University of San Carlos | Department of
COMPUTER ENGINEERING

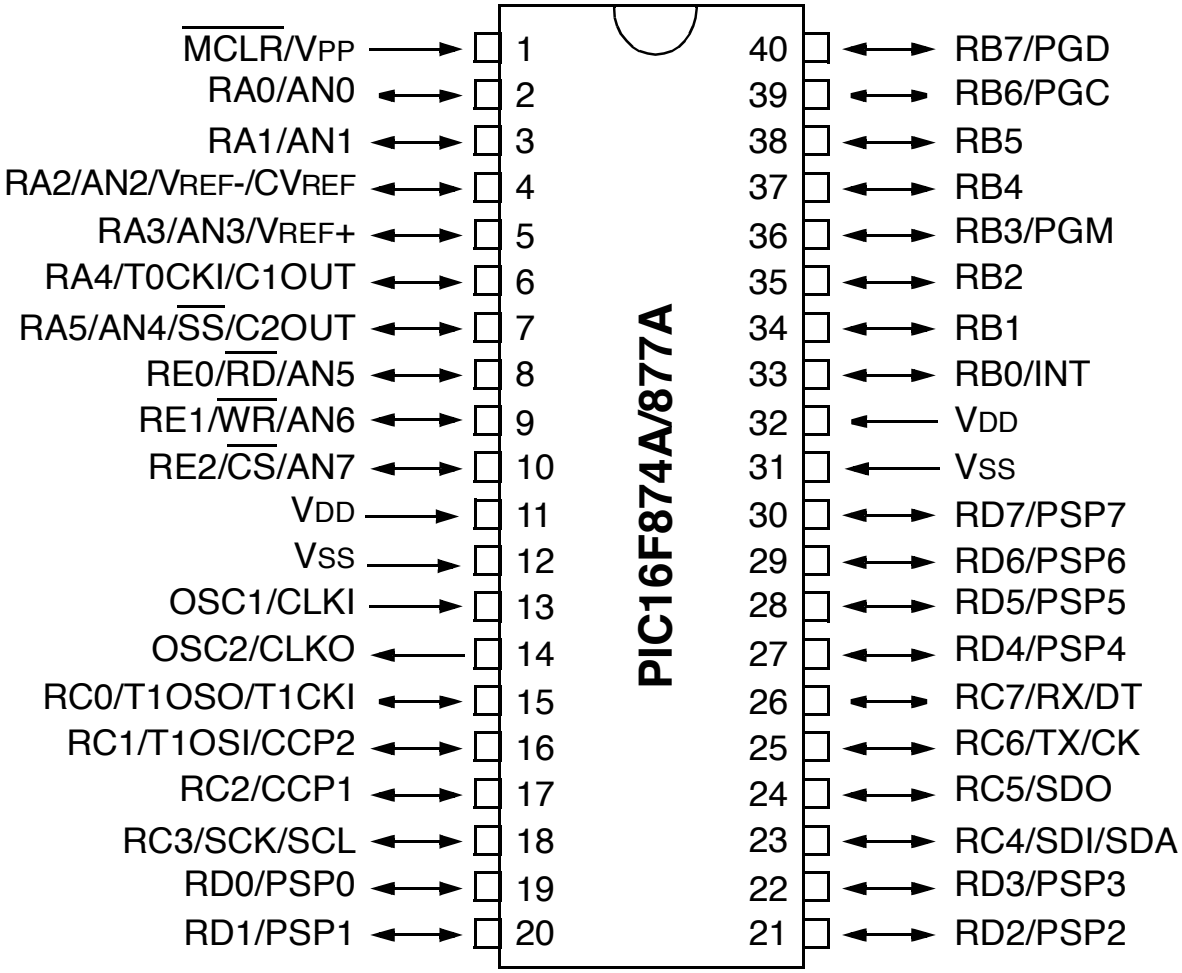
CpE 3201
Embedded Systems

Introduction to Embedded Systems

About PIC16F877A

- Mid-range 8-bit MCU from Microchip
- Shares the same architecture as PIC16F84A as well as other MCU in the PIC16FXX series
- Has a larger program memory about 8x the one in the PIC16F84A
- More I/O ports which is deal for multiple I/O interfacing

