LCDlib-Ex16

1

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Todo List

Global LCDcommand (char cmd)

This routine delays 400us after sending the byte. Instead the LCD busy flag should be checked before sending the byte. All routines using delays, however, must follow this protocol

Global LCDletter (char data)

This routine delays 400us after sending the byte. Instead the LCD busy flag should be checked before sending the byte. All routines using delays, however, must follow this protocol

Chapter 2

File Index

2.1 File List

Here is a list of all documented files with brief descriptions:

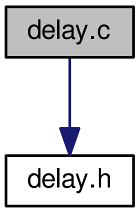
Chapter 3

File Documentation

3.1 delay.c File Reference

Routines used to provide delays for the LCD routines.

`#include "delay.h"` Include dependency graph for delay.c:



Functions

- void Delay (unsigned int delay_count)

  Delay for a specific count.
- void Delay_Us (unsigned int delayUs_count)

  Delay for a specified number of microseconds.

Variables

- unsigned int **temp_count**

3.1.1 Detailed Description

Routines used to provide delays for the LCD routines.

Definition in file delay.c.

3.1.2 Function Documentation

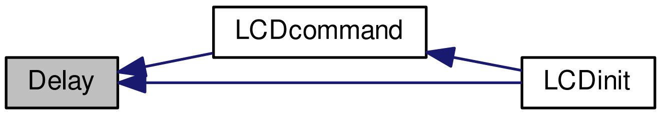
3.1.2.1 void Delay (unsigned int *delay_count*)

Delay for a specific count.

Definition at line 10 of file delay.c.

```
{
        temp_count = delay_count +1;
        asm volatile("outer: dec _temp_count");
        asm volatile("cp0 _temp_count");
        asm volatile("bra z, done");
        asm volatile("do #3200, inner" );
        asm volatile("nop");
        asm volatile("inner: nop");
        asm volatile("bra outer");
        asm volatile("done:");
}
```

Here is the caller graph for this function:



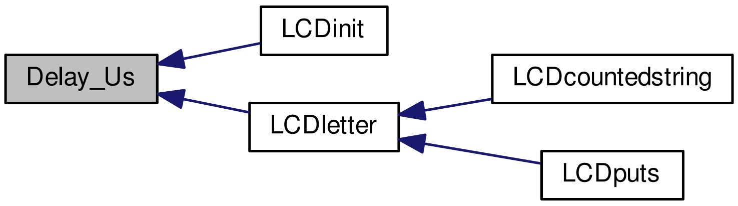
3.1.2.2 void Delay_Us (unsigned int *delayUs_count*)

Delay for a specified number of microseconds.

Definition at line 24 of file delay.c.

```
{
        temp_count = delayUs_count +1;
        asm volatile("outer1: dec _temp_count");
        asm volatile("cp0 _temp_count");
        asm volatile("bra z, done1");
        asm volatile("do #1500, inner1" );
        asm volatile("nop");
        asm volatile("inner1: nop");
        asm volatile("bra outer1");
        asm volatile("done1:");
}
```

Here is the caller graph for this function:



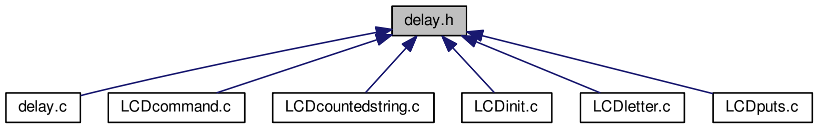
3.2 delay.c

```
#include "delay.h"

unsigned int temp_count;

void Delay( unsigned int delay_count )
{
        temp_count = delay_count +1;
        asm volatile("outer: dec _temp_count");
        asm volatile("cp0 _temp_count");
        asm volatile("bra z, done");
        asm volatile("do #3200, inner" );
        asm volatile("nop");
        asm volatile("inner: nop");
        asm volatile("bra outer");
        asm volatile("done:");
}

void Delay_Us( unsigned int delayUs_count )
{
        temp_count = delayUs_count +1;
        asm volatile("outer1: dec _temp_count");
        asm volatile("cp0 _temp_count");
        asm volatile("bra z, done1");
        asm volatile("do #1500, inner1" );
        asm volatile("nop");
        asm volatile("inner1: nop");
        asm volatile("bra outer1");
        asm volatile("done1:");
}

```

3.3 delay.h File Reference

Declarations for LCD delay routines.

This graph shows which files directly or indirectly include this file:



Defines

- #define Delay200uS_count (Fcy ∗ 0.0002) / 1080

  Counts for a 200 us delay.
- #define Delay_15mS_Cnt (Fcy ∗ 0.015) / 2950

  Counts for a 15 ms delay.
- #define Delay_1mS_Cnt (Fcy ∗ 0.001) / 2950

  Counts for a 1 ms delay.
- #define Delay_1S_Cnt (Fcy ∗ 1) / 2950

  Counts for a 1 second delay.
- #define Delay_2mS_Cnt (Fcy ∗ 0.002) / 2950

  Counts for a 2 ms delay.
- #define Delay_5mS_Cnt (Fcy ∗ 0.005) / 2950

  Counts for a 5 ms delay.
- #define Fcy 16000000

  Instruction clock Hz.

Functions

- void Delay (unsigned int delay_count)

  Delay for a specific count.
- void Delay_Us (unsigned int delayUs_count)

  Delay for a specified number of microseconds.

3.3.1 Detailed Description

Declarations for LCD delay routines.

Definition in file delay.h.

3.3.2 Define Documentation

3.3.2.1 #define Delay200uS_count (Fcy ∗ 0.0002) / 1080

Counts for a 200 us delay.

Definition at line 15 of file delay.h.

3.3.2.2 #define Delay_15mS_Cnt (Fcy ∗ 0.015) / 2950

Counts for a 15 ms delay.

Definition at line 23 of file delay.h.

