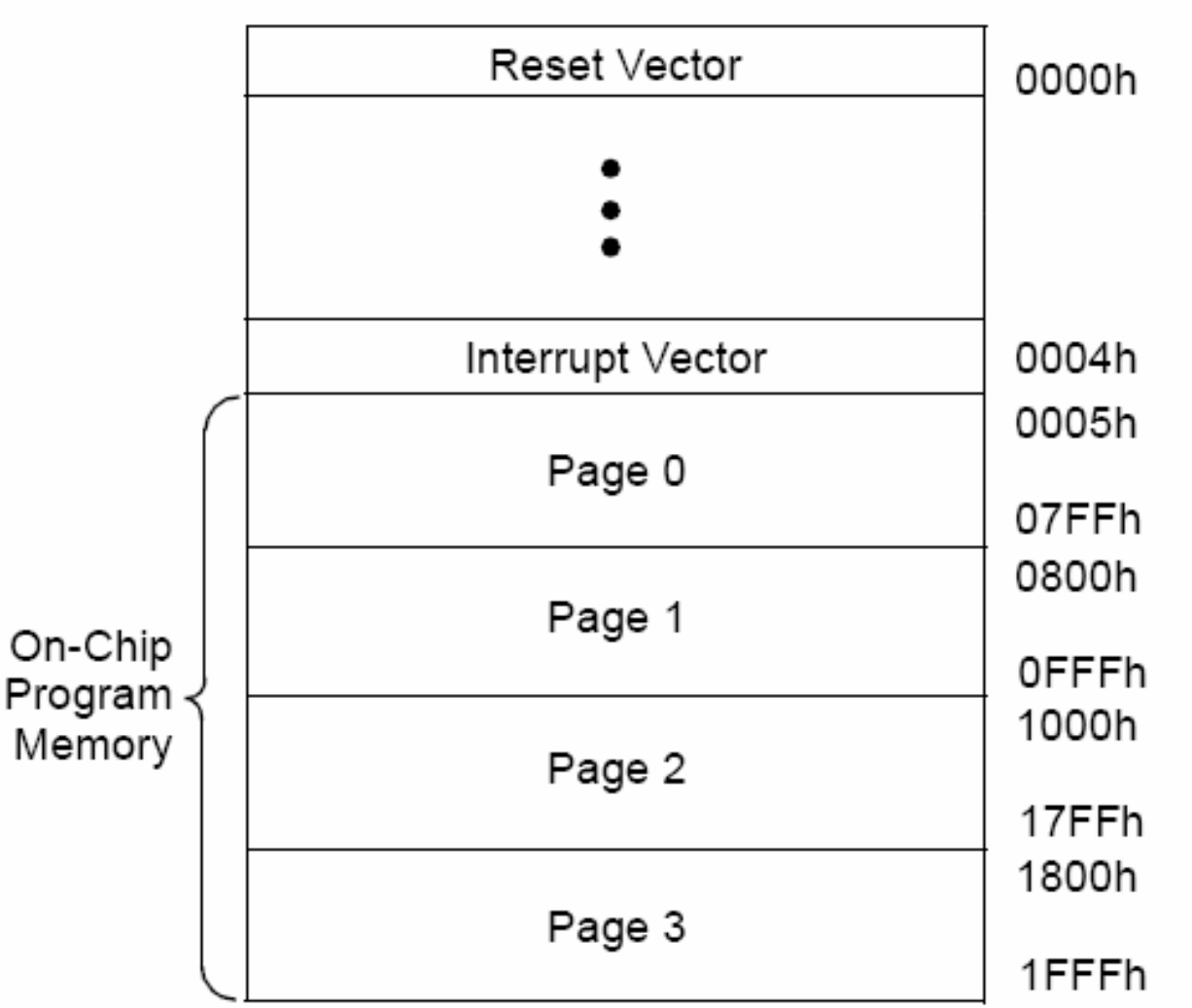
- **Migrating absolute code to relocatable code requires some effort**