40-Pin PDIP


PIC16F874A/877A
MCLR/VPP 1
RA0/AN0 2
RA1/AN1 3
RA2/AN2/VREF-/CVREF 4
RA3/AN3/VREF+ 5
RA4/T0CKI/C1OUT 6
RA5/AN4/SS/C2OUT 7
RE0/RD/AN5 8
RE1/WR/AN6 9
RE2/CS/AN7 10
VDD 11
VSS 12
OSC1/CLKI 13
OSC2/CLKO 14
RC0/T1OSO/T1CKI 15
RC1/T1OSI/CCP2 16
RC2/CCP1 17
RC3/SCK/SCL 18
RD0/PSP0 19
RD1/PSP1 20
40 RB7/PGD
39 RB6/PGC
38 RB5
37 RB4
36 RB3/PGM
35 RB2
34 RB1
33 RB0/INT
32 VDD
31 VSS
30 RD7/PSP7
29 RD6/PSP6
28 RD5/PSP5
27 RD4/PSP4
26 RC7/RX/DT
25 RC6/TX/CK
24 RC5/SDO
23 RC4/SDI/SDA
22 RD3/PSP3
21 RD2/PSP2

High Performance RISC CPU

- Only 35single - word instructions to learn
- All single - cycle instructions except for program branches, which are two-cycle
- Operating speed:DC – 20M Hz clock input
  DC – 200 ns instruction cycle
- Up to 8K x 14 words of Flash Program Memory,
  Up to 368 x 8 bytes of Data Memory (RAM), Up to 256 x 8 bytes of EEPROM Data Memory
- Pinout compatible to other 28-pin or 40/44-pin PIC16CXXX and PIC16FXXX microcontrollers