3.3.2.3 #define Delay_1mS_Cnt (Fcy ∗ 0.001) / 2950

Counts for a 1 ms delay.

Definition at line 17 of file delay.h.

3.3.2.4 #define Delay_1S_Cnt (Fcy ∗ 1) / 2950

Counts for a 1 second delay.

Definition at line 25 of file delay.h.

3.3.2.5 #define Delay_2mS_Cnt (Fcy ∗ 0.002) / 2950

Counts for a 2 ms delay.

Definition at line 19 of file delay.h.

3.3.2.6 #define Delay_5mS_Cnt (Fcy ∗ 0.005) / 2950

Counts for a 5 ms delay.

Definition at line 21 of file delay.h.

3.3.2.7 #define Fcy 16000000

Instruction clock Hz.

Definition at line 7 of file delay.h.

3.3.3 Function Documentation

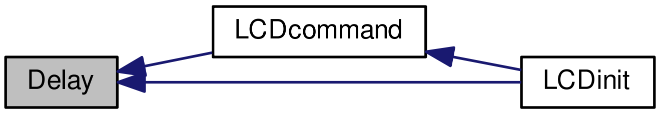
3.3.3.1 void Delay (unsigned int *delay_count*)

Delay for a specific count.

Definition at line 10 of file delay.c.

```
{
        temp_count = delay_count +1;
        asm volatile("outer: dec _temp_count");
        asm volatile("cp0 _temp_count");
        asm volatile("bra z, done");
        asm volatile("do #3200, inner" );
        asm volatile("nop");
        asm volatile("inner: nop");
        asm volatile("bra outer");
        asm volatile("done:");
}
```

Here is the caller graph for this function:



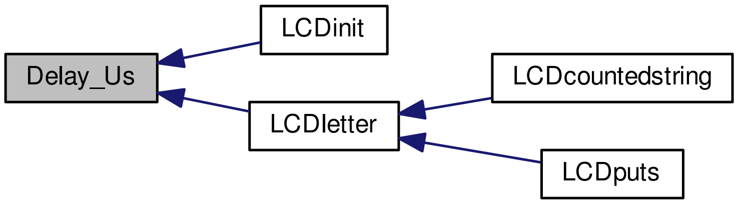
3.3.3.2 void Delay_Us (unsigned int *delayUs_count*)

Delay for a specified number of microseconds.

Definition at line 24 of file delay.c.

```
{
        temp_count = delayUs_count +1;
        asm volatile("outer1: dec _temp_count");
        asm volatile("cp0 _temp_count");
        asm volatile("bra z, done1");
        asm volatile("do #1500, inner1" );
        asm volatile("nop");
        asm volatile("inner1: nop");
        asm volatile("bra outer1");
        asm volatile("done1:");
}
```

Here is the caller graph for this function:



3.4 delay.h

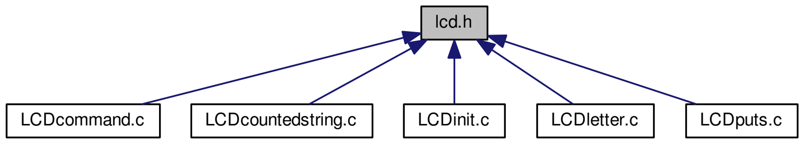
```

//#define Fcy  14754600
#define Fcy  16000000

void Delay( unsigned int delay_count );
void Delay_Us( unsigned int delayUs_count );

#define Delay200uS_count  (Fcy * 0.0002) / 1080

#define Delay_1mS_Cnt     (Fcy * 0.001) / 2950

#define Delay_2mS_Cnt     (Fcy * 0.002) / 2950

#define Delay_5mS_Cnt     (Fcy * 0.005) / 2950

#define Delay_15mS_Cnt    (Fcy * 0.015) / 2950

```

```
00025 #define Delay_1S_Cnt      (Fcy * 1) / 2950
00026
```

3.5 lcd.h File Reference

LCD definitions.

This graph shows which files directly or indirectly include this file:



Defines

- #define LCDclear() LCDcommand(0x01)

    Clear the LCD display and home cursor.
- #define LCDhome() LCDcommand(0x02)

    Set the LCD cursor to home.
- #define LCDleft() LCDcommand(0x10)

    Move the LCD cursor to the left.
- #define LCDline2() LCDcommand(0xC0)

    Position the LCD cursor to the second line.
- #define LCDposition(a) LCDcommand(0x80 + (a & 0x7f))

    Set the LCD cursor position.
- #define LCDright() LCDcommand(0x14)

    Move the LCD cursor to the right.
- #define LCDshift() LCDcommand(0x1C)

    Shift the LCD display.

Functions

- void LCDcommand (char cmd)

    Send a command to the LCD.

- void LCDcountedstring (unsigned char ∗data, unsigned char count)

  Send a counted string to the LCD.
- void LCDinit (void)

  Initialize the LCD.
- void LCDletter (char data)

  Send a character to the LCD.
- void LCDputs (char ∗)

  Send a string to the LCD.

3.5.1 Detailed Description

LCD definitions.

Definition in file lcd.h.

3.5.2 Define Documentation

3.5.2.1 #define LCDclear( ) LCDcommand(0x01)

Clear the LCD display and home cursor.

Definition at line 27 of file lcd.h.

3.5.2.2 #define LCDhome( ) LCDcommand(0x02)

Set the LCD cursor to home.

Definition at line 29 of file lcd.h.

3.5.2.3 #define LCDleft( ) LCDcommand(0x10)

Move the LCD cursor to the left.

Definition at line 23 of file lcd.h.

3.5.2.4 #define LCDline2( ) LCDcommand(0xC0)

Position the LCD cursor to the second line.

Definition at line 31 of file lcd.h.

3.5.2.5 #define LCDposition(*a*) LCDcommand(0x80 + (a & 0x7f))

Set the LCD cursor position.