Demo

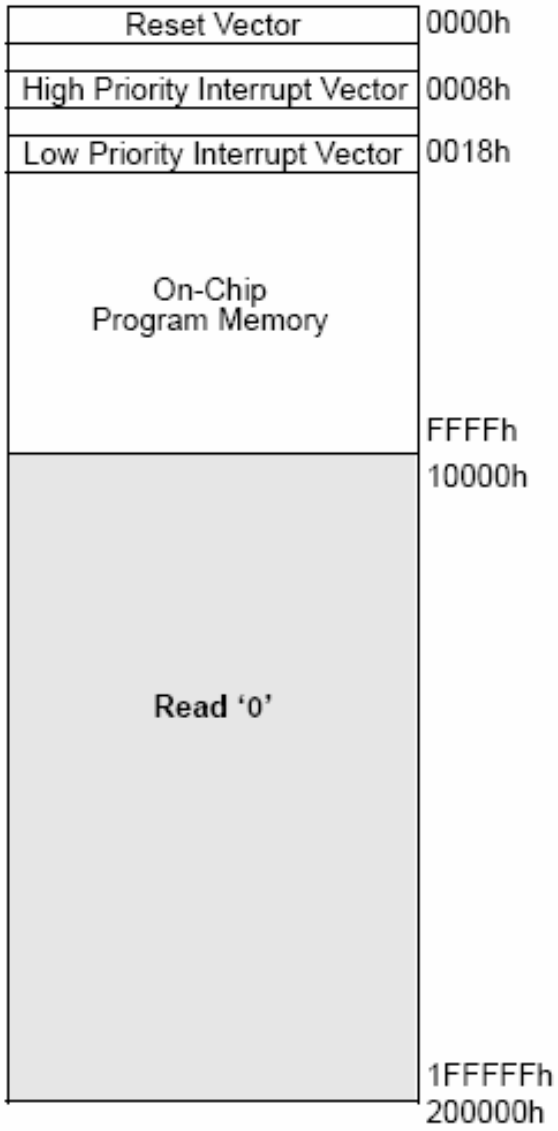
Building a Large Project

Memory Overview

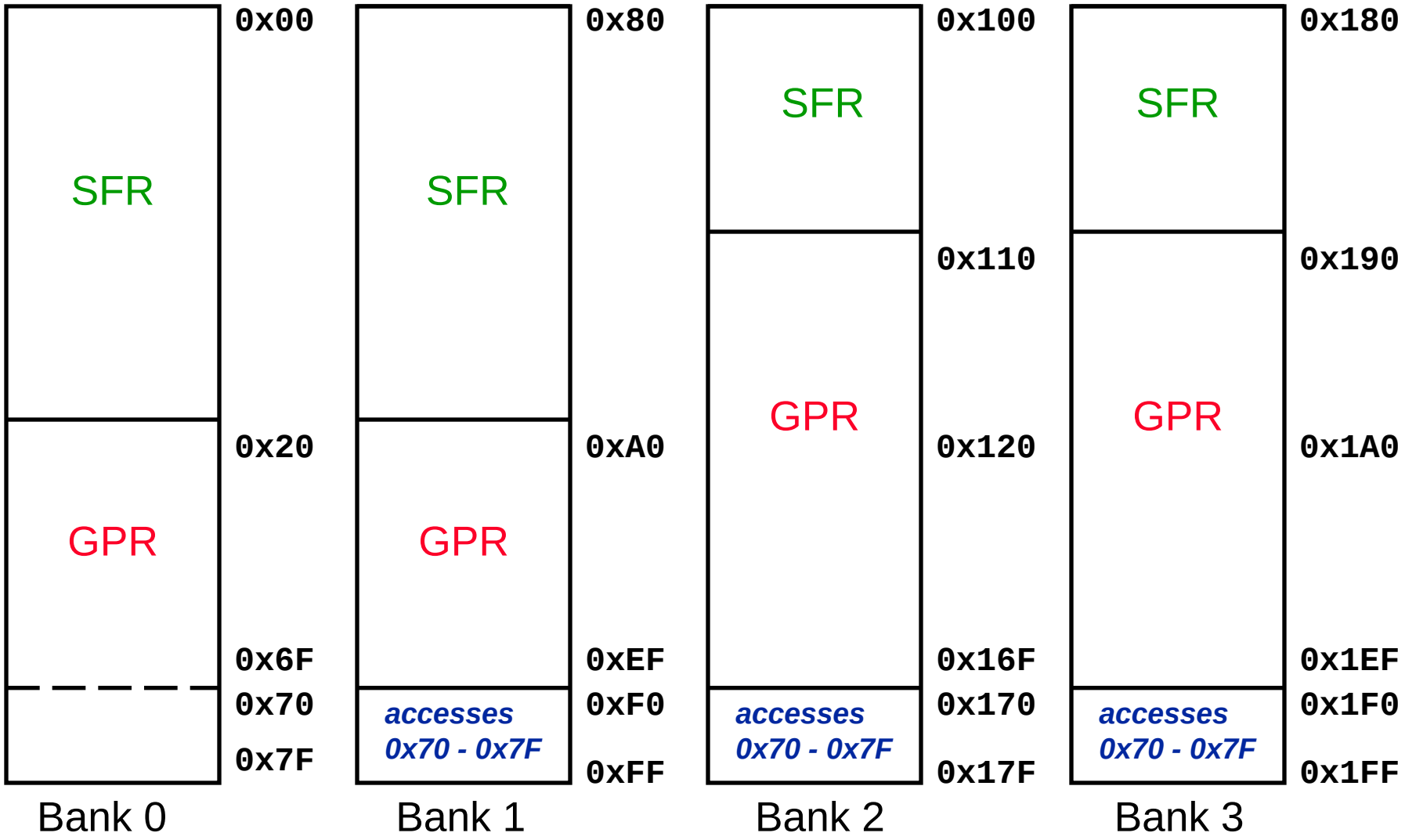
PIC16F887 Program Memory Map



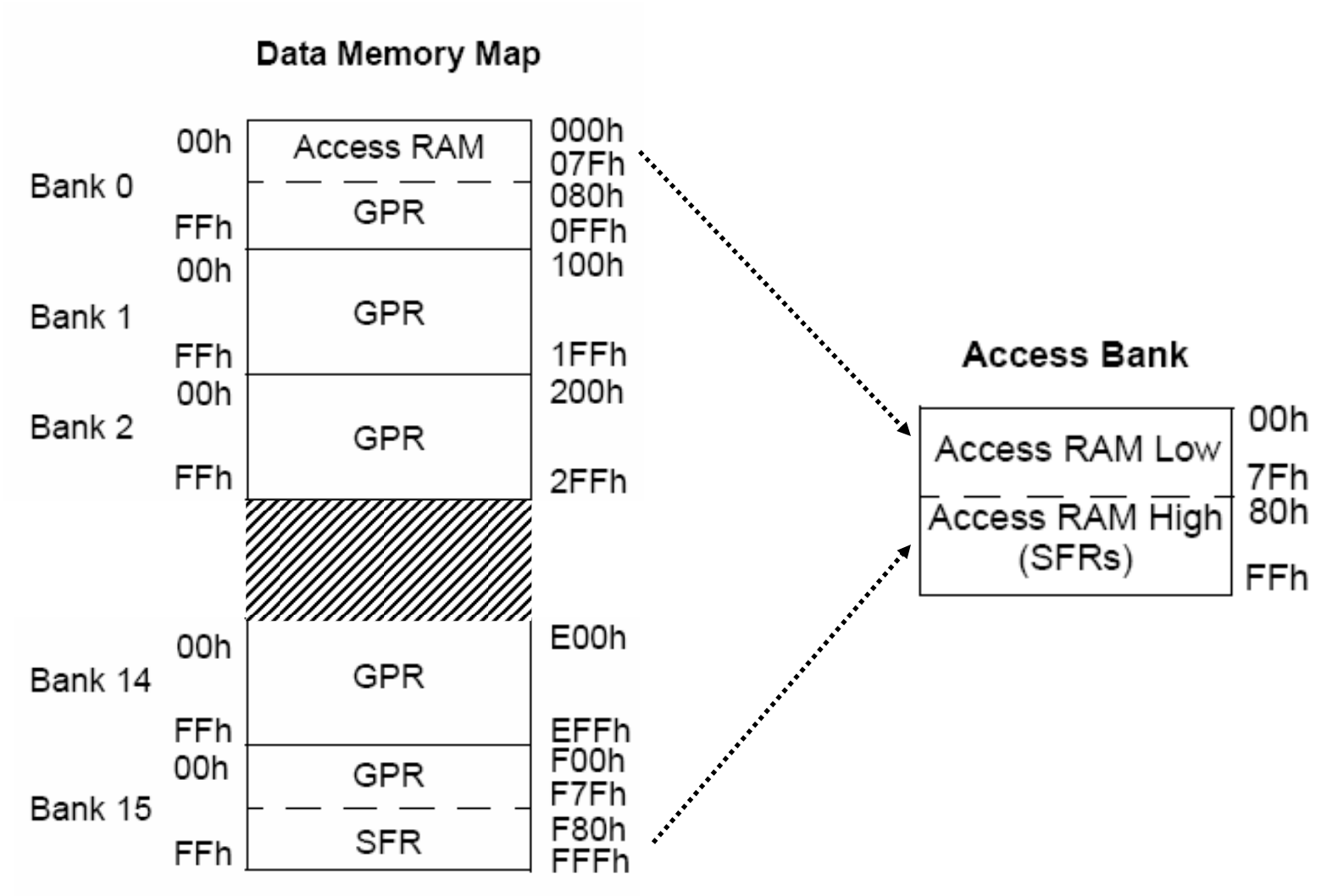
PIC18F4620 Program Memory Map



PIC16F887 Data Memory Map



PIC18F4620 Data Memory Map



Sections

Program Memory Sections

- **CODE**
  - Executable instructions
- **ROMDATA**
  - Constants in program memory

Data Memory Sections (Un-Initialized)

- **UDATA**
  - Uninitialized data in banked data memory
- **UDATA_OVR**
  - Uninitialized *overlay* data in banked data memory
- **UDATA_SHR**
  - Uninitialized data in unbanked data memory (non-PIC18 devices)
- **UDATA_ACS**
  - Uninitialized data in access RAM (PIC18 devices)
- **ACCESS_OVR**
  - Uninitialized *overlay* data in access RAM (PIC18 devices)

Data Memory Sections (Initialized)

- **IDATA**
  - Initialized data in banked data memory
- **IDATA_ACS**
  - Initialized data in access RAM (PIC18 devices)

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Declaring Sections

- **Syntax**

  `{Name}  <Section> {Address}`

  – name and address are *optional*

Note:	Two sections in the same source file are ***not*** permitted to have the same name.

Default Section Names

- For each assembly file, the assembler **creates a *default section*** of each type

Example: For file `foo.asm`

.<type>	.<type>_<filename>
Midrange Devices	**PIC18**
`.code`	`.code_foo.o`
`.idata`	`.idata_foo.o`
`.udata`	`.udata_foo.o`
`.romdata`	`.romdata_foo.o`

Declaring Variables

- **Syntax**

```
<name>   RES     <byte_size>
```

  - all fields are REQUIRED

```
DATA_TBL    UDATA
ONE_BYTE    RES     1
ONE_WORD    RES     2
```

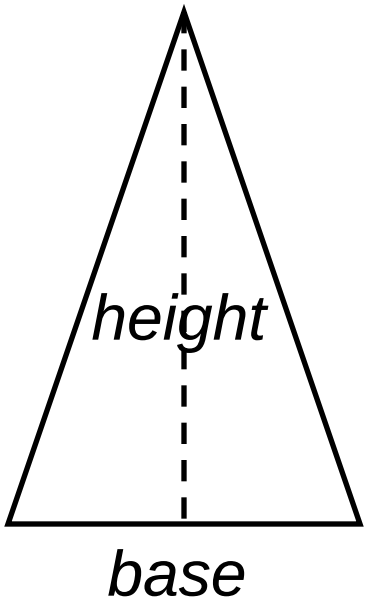
Declaring Variables (contd.)

- **Syntax**

```
<name>    DB     <init_value>
or
<name>    DW     <init_value>
or
<name>    RES    <byte_size>
```

  - **all fields are REQUIRED**

```
TRIANGLE    IDATA    0x130
BASE        DB       0x30
HEIGHT      DW       0x1000
AREA        RES      2
```



Section Examples

afile.asm

```
                udata_acs
Speed           res     1
Temperature     res     1

                idata
SetPoint        dw      0x1234

ISR_vector      code    0x0008
                goto    hi_ISR
```

IDATA Considerations

- **IDATA sections create a table of the initialization values in Program Memory**
- **Code is needed to copy this information into Data Memory**
- **This can be done using:**
  - C18 startup routines (C018i.o,C018iz.o)
  - IDASM16.ASM for Mid-range devices

Demo

Using IDATA

MPASM™ Assembler Linker Support Overview

Absolute Code

- **Use `ORG` directive to specify location of code in program memory**
- **Use `EQU` or `CBLOCK` directive to assign variable addresses**

Relocatable Code

- **Organize program code and data into sections**
  - Use `CODE` directive for Program Memory
  - Use `UDATA/IDATA` directives for Data Memory
- **Reserve space with `RES, DB, DW` directives**
- **Memory allocation is handled by MPLINK™ Linker**

Scope

Scope

- The part of a project where a symbol (variable or function) is "visible"
- Keeps symbols in different parts of the program distinct from one another
- In assembly, all symbols have file scope

Exporting Symbols

- Allows one module to access a subroutine or data from another module
- Export symbols from an MPASM™ assembler source file with the `GLOBAL` directive
- Format: `GLOBAL` *symName*

Importing Symbols

- Allows one module to access a subroutine or data from another module
- Import symbols into an MPASM™ assembler source file with the **EXTERN** directive
- Format: **EXTERN** *symName*

Importing/Exporting Symbols

declare.asm

```
   LIST   P=18F4620
   #INCLUDE "p18F1620.INC"

   GLOBAL mpy

mpy
   <subroutine code>
   return

   END
```

Exporting a symbol

reference.asm

```
   LIST   P=18F4620
   #INCLUDE "p18F1620.INC"

   EXTERN mpy

   call mpy

   END
```