Peripheral Features

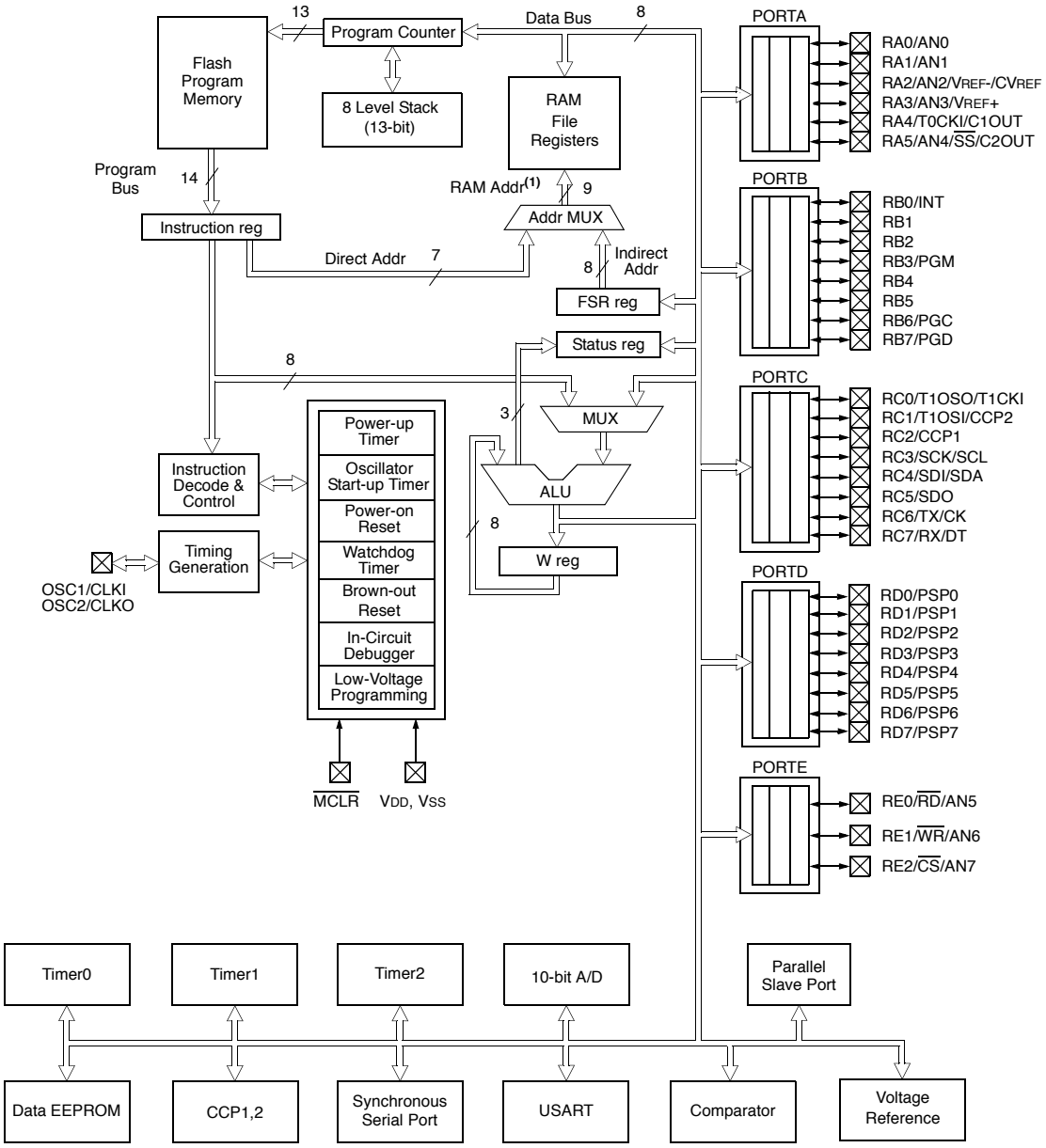
- **Timer0:** 8-bit timer/counter with 8-bit prescaler
- **Timer1:** 16-bit timer/counter with prescaler, can be incremented during Sleep via external crystal/clock
- **Timer2:** 8-bit timer/counter with 8-bit period register, prescaler and postscaler
- Two Capture, Compare, PWM modules (CCP)
  - Capture is 16-bit, max. resolution is 12.5 ns
  - Compare is 16-bit, max. resolution is 200 ns
  - PWM max. resolution is10-bit

Peripheral Features

- Synchronous Serial Port (SSP) with SPI™ (Master mode) and I2C™ (Master/Slave)
- Universal Sy nchronous Asynchronous Receiver Transmitter (USART/SCI) with 9-bit address detection
- Parallel Slave Port (PSP) – 8 bits wide with external RD, WR and CS controls (40/44-pin only)
- Brown-out detection circuitry for Brown-out Reset (BOR)