Definition at line 33 of file lcd.h.

3.5.2.6 #define LCDright( ) LCDcommand(0x14)

Move the LCD cursor to the right.

Definition at line 21 of file lcd.h.

3.5.2.7 #define LCDshift( ) LCDcommand(0x1C)

Shift the LCD display.

Definition at line 25 of file lcd.h.

3.5.3 Function Documentation

3.5.3.1 void LCDcommand (char *cmd*)

Send a command to the LCD.

This routine simple sends a data byte to the LCD. The register select pin is set to 0 notifying the LCD that the byte is to be interpreted as a command.

Parameters

cmd	char - Command byte to send to LCD

Returns

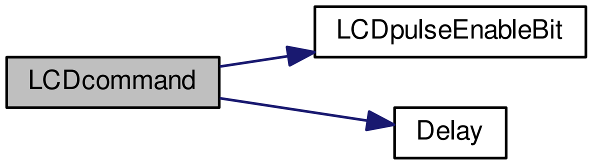
none

Todo This routine delays 400us after sending the byte. Instead the LCD busy flag should be checked before sending the byte. All routines using delays, however, must follow this protocol

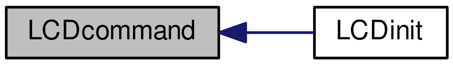
Definition at line 43 of file LCDcommand.c.

```
{
    LCD_DATA &= 0xFF00; // prepare RD0 - RD7
    LCD_DATA |= cmd; // command byte to lcd
    LCD_RW = 0; // ensure RW is 0
    LCD_RS = 0;
    LCDpulseEnableBit();
    Delay(Delay_5mS_Cnt); // 5ms delay
}
```

Here is the call graph for this function:



Here is the caller graph for this function:



3.5.3.2 void LCDcountedstring (unsigned char ∗ *data,* unsigned char *count*)

Send a counted string to the LCD.

In C, strings are always terminated with a null character, so there is no need to count characters. However, it is possible to send something else to the LCD, thinking it is a string when in fact, it is not terminated. Therefore, in embedded applications, it is safer to count characters so the string display is guaranteed to complete no matter what the data.

Parameters

data	unsigned char ∗ - pointing to the string to be displayed
count	int - count of number of characters to send to LCD

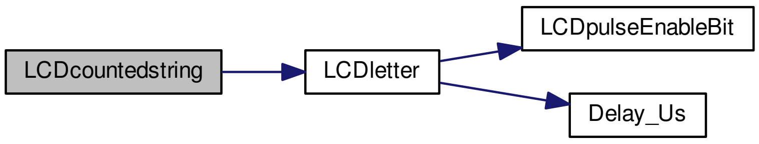
Returns

none

Definition at line 44 of file LCDcountedstring.c.

```
{
    while (count)
    {
        LCDletter(*data++);
        count--;
    }
}
```

Here is the call graph for this function:



3.5.3.3 void LCDinit (void)

Initialize the LCD.

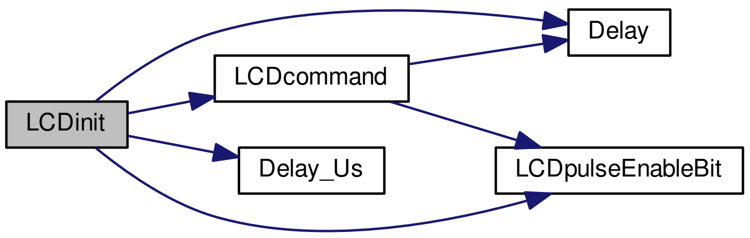
LCDinit() first delays 15ms to allow the LCD internals to finish responding to power on. This is not always necessary, but typically only happens once in a program. The LCD initialization sequence is then sent, setting the LCD to bit data.

LCD options are then sent, LCD 2 line, 5x7 font, entry mode to not shift, display on, cursor off.

Definition at line 40 of file LCDinit.c.

```
                    {
    // 15mS delay after Vdd reaches nnVdc before proceeding with LCD
       initialization
    // not always required and is based on system Vdd rise rate
    Delay(Delay_15mS_Cnt); // 15ms delay

    /* set initial states for the data and control pins */
    LCD_DATA &= 0xFF00;
    LCD_RW = 0; // R/W state set low
    LCD_RS = 0; // RS state set low
    LCD_ENABLE = 0; // E state set low

    /* set data and control pins to outputs */
    LCD_DATATRIS &= 0xFF00;
    LCD_RW_TRIS = 0; // RW pin set as output
    LCD_RS_TRIS = 0; // RS pin set as output
    LCD_ENABLE_TRIS = 0; // E pin set as output

    /* 1st LCD initialization sequence */
    LCD_DATA &= 0xFF00;
    LCD_DATA |= 0x0038;
    LCDpulseEnableBit();
    Delay(Delay_5mS_Cnt); // 5ms delay

    /* 2nd LCD initialization sequence */
    LCD_DATA &= 0xFF00;
    LCD_DATA |= 0x0038;
    LCDpulseEnableBit();
    Delay_Us(Delay200uS_count); // 200uS delay

    /* 3rd LCD initialization sequence */
    LCD_DATA &= 0xFF00;
    LCD_DATA |= 0x0038;
    LCDpulseEnableBit();
    Delay_Us(Delay200uS_count); // 200uS delay

    // Establish the LCD options
    // LCD_FUN_SET | DL_8 | 2_LINE _ 5x7_FONT
    LCDcommand(0x38); // function set
    // LCD_DISPLAY | DISP_ON | CURS_OFF | BLINK_OFF
    LCDcommand(0x0C); // Display on/off control, cursor blink off (0x0C)
    // LCD_ENTRY_MODE | DIC_INCR | NO_SHIFT
    LCDcommand(0x06); // entry mode set (0x06)
}
```

Here is the call graph for this function:



3.5.3.4 void LCDletter (char *data*)

Send a character to the LCD.