Importing a symbol

Lab 1

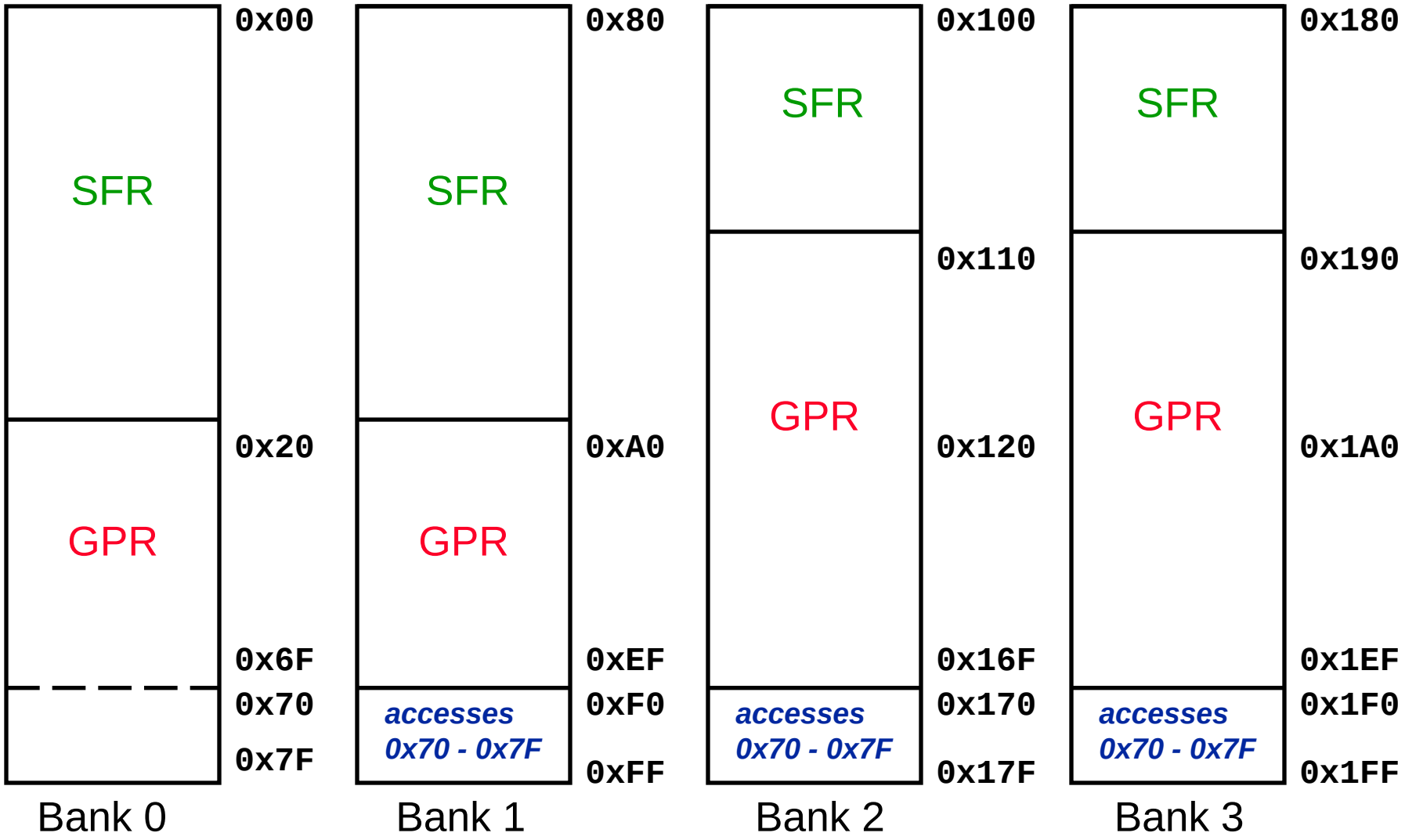
Migrating from Absolute Assembly Code

Lab 1
Migrating from Absolute Assembly

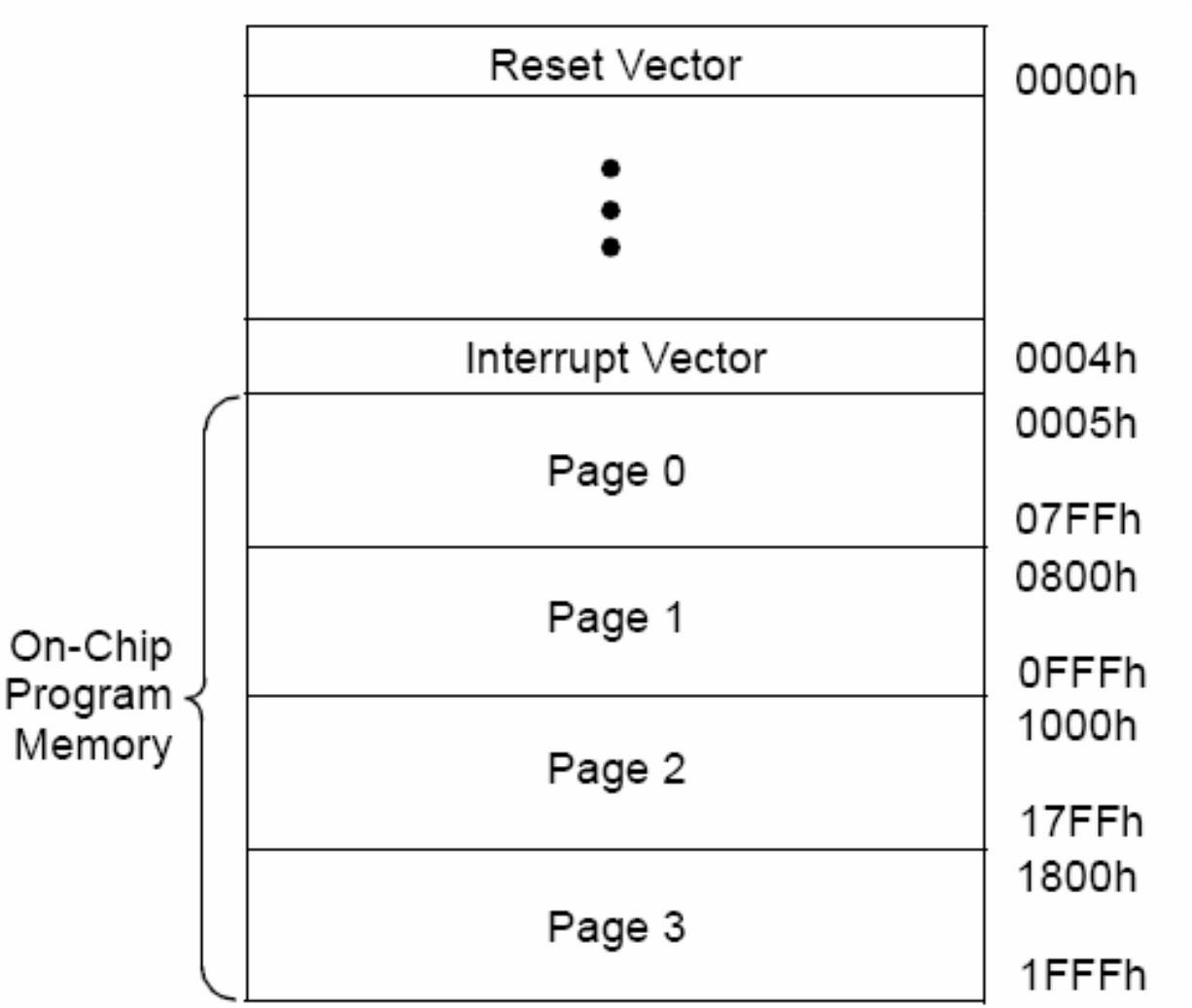
- **Reorganize program into sections**
  - CODE
    - **ORG → CODE sections**
  - DATA
    - **EQU → UDATA sections**
      RES statements
- **See handout for additional instructions.**

Banking and Paging

PIC16F887 Data Memory Map



PIC16F887 Program Memory Map



Banking and Paging Issues

- **Problem:**
  - Since sections are relocatable, we do not necessarily know where a section will reside
- **Question:**
  - How do we access these variables if we don't know what bank our variables are in or what page our code is in?

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BANKSEL and PAGESEL

- We can use the **BANKSEL** and **PAGESEL** directives!
- These directives act like an internal macro

BANKSEL	PAGESEL
bank selection of Data Memory	page selection of Program Memory

BANKSEL

- **BANKSEL sets the bank selection bits to access the correct Data Memory location**

```
BANKSEL     MyVariable
clrf        MyVariable
```

might generate:

```
bcf         STATUS, RP0
bsf         STATUS, RP1
```

PAGESEL

- **PAGESEL sets the page (PCLATH or page select bits) to access the correct page of Program Memory**

```
PAGESEL     MyFunction
call        MyFunction
```

might generate:

```
bsf         PCLATH, 3
bcf         PCLATH, 4
```

BANKSEL and PAGESEL

```
; define processor
    list    p=16f887
; SFR and config bit definitions
    #include    <p16f887.inc>
    EXTERN      delay100

MAIN    CODE
start
    PAGESEL     delay100
    call        delay100
    ...
```

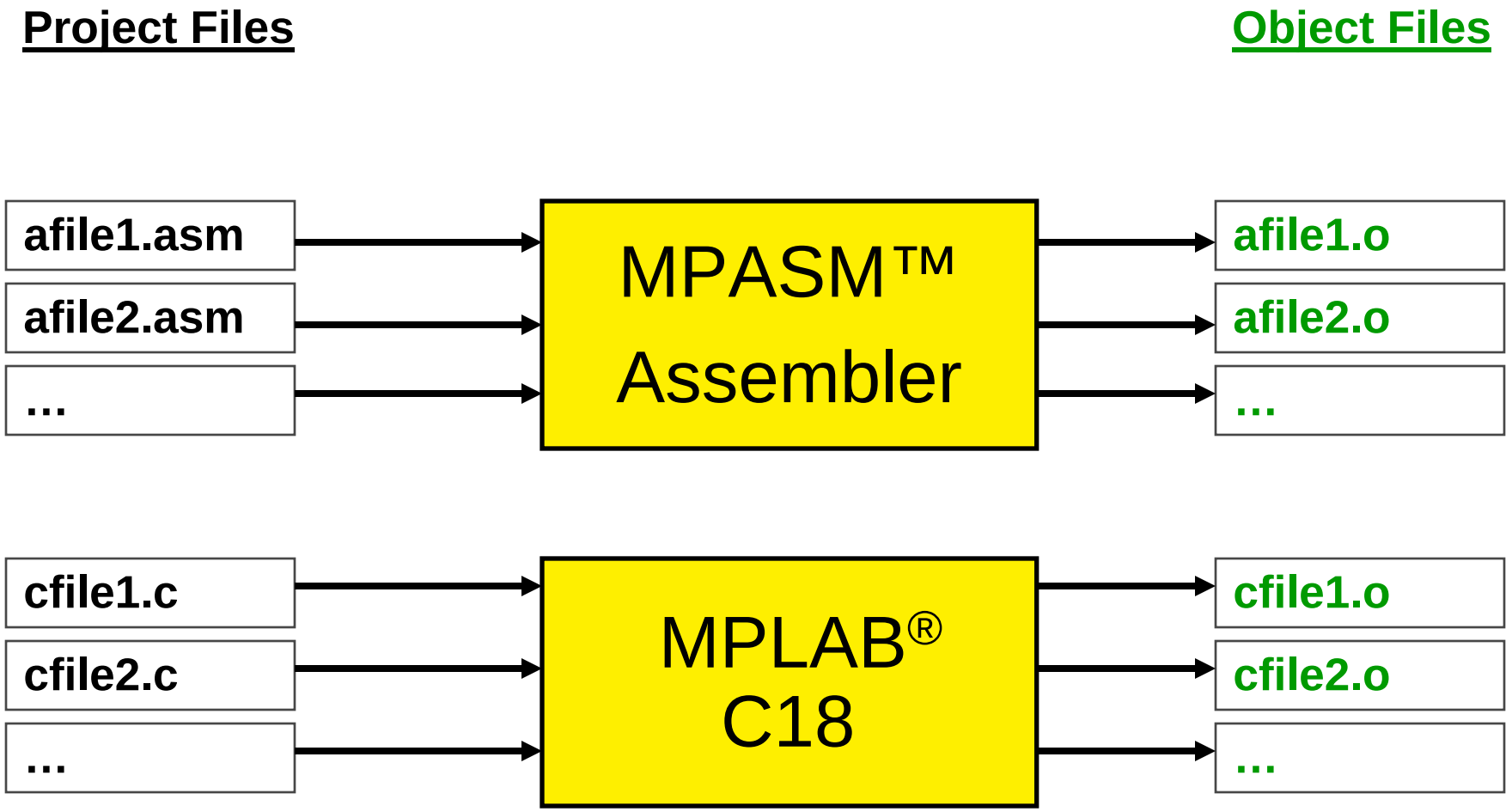
```
; define processor
    list    p=16f887
; SFR and config bit definitions
    #include    <p16f887.inc>
    GLOBAL      delay100

    UDATA
delay_count     RES 1

DELAY   CODE
delay100
    movlw       .101
    BANKSEL     delay_count
    movwf       delay_count
Lp: decfsz      delay_count, F
    goto        Lp
    return
```