Analog Features

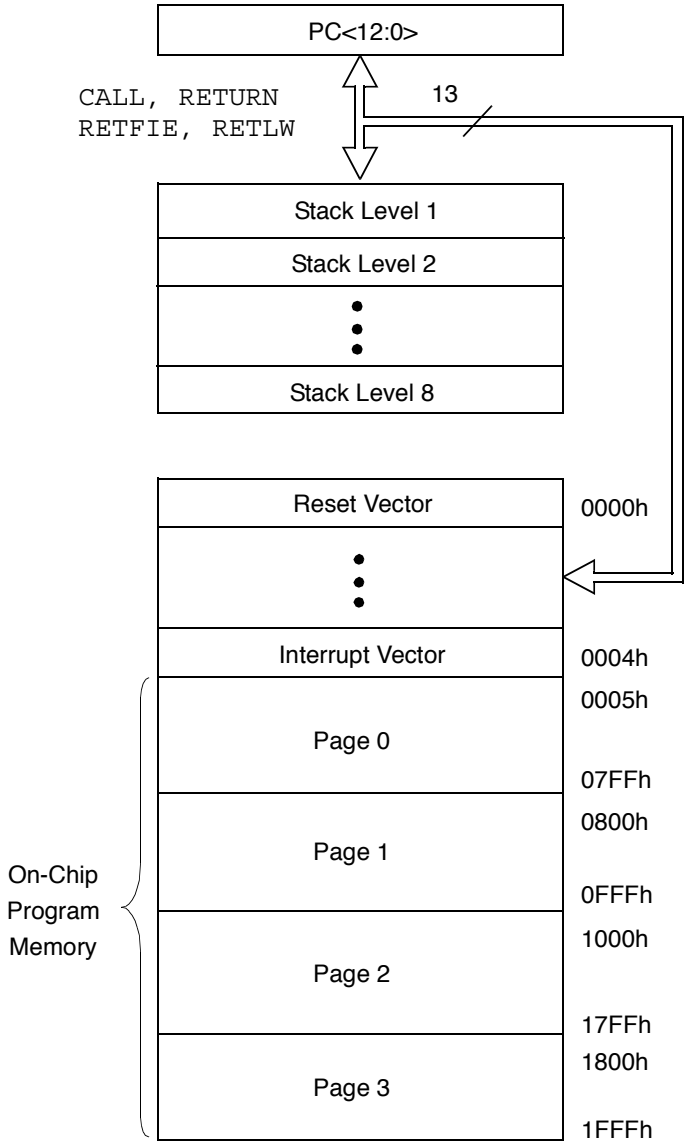
- 10-bit, up to 8-channel Analog-to-Digital Converter (A/D)
- Brown-out Reset (BOR)
- Analog Comparator module with:
  - Two analog comparators
  - Programmable on-chip voltage reference (VREF) module
  - Programmable input multiplexing from device inputs and internal voltage reference
  - Comparator outputs are externally accessible



Block Diagram of PIC16F87xx

Memory Organization

- There are three memory blocks in each of the PIC16F87XA devices
- The program memory and data memory have separate buses so that concurrent access can occur