This routine simply sends a data byte to the LCD. The register select pin is set to 1 notifying the LCD that the byte is to be used as a displayed character.

Parameters

data	char - Character to send to the LCD

Returns

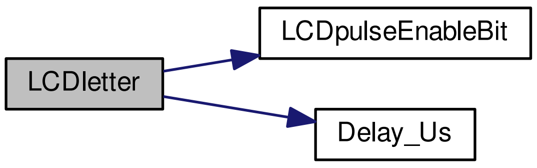
none

Todo This routine delays 400us after sending the byte. Instead the LCD busy flag should be checked before sending the byte. All routines using delays, however, must follow this protocol

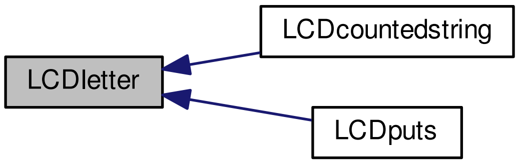
Definition at line 43 of file LCDletter.c.

```
{
    LCD_RW = 0; // ensure RW is 0
    LCD_RS = 1; // assert register select to 1
    LCD_DATA &= 0xFF00; // prepare RD0 - RD7
    LCD_DATA |= data; // data byte to lcd
    LCDpulseEnableBit();
    LCD_RS = 0; // negate register select to 0
    Delay_Us(Delay200uS_count); // 200uS delay
    Delay_Us(Delay200uS_count); // 200uS delay
}
```

Here is the call graph for this function:



Here is the caller graph for this function:



3.5.3.5 void LCDputs (char ∗ *p*)

Send a string to the LCD.

Sends a null-terminated string to the LCD

Parameters

p	char ∗ - pointer to string to be displayed

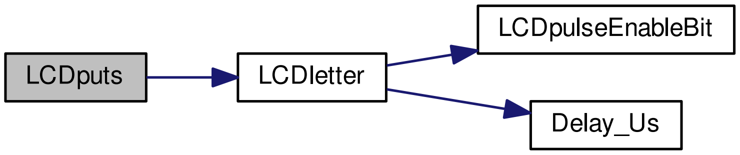
Returns

none

Definition at line 37 of file LCDputs.c.

```
{
    while (*p)
    {
        LCDletter(*p);
        p++;
    }
}
```

Here is the call graph for this function:



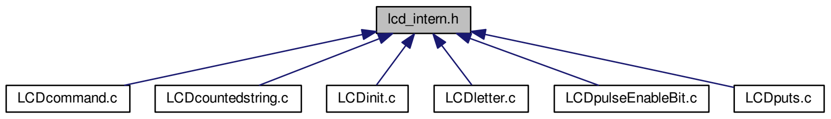
3.6 lcd.h

```
/****** LCD FUNCTION PROTOYPES ******/

void LCDinit( void );                    // initialize display
void LCDcommand( char cmd );             // write command to lcd
void LCDletter( char data );                 // write data to lcd
void LCDcountedstring ( unsigned char *data, unsigned char count );
void LCDputs( char * );

/*****  LCD COMMAND FUCNTION PROTOTYPES  *****/
#define LCDright()      LCDcommand( 0x14 )

#define LCDleft()       LCDcommand( 0x10 )

#define LCDshift()      LCDcommand( 0x1C )

#define LCDclear()      LCDcommand( 0x01 )

#define LCDhome()       LCDcommand( 0x02 )

#define LCDline2()      LCDcommand( 0xC0 ) // (0xC0)

#define LCDposition(a)  LCDcommand( 0x80 + ( a & 0x7f) )
```

3.7 lcd_intern.h File Reference

Definitions used within LCD routines.

This graph shows which files directly or indirectly include this file:



Defines

- #define LCD_DATA LATE

  LCD data port latch.
- #define LCD_DATAPORT PORTE

  LCD data port.
- #define LCD_DATATRIS TRISE

  LCD data port direction register.
- #define LCD_ENABLE LATDbits.LATD4

  LCD Enable pin.
- #define LCD_ENABLE_TRIS TRISDbits.TRISD4

  LCD Enable direction register bit.
- #define LCD_RS LATBbits.LATB15

  LCD Register select pin.
- #define LCD_RS_TRIS TRISBbits.TRISB15

  LCD Register select direction register bit.
- #define LCD_RW LATDbits.LATD5

  LCD Read/Write pin.
- #define LCD_RW_TRIS TRISDbits.TRISD5

  LCD Read/Write direction register bit.

Functions

- void LCDpulseEnableBit (void)

  Toggle the LCD enable bit.

3.7.1 Detailed Description

Definitions used within LCD routines. This file contains definitions of the various connections to the LCD on the Explorer 16 board. They are uninteresting outside the LCD routines.

Definition in file lcd_intern.h.

3.7.2 Define Documentation

3.7.2.1 #define LCD_DATA LATE

LCD data port latch.

Definition at line 49 of file lcd_intern.h.

3.7.2.2 #define LCD_DATAPORT PORTE

LCD data port.

Definition at line 51 of file lcd_intern.h.

3.7.2.3 #define LCD_DATATRIS TRISE

LCD data port direction register.

Definition at line 53 of file lcd_intern.h.

3.7.2.4 #define LCD_ENABLE LATDbits.LATD4

LCD Enable pin.

Definition at line 37 of file lcd_intern.h.

3.7.2.5 #define LCD_ENABLE_TRIS TRISDbits.TRISD4

LCD Enable direction register bit.

Definition at line 45 of file lcd_intern.h.

3.7.2.6 #define LCD_RS LATBbits.LATB15

LCD Register select pin.

Definition at line 35 of file lcd_intern.h.