MPLINK™ Linker

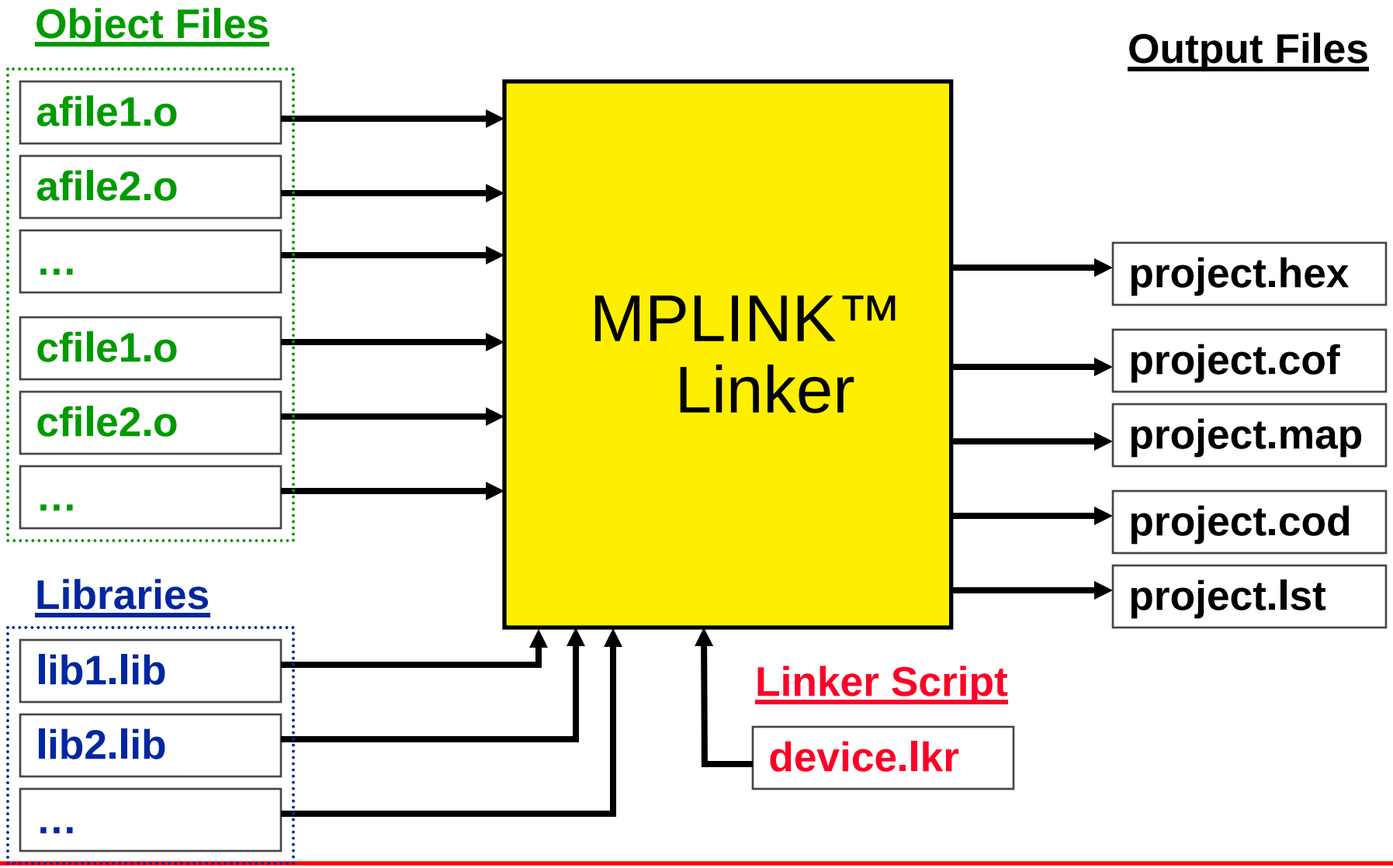
Object Files

- Object files are the relocatable code produced from source files
- If *any* section (subroutine or variable) within the object file is used, the *entire* object is placed into Program/Data Memory
- If *no* sections are used, the object is *not placed* into memory

Build Process - Compilation



Build Process - Linking



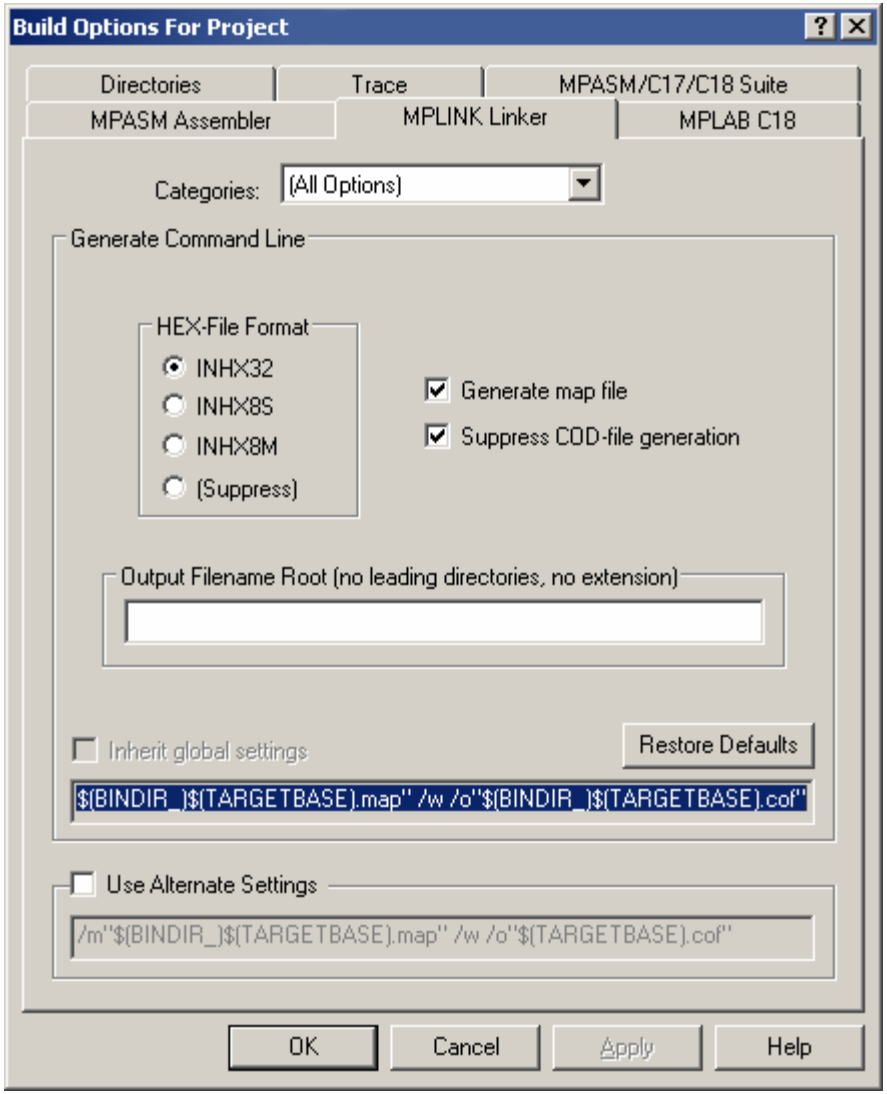
Linker Outputs

- **HEX file (.hex)**
  - Binary image with no debug information
- **COFF file (.out, .cof)**
  - Program code + debug information used by MPLAB® IDE v6.xx & later
- **Code file (.cod)**
  - Simplified version of COFF file used by MPLAB IDE v5.xx & earlier