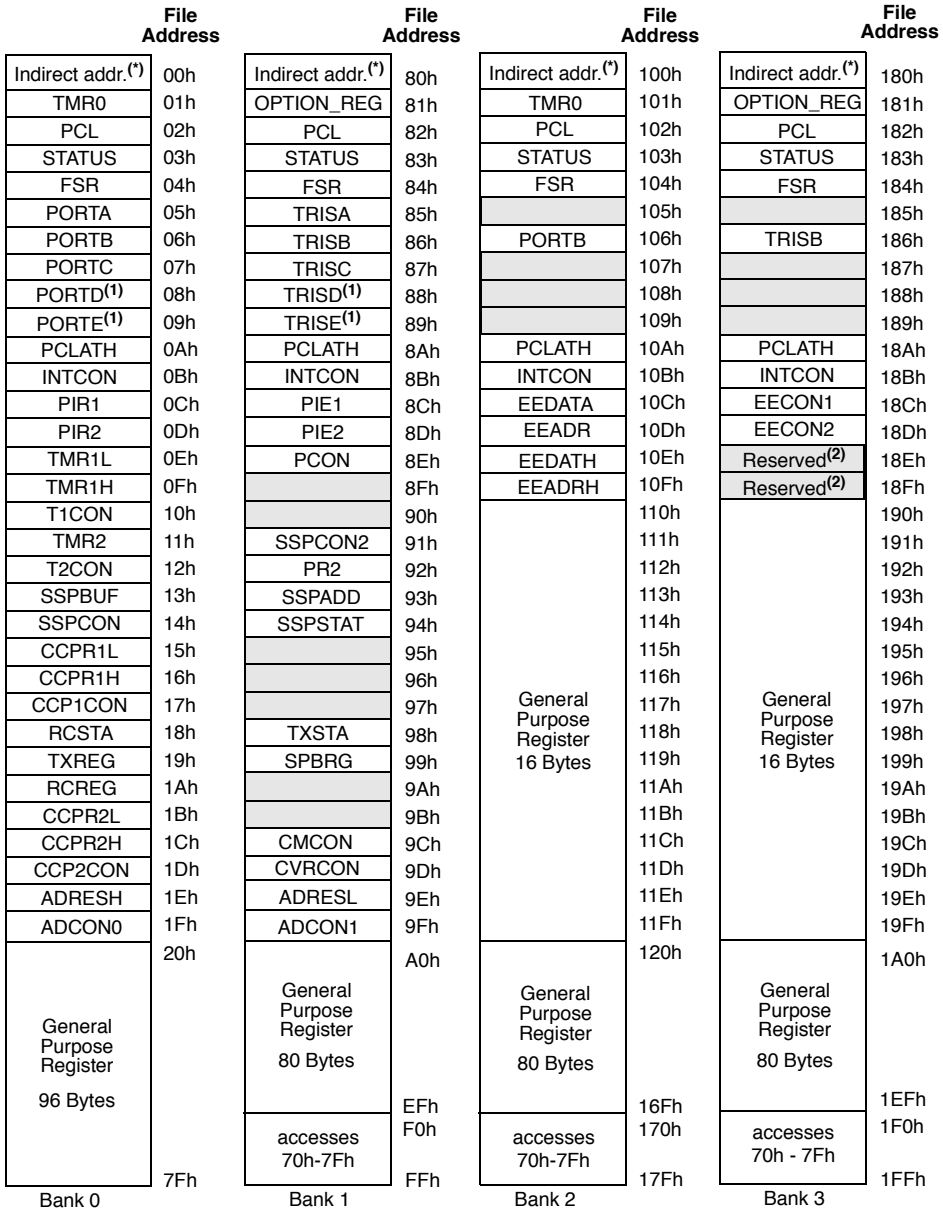


Program Memory Map & Stack

Data Memory Organization

- The data memory is partitioned into multiple banks which contain the General Purpose Registers and the Special Function Registers. Bits RP1 (Status<6>) and RP0 (Status<5>) are the bank select bits.