3.7.2.7 #define LCD_RS_TRIS TRISBbits.TRISB15

LCD Register select direction register bit.

Definition at line 43 of file lcd_intern.h.

3.7.2.8 #define LCD_RW LATDbits.LATD5

LCD Read/Write pin.

Definition at line 33 of file lcd_intern.h.

3.7.2.9 #define LCD_RW_TRIS TRISDbits.TRISD5

LCD Read/Write direction register bit.

Definition at line 41 of file lcd_intern.h.

3.7.3 Function Documentation

3.7.3.1 void LCDpulseEnableBit (void)

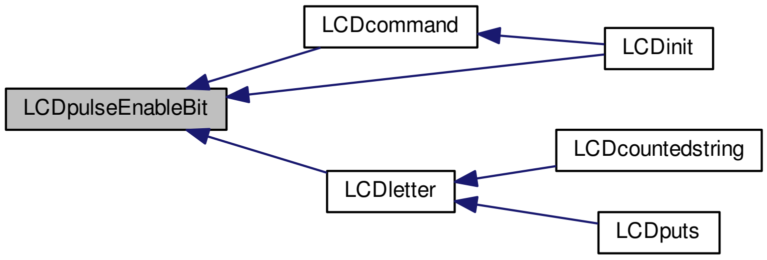
Toggle the LCD enable bit.

Each LCD command is strobed into the device by raising the enable bit for at least 40 microseconds. This routine provides this function to the other functions in the library.

Definition at line 35 of file LCDpulseEnableBit.c.

```
{
    LCD_ENABLE = 1;
    Nop();
    Nop();
    Nop();
    LCD_ENABLE = 0; // toggle E signal

}
```

Here is the caller graph for this function:



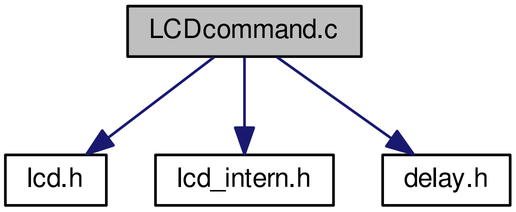
3.8 lcd_intern.h

```

/*
 * File:   lcd_intern.h
 * Author: jjmcd
 *
 * Created on June 19, 2012, 12:57 PM
 */

#ifndef LCD_INTERN_H
#define LCD_INTERN_H

#ifdef  __cplusplus
extern "C" {
#endif

/*
   For Explorer 16 board, here are the data and control signal definitions
   RS  -> RB15
   E   -> RD4
   LCD_RW -> RD5
   DATA -> RE0 - RE7
*/

// Control signal data pins
#define  LCD_RW         LATDbits.LATD5

#define  LCD_RS         LATBbits.LATB15

#define  LCD_ENABLE     LATDbits.LATD4

// Control signal pin direction
#define  LCD_RW_TRIS        TRISDbits.TRISD5

#define  LCD_RS_TRIS        TRISBbits.TRISB15

#define  LCD_ENABLE_TRIS    TRISDbits.TRISD4

// Data signals and pin direction
#define  LCD_DATA      LATE

#define  LCD_DATAPORT  PORTE

#define  LCD_DATATRIS  TRISE

void LCDpulseEnableBit( void );

#ifdef  __cplusplus
}
#endif

#endif  /* LCD_INTERN_H */

```

3.9 LCDcommand.c File Reference

Send a command to the LCD.

`#include "lcd.h" #include "lcd_intern.h" #include "delay.-h"` Include dependency graph for LCDcommand.c:



Functions

- void LCDcommand (char cmd)

    Send a command to the LCD.

3.9.1 Detailed Description

Send a command to the LCD.

Definition in file LCDcommand.c.

3.9.2 Function Documentation

3.9.2.1 void LCDcommand (char *cmd*)

Send a command to the LCD.

This routine simple sends a data byte to the LCD. The register select pin is set to 0 notifying the LCD that the byte is to be interpreted as a command.

Parameters

cmd	char - Command byte to send to LCD

Returns

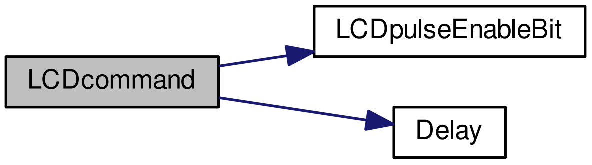
none

Todo This routine delays 400us after sending the byte. Instead the LCD busy flag should be checked before sending the byte. All routines using delays, however, must follow this protocol

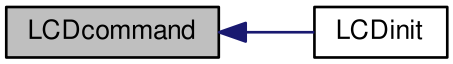
Definition at line 43 of file LCDcommand.c.

```
{
    LCD_DATA &= 0xFF00; // prepare RD0 - RD7
    LCD_DATA |= cmd; // command byte to lcd
    LCD_RW = 0; // ensure RW is 0
    LCD_RS = 0;
    LCDpulseEnableBit();
    Delay(Delay_5mS_Cnt); // 5ms delay
}
```

Here is the call graph for this function:



Here is the caller graph for this function:



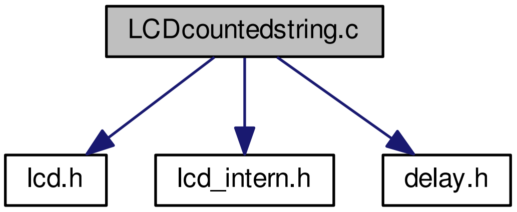
3.10 LCDcommand.c

```
#if defined(__PIC24E__)
#include <p24Exxxx.h>

#elif defined (__PIC24F__)
#include <p24Fxxxx.h>

#elif defined(__PIC24H__)
#include <p24Hxxxx.h>

#elif defined(__dsPIC30F__)
#include <p30Fxxxx.h>

#elif defined (__dsPIC33E__)
#include <p33Exxxx.h>

#elif defined(__dsPIC33F__)
#include <p33Fxxxx.h>

#endif

#include "lcd.h"
#include "lcd_intern.h"
#include "delay.h"


void LCDcommand( char cmd )
{
    LCD_DATA &= 0xFF00; // prepare RD0 - RD7
    LCD_DATA |= cmd; // command byte to lcd
    LCD_RW = 0; // ensure RW is 0
    LCD_RS = 0;
    LCDpulseEnableBit();
    Delay(Delay_5mS_Cnt); // 5ms delay
}

```

3.11 LCDcountedstring.c File Reference

Send a specific number of characters to the LCD.