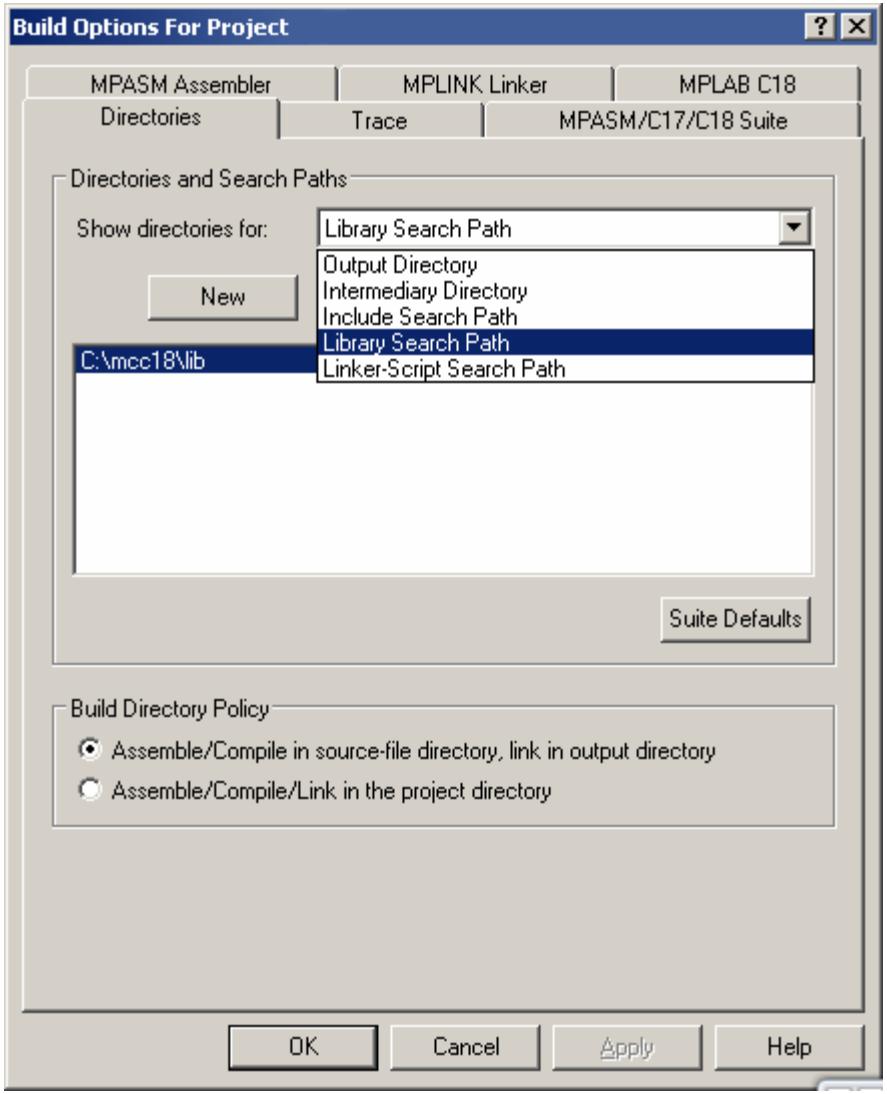
Linker Outputs (contd.)

- **Listing file (.lst)**
  - Original source code side-by-side with final assembly code
- **Map file (.map)**
  - Shows the memory layout after linking, indicates used and unused memory regions

MPLINK™ Linker Build Options



MPLINK™ Linker Build Options



MPLINK™ Linker Placement Algorithm

1. Place all absolute sections

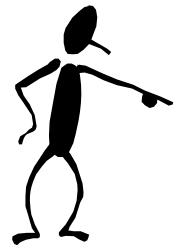
2. Place all assigned sections, using best-fit algorithm

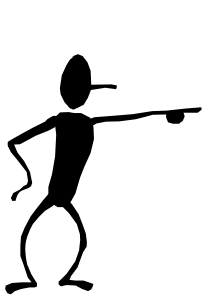
3. Place all unassigned sections, using best-fit algorithm

Linker Scripts

Linker Scripts

- **Linker scripts direct the linker in placement of code and variables**
- **They describe:**
  - Memory Regions
  - Logical Sections
  - Stack Size and Location





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Example Linker Script

modified C18 18F4620i.LKR

Command Line Options

```
LIBPATH .

FILES c018i.o
FILES clib.lib
FILES p18f4620.lib
```

Memory Region

```
CODEPAGE   NAME=vectors    START=0x0          END=0x29          PROTECTED
CODEPAGE   NAME=page       START=0x2A         END=0xFD7F
CODEPAGE   NAME=debug      START=0xFD80       END=0xFFFF        PROTECTED
CODEPAGE   NAME=idlocs     START=0x200000     END=0x200007      PROTECTED
CODEPAGE   NAME=config     START=0x300000     END=0x30000D      PROTECTED
CODEPAGE   NAME=devid      START=0x3FFFFE     END=0x3FFFFF      PROTECTED
CODEPAGE   NAME=eedata     START=0xF00000     END=0xF003FF      PROTECTED

ACCESSBANK NAME=accessram  START=0x0          END=0x7F
DATABANK   NAME=gpr0       START=0x80         END=0xFF
DATABANK   NAME=gpr1       START=0x100        END=0x1FF
DATABANK   NAME=gpr2       START=0x200        END=0x2FF
…
DATABANK   NAME=gpr14      START=0xE00        END=0xEF3
DATABANK   NAME=dbgspr     START=0xEF4        END=0xEFF         PROTECTED
DATABANK   NAME=gpr15      START=0xF00        END=0xF7F
ACCESSBANK `NAME=accesssfr  START=0xF80         END=0xFFF          PROTECTED
```

Logical Sections

```
SECTION    NAME=CONFIG     ROM=config
SECTION    NAME=DEEPROM    ROM=eedata
```

Stack

```
STACK      SIZE=0x100       RAM=gpr13
```

Command Line Options

modified C18 18F4620i.LKR

```
LIBPATH .

FILES c018i.o
FILES clib.lib
FILES p18f4620.lib
```

Linker Script Directives
Command Line Options

- **FILES**
  - specify source or library files to include in linkage
- **INCLUDE**
  - specify additional linker script files to use for this linkage
- **LIBPATH**
  - specify library search path
- **LKRPATH**
  - specify linker script search path

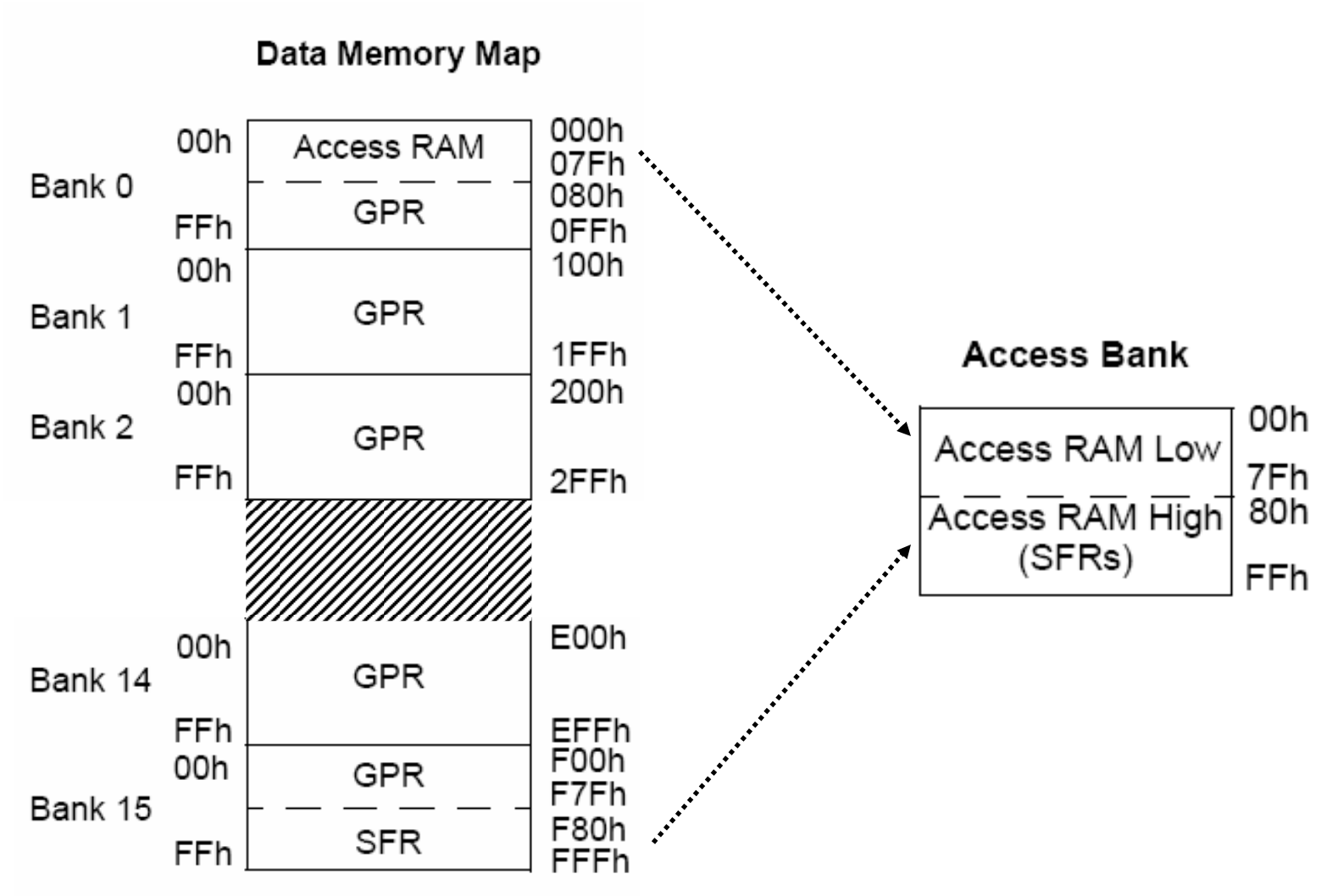
Memory Region

modified C18 18F4620i.LKR

```
CODEPAGE   NAME=vectors    START=0x0        END=0x29        PROTECTED
CODEPAGE   NAME=page       START=0x2A       END=0xFD7F
CODEPAGE   NAME=debug      START=0xFD80     END=0xFFFF      PROTECTED
CODEPAGE   NAME=idlocs     START=0x200000   END=0x200007    PROTECTED
CODEPAGE   NAME=config     START=0x300000   END=0x30000D    PROTECTED
CODEPAGE   NAME=devid      START=0x3FFFFE   END=0x3FFFFF    PROTECTED
CODEPAGE   NAME=eedata     START=0xF00000   END=0xF003FF    PROTECTED

ACCESSBANK NAME=accessram  START=0x0        END=0x7F
DATABANK   NAME=gpr0       START=0x80       END=0xFF
DATABANK   NAME=gpr1       START=0x100      END=0x1FF
DATABANK   NAME=gpr2       START=0x200      END=0x2FF
…
DATABANK   NAME=gpr14      START=0xE00      END=0xEF3
DATABANK   NAME=dbgspr     START=0xEF4      END=0xEFF       PROTECTED
DATABANK   NAME=gpr15      START=0xF00      END=0xF7F
ACCESSBANK NAME=accesssfr  START=0xF80      END=0xFFF       PROTECTED
```