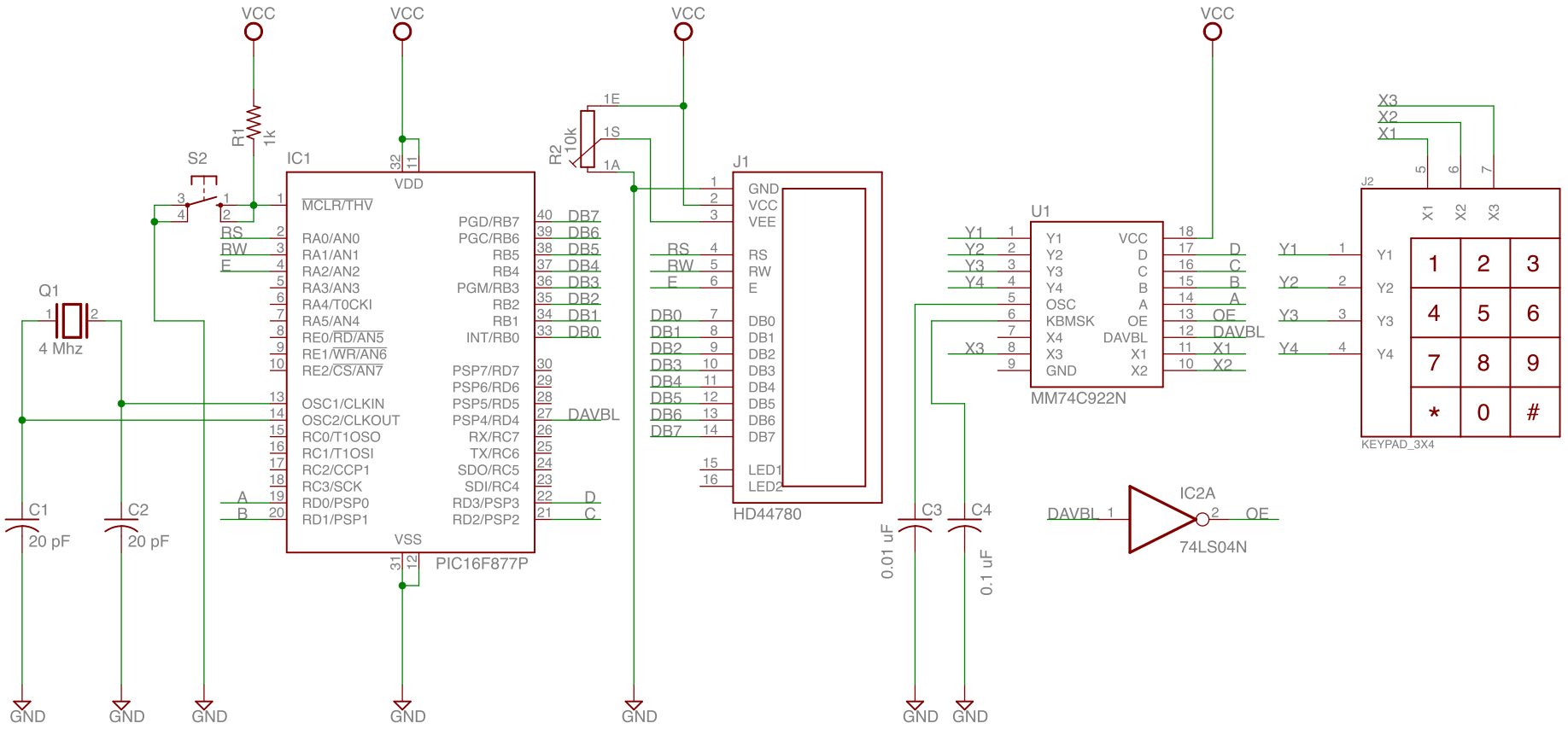
RP1:RP0	Bank
00	0
01	1
10	2
11	3



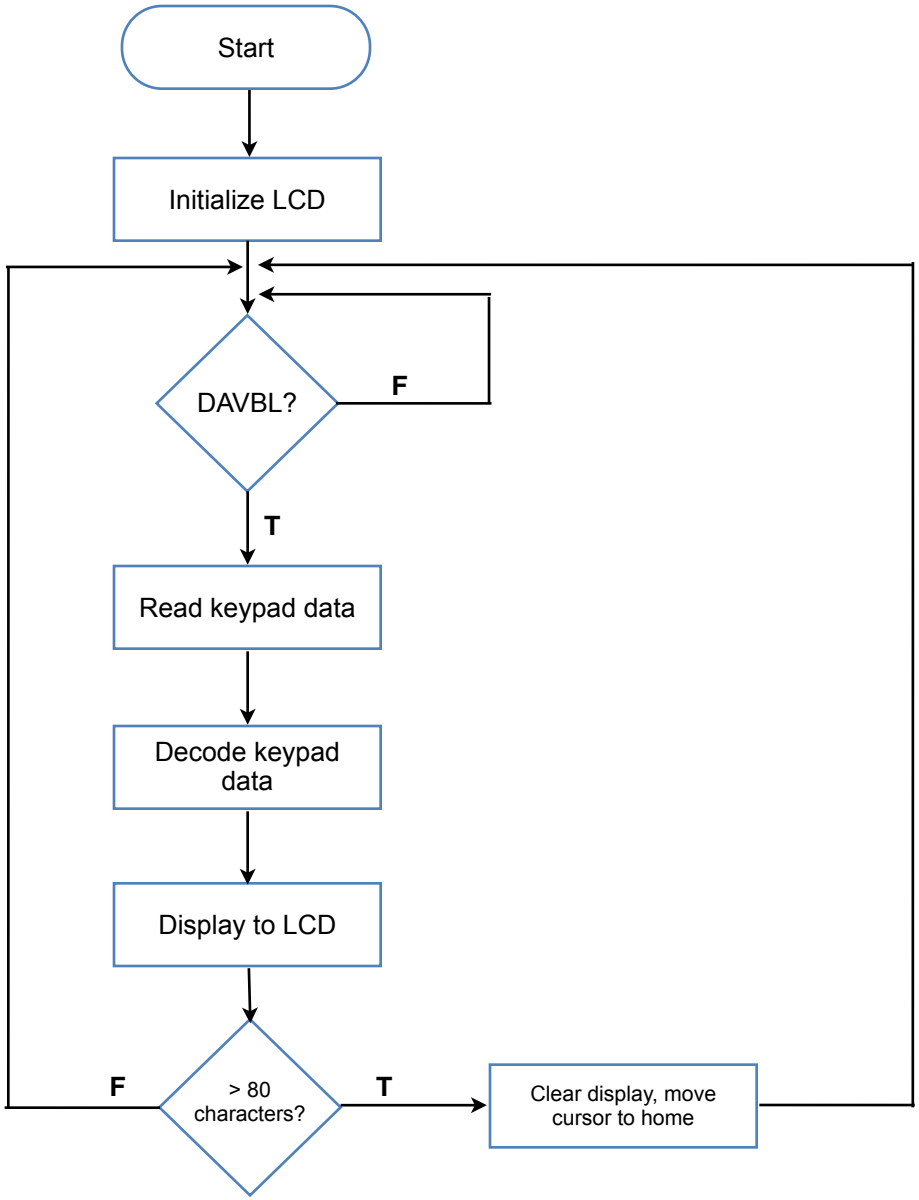
Register File Map of PIC16F87xx

Design Example

- An 5x7-dot LCD and a 3x4 numeric keypad is interfaced to the PIC16F877A MCU. The LCD will display the key pressed to LCD. Once the display is full, the display automatically clears and moves the cursor to the home position and continues.



PIC16F877A interfaced with LCD and keypad



Super loop solution to problem

C programming

LCD Functions

```
void Inst_Ctrl (unsigned char INST)
{
    PORTB = INST;          // load instruction to PORTB
    RA0 = 0;               // set RS to 0 (instruction reg)
    RA1 = 0;               // set RW to 0 (write)
    RA2 = 1;               // set E to 1
    delay(1);              // 1 ms delay (estimate)
    RA2 = 0;               // set E to 0 (strobe)
 }
```

C programming

LCD Functions

```
void Data_Ctrl (unsigned char DATA)
{
    PORTB = DATA;          // load data to PORTB
    RA0 = 1;               // set RS to 1 (data reg)
    RA1 = 0;               // set RW to 0 (write)
    RA2 = 1;               // set E to 1
    delay(1);              // 1 ms delay (estimate)
    RA2 = 0;               // set E to 0 (strobe)
 }
```

C programming

Delay Function

```
void delay (unsigned char MUL)
{
     unsigned char i,j;

     for (i=MUL; i != 0; i--)                  // loop until i = 0
        for (j=0; j < 256; j++);               // loop until j = 0
 }
```

* Approximate delay method. Adjust inner loop if necessary

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End of Lecture

References:

- PIC16F87XA Datasheet, Microchip Technology Inc., 2003.
- Ramesh S. Gaonkar. Fundamentals of Microcontrollers and Applications in Embedded Systems. Thomson Delmar Learning, 2007.