`#include "lcd.h" #include "lcd_intern.h" #include "delay.h"` Include dependency graph for LCDcountedstring.c:



Functions

- void LCDcountedstring (unsigned char ∗data, unsigned char count)

  Send a counted string to the LCD.

3.11.1 Detailed Description

Send a specific number of characters to the LCD.

Definition in file LCDcountedstring.c.

3.11.2 Function Documentation

3.11.2.1 void LCDcountedstring (unsigned char ∗ *data,* unsigned char *count*)

Send a counted string to the LCD.

In C, strings are always terminated with a null character, so there is no need to count characters. However, it is possible to send something else to the LCD, thinking it is a string when in fact, it is not terminated. Therefore, in embedded applications, it is safer to count characters so the string display is guaranteed to complete no matter what the data.

Parameters

data	unsigned char ∗ - pointing to the string to be displayed
count	int - count of number of characters to send to LCD

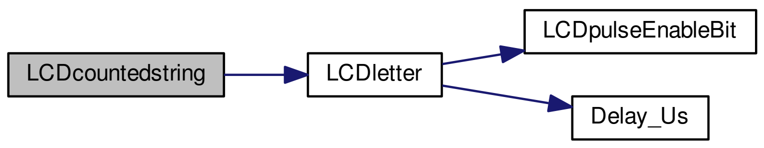
Returns

none

Definition at line 44 of file LCDcountedstring.c.

```
{
    while (count)
    {
        LCDletter(*data++);
        count--;
    }
}
```

Here is the call graph for this function:



3.12 LCDcountedstring.c

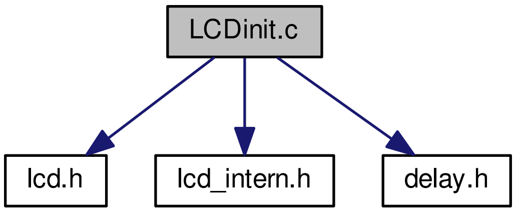
```

#if defined(__PIC24E__)
#include <p24Exxxx.h>

#elif defined (__PIC24F__)
#include <p24Fxxxx.h>

#elif defined(__PIC24H__)
#include <p24Hxxxx.h>

#elif defined(__dsPIC30F__)
#include <p30Fxxxx.h>

#elif defined (__dsPIC33E__)
#include <p33Exxxx.h>

#elif defined(__dsPIC33F__)
#include <p33Fxxxx.h>

#endif

#include "lcd.h"
#include "lcd_intern.h"
#include "delay.h"

```

```
void LCDcountedstring( unsigned char *data, unsigned char count)
{
    while (count)
    {
        LCDletter(*data++);
        count--;
    }
}
```

3.13 LCDinit.c File Reference

Initialize the LCD.

`#include "lcd.h"` `#include "lcd_intern.h"` `#include "delay.h"` Include dependency graph for LCDinit.c:



Functions

- void LCDinit (void)
  Initialize the LCD.

3.13.1 Detailed Description

Initialize the LCD.

Definition in file LCDinit.c.

3.13.2 Function Documentation

3.13.2.1 void LCDinit (void)

Initialize the LCD.

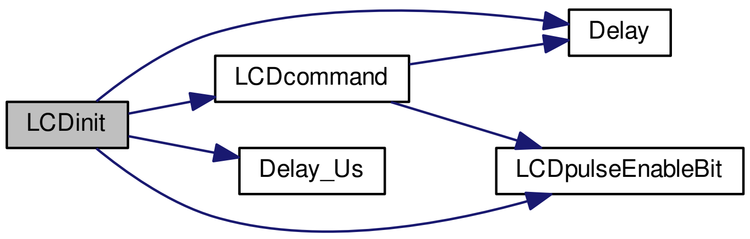
LCDinit() first delays 15ms to allow the LCD internals to finish responding to power on. This is not always necessary, but typically only happens once in a program. The LCD initialization sequence is then sent, setting the LCD to bit data.

LCD options are then sent, LCD 2 line, 5x7 font, entry mode to not shift, display on, cursor off.

Definition at line 40 of file LCDinit.c.

```
                    {
    // 15mS delay after Vdd reaches nnVdc before proceeding with LCD
       initialization
    // not always required and is based on system Vdd rise rate
    Delay(Delay_15mS_Cnt); // 15ms delay

    /* set initial states for the data and control pins */
    LCD_DATA &= 0xFF00;
    LCD_RW = 0; // R/W state set low
    LCD_RS = 0; // RS state set low
    LCD_ENABLE = 0; // E state set low

    /* set data and control pins to outputs */
    LCD_DATATRIS &= 0xFF00;
    LCD_RW_TRIS = 0; // RW pin set as output
    LCD_RS_TRIS = 0; // RS pin set as output
    LCD_ENABLE_TRIS = 0; // E pin set as output

    /* 1st LCD initialization sequence */
    LCD_DATA &= 0xFF00;
    LCD_DATA |= 0x0038;
    LCDpulseEnableBit();
    Delay(Delay_5mS_Cnt); // 5ms delay

    /* 2nd LCD initialization sequence */
    LCD_DATA &= 0xFF00;
    LCD_DATA |= 0x0038;
    LCDpulseEnableBit();
    Delay_Us(Delay200uS_count); // 200uS delay

    /* 3rd LCD initialization sequence */
    LCD_DATA &= 0xFF00;
    LCD_DATA |= 0x0038;
    LCDpulseEnableBit();
    Delay_Us(Delay200uS_count); // 200uS delay

    // Establish the LCD options
    // LCD_FUN_SET | DL_8 | 2_LINE _ 5x7_FONT
    LCDcommand(0x38); // function set
    // LCD_DISPLAY | DISP_ON | CURS_OFF | BLINK_OFF
    LCDcommand(0x0C); // Display on/off control, cursor blink off (0x0C)
    // LCD_ENTRY_MODE | DIC_INCR | NO_SHIFT
    LCDcommand(0x06); // entry mode set (0x06)
}
```