PIC18F4620 Data Memory Map



Linker Script Directives
Memory Region Description

- **CODEPAGE**
  - Program Memory
- **DATABANK**
  - Banked Data Memory
- **SHAREBANK**
  - Unbanked Data Memory (non-PIC18 core)
- **ACCESSBANK**
  - Access RAM (PIC18 core)

PROTECTED Regions

- *The **PROTECTED** keyword restricts a region to assigned sections only*

```
DEEPROM     CODE
DB    “ABC”
```

```
CODE  0xF00000
DB    “ABC”
```

- **Examples**
  - Bootloaders
  - ICD2

Logical Sections

modified C18 18F4620i.LKR

```
SECTION    NAME=CONFIG      ROM=config
SECTION    NAME=DEEPROM     ROM=eedata
```

From Memory Region description

```
CODEPAGE   NAME=config      START=0x300000        END=0x30000D
…
CODEPAGE   NAME=eedata      START=0xF00000        END=0xF003FF
```

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Linker Script Directives
Logical Section Description

- *Logical Section Syntax:*

```
SECTION NAME=<scn name> ROM=<region name>
SECTION NAME=<scn name> RAM=<region name>
```

Stack

modified C18 18F4620i.LKR

```
STACK       SIZE=0x100              RAM=gpr13
```

Linker Script Directives
Stack Description

- *Stack Definition Syntax:*

```
STACK SIZE=<stack size> {RAM=<region name>}
```

Where can I find my device's linker script?

- **MPASM™ Assembler**
  - C:\Program Files\Microchip\MPASM Suite\LKR
- **MPLAB® C18**
  - C:\MCC18\LKR

Note:

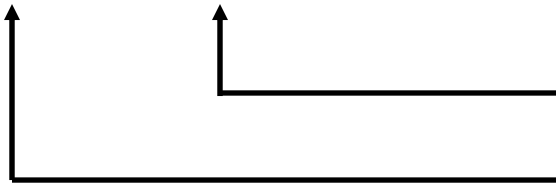
C18's linker scripts must be used in C18 projects.

They include the device's SFR definitions, standard C and peripheral libraries, and startup routines.

Linker Scripts

- **Make sure that you use the correct linker script:**

```
proc[i][_e].lkr
```



Extended Instruction Set

ICD2 Debugging

- **Example:**

	No ICD2	ICD2
Not extended	18f4620.lkr	18f4620i.lkr
Extended	18f4620_e.lkr	18f4620i_e.lkr

Map Files

Map Files

- **Map files provide information on the results of the link process**
- **They detail:**
  - Sections
  - Subroutines/Functions
  - Variables
  - Memory Use

Example Map File

demo0.map

```
                    Section Info
      Section       Type    Address   Location Size(Bytes)
    ---------  ---------  ---------  ---------  ---------
        .code       code   0x000000    program   0x000004
       .cinit    romdata   0x00002a    program   0x00000e
     .idata_i    romdata   0x000038    program   0x000007
       .idata      idata   0x000080       data   0x000007
       .udata      udata   0x000087       data   0x000004

                 Program Memory Usage
                  Start         End
                ---------   ---------
                0x000000    0x000003
                0x00002a    0x00003e
25 out of 66584 program addresses used, program memory utilization is 0%

                  Symbols - Sorted by Name
        Name    Address   Location    Storage File
    ---------  ---------  ---------  --------- ---------
  _.code_0000   0x000000    program     static C:\MASTERs\11034 MPL\LABS\DEMO0\main.asm
     ROMDATA   0x000083       data     static C:\MASTERs\11034 MPL\LABS\DEMO0\main.asm
   idata_var0   0x000082       data     static C:\MASTERs\11034 MPL\LABS\DEMO0\main.asm
   idata_var1   0x000080       data     static C:\MASTERs\11034 MPL\LABS\DEMO0\main.asm
 romdata_var0   0x000085       data     static C:\MASTERs\11034 MPL\LABS\DEMO0\main.asm
 romdata_var1   0x000083       data     static C:\MASTERs\11034 MPL\LABS\DEMO0\main.asm
   udata_var0   0x000089       data     static C:\MASTERs\11034 MPL\LABS\DEMO0\main.asm
   udata_var1   0x000087       data     static C:\MASTERs\11034 MPL\LABS\DEMO0\main.asm

                  Symbols - Sorted by Address
        Name    Address   Location    Storage File
    ---------  ---------  ---------  --------- ---------
  _.code_0000   0x000000    program     static C:\MASTERs\11034 MPL\LABS\DEMO0\main.asm
   idata_var1   0x000080       data     static C:\MASTERs\11034 MPL\LABS\DEMO0\main.asm
   idata_var0   0x000082       data     static C:\MASTERs\11034 MPL\LABS\DEMO0\main.asm
     ROMDATA   0x000083       data     static C:\MASTERs\11034 MPL\LABS\DEMO0\main.asm
 romdata_var1   0x000083       data     static C:\MASTERs\11034 MPL\LABS\DEMO0\main.asm
 romdata_var0   0x000085       data     static C:\MASTERs\11034 MPL\LABS\DEMO0\main.asm
   udata_var1   0x000087       data     static C:\MASTERs\11034 MPL\LABS\DEMO0\main.asm
   udata_var0   0x000089       data     static C:\MASTERs\11034 MPL\LABS\DEMO0\main.asm
```

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Section Info

Section Info

Section	Type	Address	Location	Size(Bytes)
.code	code	0x000000	program	0x000004
.cinit	romdata	0x00002a	program	0x00000e
.idata_i	romdata	0x000038	program	0x000007
.idata	idata	0x000080	data	0x000007
.udata	udata	0x000087	data	0x000004

Program Memory Usage

```
Program Memory Usage
                    Start        End
                  ---------   ---------
                  0x000000    0x000003
                  0x00002a    0x00003e
25 out of 66584 program addresses used,
 program memory utilization is 0%
```

Symbols - Sorted by Name

Symbols - Sorted by Name

Name	Address	Location	Storage	File
_.code_0000	0x000000	program	static	main.asm
ROMDATA	0x000083	data	static	main.asm
idata_var0	0x000082	data	static	main.asm
idata_var1	0x000080	data	static	main.asm
romdata_var0	0x000085	data	static	main.asm
romdata_var1	0x000083	data	static	main.asm
udata_var0	0x000089	data	static	main.asm
udata_var1	0x000087	data	static	main.asm

Symbols - Sorted by Address

Symbols - Sorted by Address

Name	Address	Location	Storage	File
_.code_0000	0x000000	program	static	main.asm
idata_var1	0x000080	data	static	main.asm
idata_var0	0x000082	data	static	main.asm
ROMDATA	0x000083	data	static	main.asm
romdata_var1	0x000083	data	static	main.asm
romdata_var0	0x000085	data	static	main.asm
udata_var1	0x000087	data	static	main.asm
udata_var0	0x000089	data	static	main.asm

Good Practices

Using #define

#define Pinouts

- **Use #define statements to define pins used in one central location**

```
; LCD Pins
#define LCDEN      PORTA, 1
#define LCDRW      PORTA, 2
#define LCDREGSEL  PORTA, 3
```

#define Overview

- **A #define statement simply is a text substitution when used**

```
#define MYLABEL  PORTD, 4


bcf MYLABEL   ;
```

turns into:

```
bcf PORTD, 4   ;
```

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Using #define

- **Use:**

```
#define LCDEN    PORTA, 4
bcf   LCDEN      ; Set EN low
```

- **Use for C18:**

```
#define LCDEN    PORTAbits.RA4
LCDEN = 0;       // Set EN low
```

Benefits To #define

- **Changing a #define changes all uses of that definition**

  (easy update/migration of file)

- **More 'readable' code**

  (names not numbers)

Function Size

Split Up Large Functions

- **Split large functions into smaller functions which are reusable**
  - Allows for easier reuse by other parts of your project
  - Improves reuse in future projects

- **Downside**
  - Many nested calls may lead to stack overflow

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Paging and Banking Tips

Banking

- **Use at the start of a call.**
  Assume prior bank is unknown.

```
LoadVariable:
    BANKSEL  MyVariable ;Before use
    movlw    0xFF
    movwf    MyVariable
    return
```

PAGESEL

- **Use PAGESEL before a call to an external label.**
  Assume page is unknown.

```
    .
    .
PAGESEL LoadVariable
call    LoadVariable
    .
    .
```

PAGESEL

- Each SECTION must fit in a page, and so calls within that SECTION are safe
- Calls to external labels are key points for potential error

Improper Use of BANKSEL & PAGESEL

- **Improper bank and page selection:**
  - Won't throw a build or link error
  - May cause erratic behavior
  - Are very frustrating to debug!

Banksel & Pagesel Summary

- **Use `BANKSEL` liberally to ensure proper banking at all times**

- **Projects larger than one page of Program Memory must:**
  - Use **`PAGESEL`** to ensure proper behavior

Common Linker Errors

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Oversize Section

- Symptom:
  “section ‘.udata_test.o’ can not fit the section.

  Section ‘.udata_test.o’ length = 0x0000012c”

- Remedy:
  Use the error map file to see how memory was allocated when a failure occurred.

Oversize Section

Questions:

- **Does my data/code size exceed the parts resources?**
  - Enable optimizations
  - Move data between shared/GPR/access memories
- **Are my sections bigger than available memory regions?**
  - Break into smaller chunks

Undefined Symbol

- **Symptom:**

  “Error – could not find definition of symbol ‘FSR2L’ in file ‘./test.o’.”

Undefined Symbol

- **Questions:**
  - For MPLAB® C18, use compiler linker scripts, not the MPASM™ assembler linker scripts
  - Is your library search path correct?
  - Are all source files and libraries included?
  - Are all labels (symbols) properly defined? *(does other file use* **`global`***)*
  - Verify file containing symbol exists on linker command line *(make sure it is included in the link)*

Lab 2

Creating a Multi-file Project

Lab 2
Creating a Multi-file Project

- **See handout for instructions.**

Libraries

Using MPLIB™ Librarian

What is a Library?

- A collection of .o files placed into a .lib, library file
- Allows grouping of logical reusable subroutines

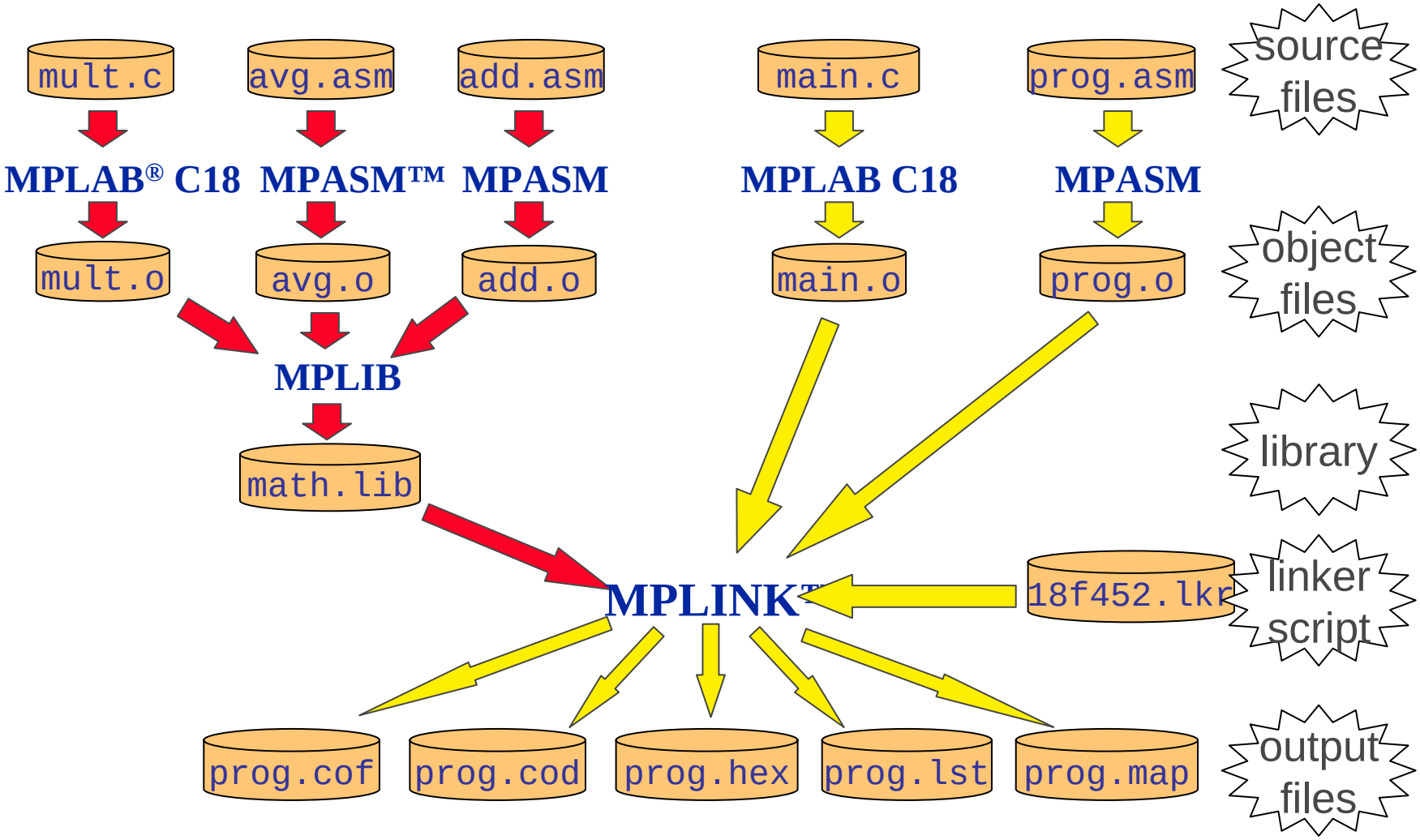
Other Benefits to a .lib

- **Must only link a single file**
  math.lib VS mult.o, div.o, add.o ...

- **Only .o files called within the project are used during linking and build.**
  (minimum space used)

- **Example:**
  Using multiply call from within math.lib does not use division calls from div.o

MPLINK™ Linker Build Process



Making Library Files

- **Two Options:**
  1. MPLAB® IDE Interface
  2. Command Line

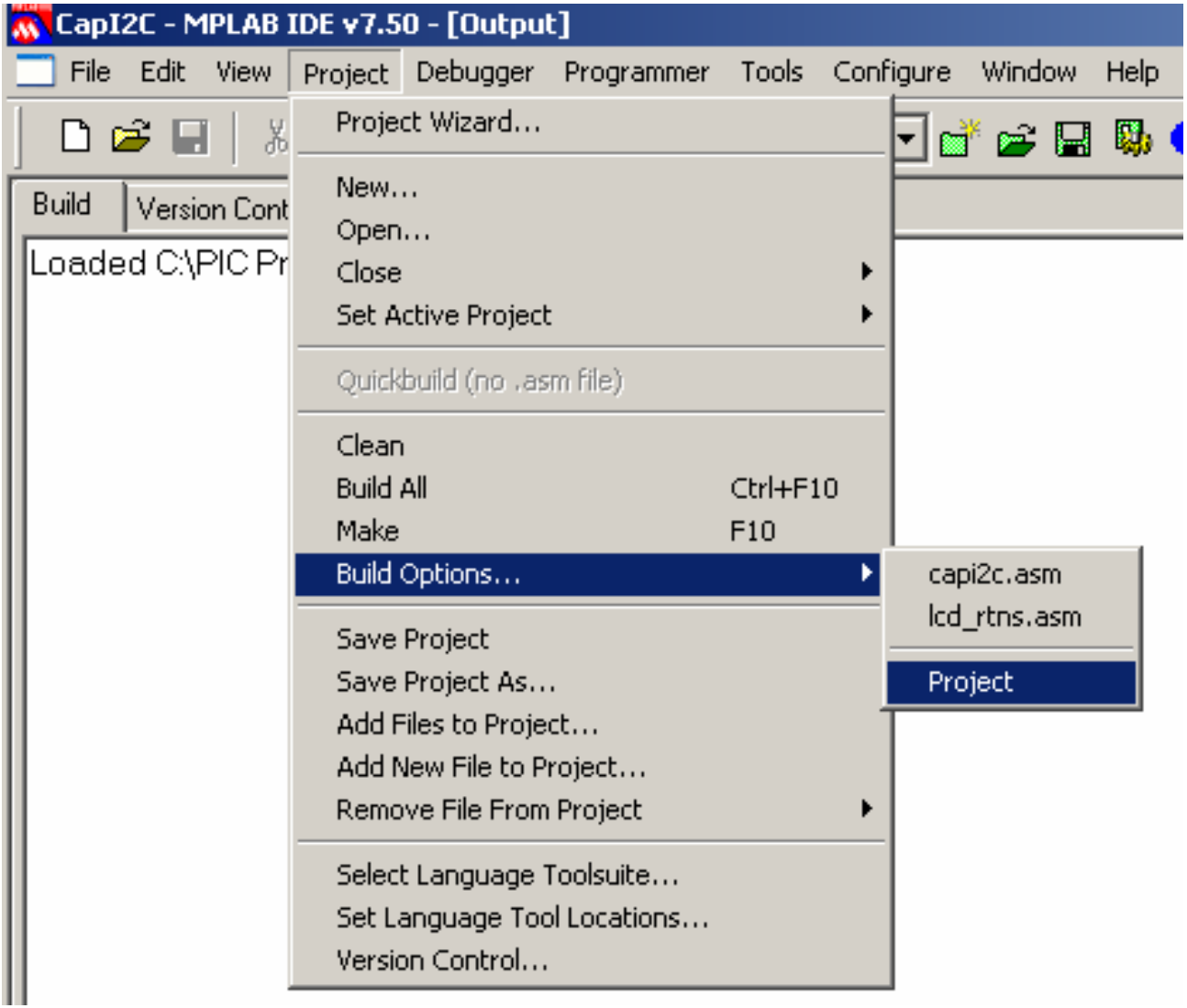
MPLAB® IDE Interface

MPLAB® IDE Interface

- **Easy GUI Interface**
- **Output .lib instead of .hex**
- **Change Project Build Options:**

  Project>Build Options>Project…
  (Opens new window)