Here is the call graph for this function:



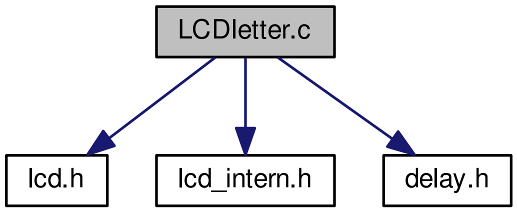
3.14 LCDinit.c

```

#if defined(__PIC24E__)
#include <p24Exxxx.h>

#elif defined (__PIC24F__)
#include <p24Fxxxx.h>

#elif defined(__PIC24H__)
#include <p24Hxxxx.h>

#elif defined(__dsPIC30F__)
#include <p30Fxxxx.h>

#elif defined (__dsPIC33E__)
#include <p33Exxxx.h>

#elif defined(__dsPIC33F__)
#include <p33Fxxxx.h>

#endif

#include "lcd.h"
#include "lcd_intern.h"
#include "delay.h"


void LCDinit( void) {
    // 15mS delay after Vdd reaches nnVdc before proceeding with LCD initialization
    // not always required and is based on system Vdd rise rate
    Delay(Delay_15mS_Cnt); // 15ms delay

    /* set initial states for the data and control pins */
    LCD_DATA &= 0xFF00;
    LCD_RW = 0; // R/W state set low
    LCD_RS = 0; // RS state set low
    LCD_ENABLE = 0; // E state set low

    /* set data and control pins to outputs */
    LCD_DATATRIS &= 0xFF00;
    LCD_RW_TRIS = 0; // RW pin set as output
    LCD_RS_TRIS = 0; // RS pin set as output
    LCD_ENABLE_TRIS = 0; // E pin set as output

    /* 1st LCD initialization sequence */
    LCD_DATA &= 0xFF00;
    LCD_DATA |= 0x0038;
    LCDpulseEnableBit();
    Delay(Delay_5mS_Cnt); // 5ms delay

    /* 2nd LCD initialization sequence */
    LCD_DATA &= 0xFF00;
    LCD_DATA |= 0x0038;
    LCDpulseEnableBit();
    Delay_Us(Delay200uS_count); // 200uS delay

    /* 3rd LCD initialization sequence */
    LCD_DATA &= 0xFF00;
    LCD_DATA |= 0x0038;
    LCDpulseEnableBit();
    Delay_Us(Delay200uS_count); // 200uS delay

    // Establish the LCD options
    // LCD_FUN_SET | DL_8 | 2_LINE _ 5x7_FONT
    LCDcommand(0x38); // function set
    // LCD_DISPLAY | DISP_ON | CURS_OFF | BLINK_OFF
    LCDcommand(0x0C); // Display on/off control, cursor blink off (0x0C)
    // LCD_ENTRY_MODE | DIC_INCR | NO_SHIFT
    LCDcommand(0x06); // entry mode set (0x06)
}
```

3.15 LCDletter.c File Reference

Send a character to the LCD.

`#include "lcd.h" #include "lcd_intern.h" #include "delay.h"` Include dependency graph for LCDletter.c:



Functions

- void LCDletter (char data)

  Send a character to the LCD.

3.15.1 Detailed Description

Send a character to the LCD.

Definition in file LCDletter.c.

3.15.2 Function Documentation

3.15.2.1 void LCDletter (char *data*)

Send a character to the LCD.

This routine simply sends a data byte to the LCD. The register select pin is set to 1 notifying the LCD that the byte is to be used as a displayed character.

Parameters

data	char - Character to send to the LCD

Returns

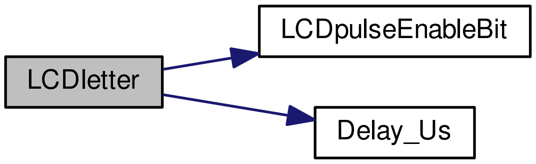
none

Todo This routine delays 400us after sending the byte. Instead the LCD busy flag should be checked before sending the byte. All routines using delays, however, must follow this protocol

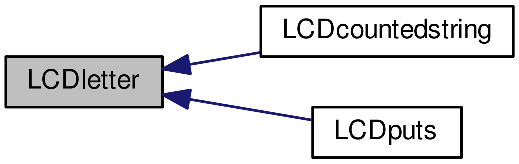
Definition at line 43 of file LCDletter.c.

```
{
    LCD_RW = 0; // ensure RW is 0
    LCD_RS = 1; // assert register select to 1
    LCD_DATA &= 0xFF00; // prepare RD0 - RD7
    LCD_DATA |= data; // data byte to lcd
    LCDpulseEnableBit();
    LCD_RS = 0; // negate register select to 0
    Delay_Us(Delay200uS_count); // 200uS delay
    Delay_Us(Delay200uS_count); // 200uS delay
}
```

Here is the call graph for this function:



Here is the caller graph for this function:



3.16 LCDletter.c

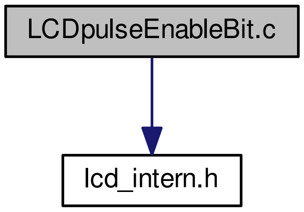
```
#if defined(__PIC24E__)
#include <p24Exxxx.h>

#elif defined (__PIC24F__)
#include <p24Fxxxx.h>

#elif defined(__PIC24H__)
#include <p24Hxxxx.h>

#elif defined(__dsPIC30F__)
#include <p30Fxxxx.h>

#elif defined (__dsPIC33E__)
#include <p33Exxxx.h>

```

```
#elif defined(__dsPIC33F__)
#include <p33Fxxxx.h>

#endif

#include "lcd.h"
#include "lcd_intern.h"
#include "delay.h"



void LCDletter( char data )
{
    LCD_RW = 0; // ensure RW is 0
    LCD_RS = 1; // assert register select to 1
    LCD_DATA &= 0xFF00; // prepare RD0 - RD7
    LCD_DATA |= data; // data byte to lcd
    LCDpulseEnableBit();
    LCD_RS = 0; // negate register select to 0
    Delay_Us(Delay200uS_count); // 200uS delay
    Delay_Us(Delay200uS_count); // 200uS delay
}
```

3.17 LCDpulseEnableBit.c File Reference

Pulse the LCD enable bit for long enough.

`#include "lcd_intern.h"` Include dependency graph for LCDpulseEnableBit.c:



Functions

- void LCDpulseEnableBit (void)

  Toggle the LCD enable bit.

3.17.1 Detailed Description

Pulse the LCD enable bit for long enough.

Definition in file LCDpulseEnableBit.c.

3.17.2 Function Documentation

3.17.2.1 void LCDpulseEnableBit (void)

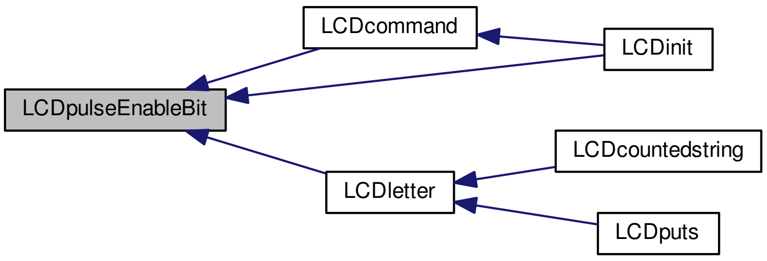
Toggle the LCD enable bit.

Each LCD command is strobed into the device by raising the enable bit for at least 40 microseconds. This routine provides this function to the other functions in the library.

Definition at line 35 of file LCDpulseEnableBit.c.

```
{
    LCD_ENABLE = 1;
    Nop();
    Nop();
    Nop();
    LCD_ENABLE = 0; // toggle E signal

}
```

Here is the caller graph for this function:



3.18 LCDpulseEnableBit.c

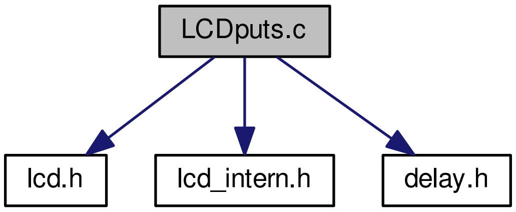
```
00001
00007 #if defined(__PIC24E__)
```

```
#include <p24Exxxx.h>

#elif defined (__PIC24F__)
#include <p24Fxxxx.h>

#elif defined(__PIC24H__)
#include <p24Hxxxx.h>

#elif defined(__dsPIC30F__)
#include <p30Fxxxx.h>

#elif defined (__dsPIC33E__)
#include <p33Exxxx.h>

#elif defined(__dsPIC33F__)
#include <p33Fxxxx.h>

#endif

#include "lcd_intern.h"


void LCDpulseEnableBit( void )
{
    LCD_ENABLE = 1;
    Nop();
    Nop();
    Nop();
    LCD_ENABLE = 0; // toggle E signal

}
```

3.19 LCDputs.c File Reference

Put a string to the LCD.

`#include "lcd.h"` `#include "lcd_intern.h"` `#include "delay.h"` Include dependency graph for LCDputs.c:



Functions

- void LCDputs (char ∗p)

  Send a string to the LCD.

3.19.1 Detailed Description

Put a string to the LCD.

Definition in file LCDputs.c.

3.19.2 Function Documentation

3.19.2.1 void LCDputs (char ∗ *p*)

Send a string to the LCD.

Sends a null-terminated string to the LCD

Parameters

p	char ∗ - pointer to string to be displayed

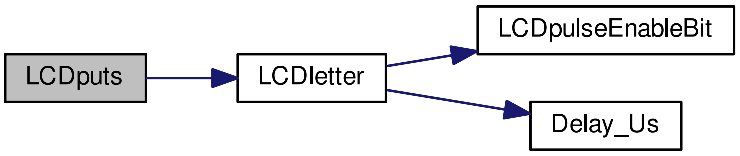
Returns

none

Definition at line 37 of file LCDputs.c.

```
{
    while (*p)
    {
        LCDletter(*p);
        p++;
    }
}
```

Here is the call graph for this function:



3.20 LCDputs.c

```
#if defined(__PIC24E__)
#include <p24Exxxx.h>

#elif defined (__PIC24F__)
#include <p24Fxxxx.h>

#elif defined(__PIC24H__)
#include <p24Hxxxx.h>

#elif defined(__dsPIC30F__)
#include <p30Fxxxx.h>

#elif defined (__dsPIC33E__)
#include <p33Exxxx.h>

#elif defined(__dsPIC33F__)
#include <p33Fxxxx.h>

#endif

#include "lcd.h"
#include "lcd_intern.h"
#include "delay.h"



void LCDputs( char *p )
{
    while (*p)
    {
        LCDletter(*p);
        p++;
    }
}
```