MPLAB® IDE Interface



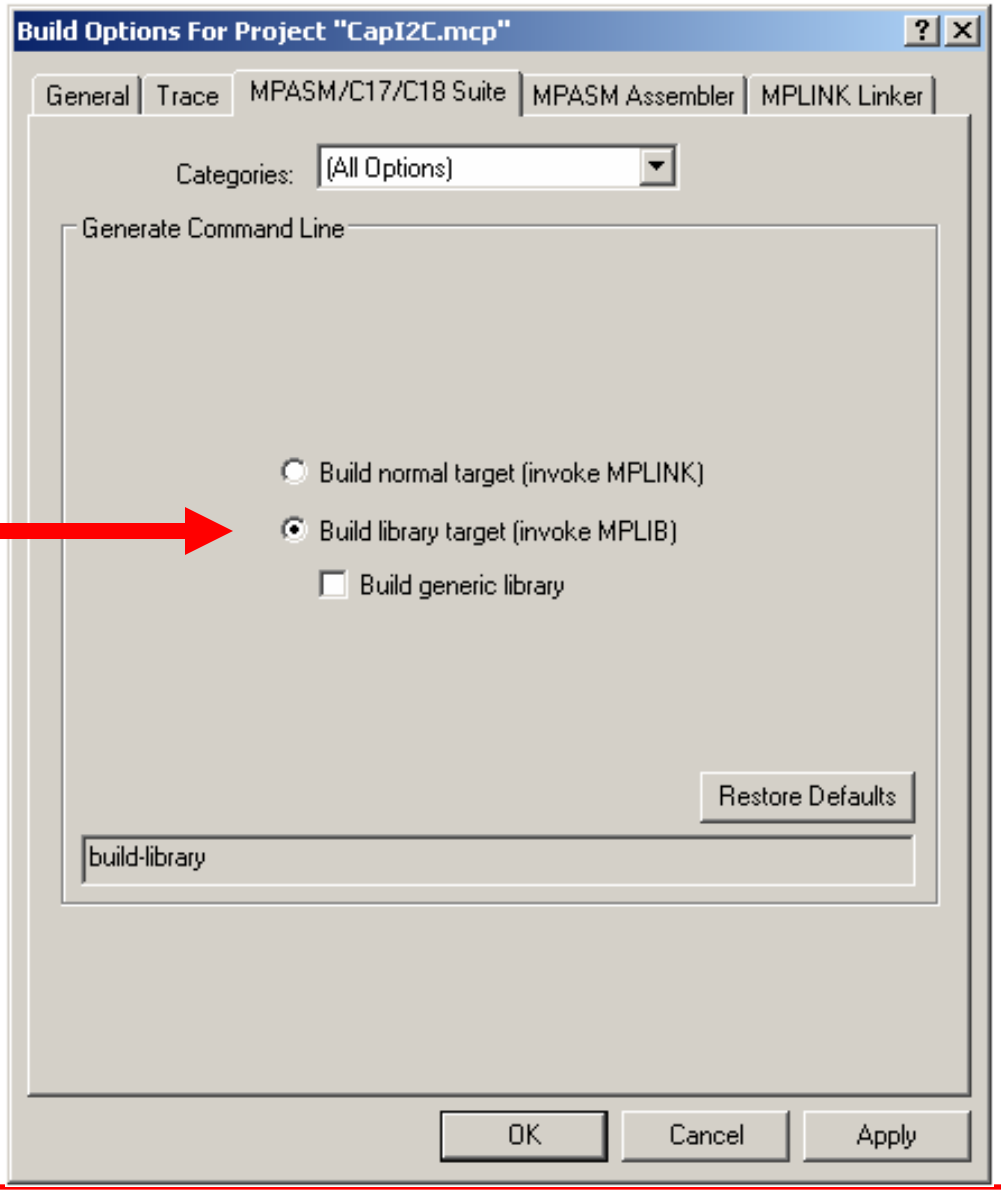
MPLAB® IDE Interface

- **With Project Window Open…**

- **Perform Two Steps:**
  1. Select MPASM/C17/C18 Suite Tab
  2. Check Radio Button
     "Build Library Target (invoke MPLIB)"

MPLAB® IDE Interface

Invoke MPLIB™ Librarian



Command Line Interface

Command Line Interface

- **Use:**

```
mplib [/q] /{ctdrx} LIBRARY [MEMBER...]
```

Option	Description
/c	Create Library
/d	Delete Member
/q	Quiet Mode
/r	Add/Replace Member
/t	List Members
/x	Extract Member

MPLAB® IDE Interface only uses this option.

Command Line Interface

- **Why use the command line?**
  - Manual and exact control for managing a library file's contents
  - Editing a library file built from a project
  - Automated Batch File Processing

Interface Summary Suggestion

- **Use MPLAB® IDE when creating a new library file**
  - Organize each desired .o as a file
  - Keep each .o as small as possible (Entire .o is linked for just 1 call)
  - Setup the project to output a .lib file
  - Build the project

Creating .lib Files

Creating Library Files

- **Elements of a good library:**
  - Subroutines/Functions which will be used often, but only written once
  - Clearly defined and documented interface for calls into the library

Creating Library Files

- **Exported Names**
  - Only 1 Instance of an exported name allowed via **`global`** directive
  - Applies across all .o files
  - If another .o file attempts to export the same name, an error occurs

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Creating Library Files

8 and 16-bit addition: Sum = A + B

"add8.asm"

```
global A
global B
global Sum
```

"add16.asm"

```
global A
global B
global Sum
```

MPLIB™ Librarian Error!

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Creating Library Files

8 and 16-bit addition: Sum = A + B

"add8.asm"

```
global A8
global B8
global Sum8
```

"add16.asm"

```
global A16
global B16
global Sum16
```

MPLIB™ Librarian Success

Creating Library Files

- **Suggested Naming Convention**
- **Use module descriptor at start of Label, Function, or Variable**

```
LCD_SendData
LCD_Clear
LCD_Goto
```

Creating Library Files

- When creating a library file, also create associated header file
- Useful to define all exported calls, variables, #defines located within the library
- Helps document the library file

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Include File

- **Import Calls and Variables**

- **To use math.lib file:**

"math.inc"

```
extern A8          ; Import
extern B8          ; variables
extern Sum8        ; and call
extern Add8        ; from
                   ; add8.o
```

Using a Library File

- `#include` your .inc/.h file in your assembly or C code
- Link in your .lib file
- Use your library calls

Lab 3

Creating and Using Libraries

Lab 3
Creating and Using Libraries

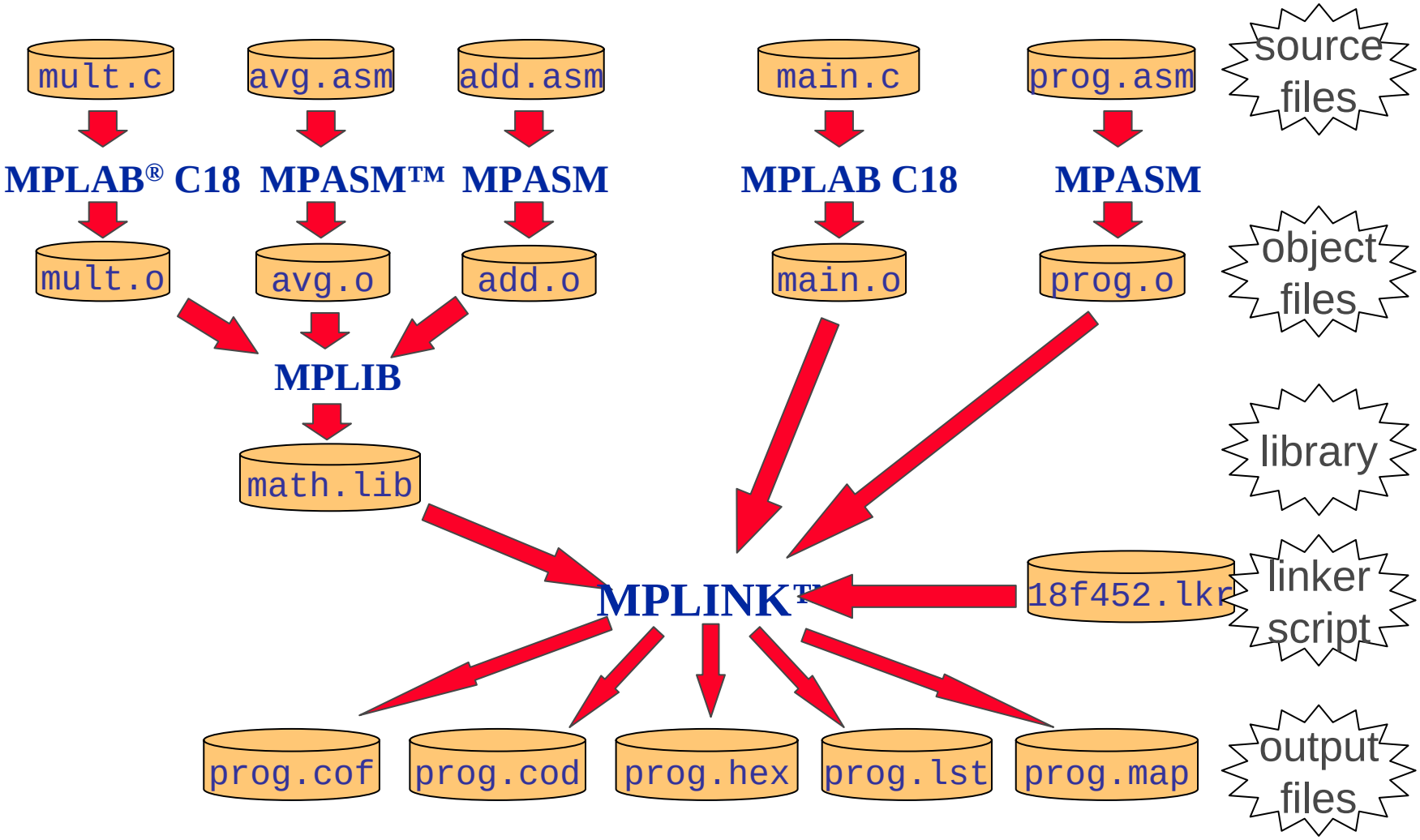
- **See handout for instructions.**

Summary

Summary

- **Relocatable code is:**
  - Modular
  - Flexible
  - Easy to use/reuse
  - Well suited for large projects

MPLINK™ Linker Build Process



MPLINK™ Linker Summary

- MPLINK Linker converts object files to an executable .hex file
- Source file inputs: .lib, .o, .lkr
- Linker script (.lkr) directs linker placement of variables and code from object (.o) and library (.lib) files

MPLIB™ Librarian Summary

- Creates a collection of object files from MPASM™ assembler or C18 .o files
- Use Build option to create .lib file
- Library files may be used in full or partially as needed
- Document your library!

Dev Tools used in this class

- **DV164006 – PICDEM™ 2 Plus Kit**
  - DM163022 - PICDEM 2 Plus board
  - DV164007 – MPLAB® ICD 2

Additional References

- DS33014 - MPASM™ Assembler/MPLINK™ Linker/MPLIB™ Librarian User's Guide
- MPLINK Linker and MPLIB Librarian documentation is available from within MPLAB® IDE

Other MASTERs Classes

- 11001 GS1 - Getting Started w/ Microchip Tools
- 11002 GS2 - Getting Started w/ Mid-Range Microcontroller Family
- 11003 GS3 Getting Started w/ PIC18

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