RAiO

RA8806

Two Layers
Character/Graphic
LCD Controller

FAQ

Preliminary Version 1.0

June 24, 2009

RAiO Technology Inc.

Update History		
Version	**Date**	**Description**
1.0	June 24, 2009	Preliminary Version

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1. General Functions

1-1 Basic Functions Introduction

RA8806 is a strong and easy to use STN LCD controller.Additionally, excepting the STN LCD display functions, it also contains the function of BIG5 (or GB) and ASCII font ROM、smart ADC touch controller and smart key-scan controller. Users can save lots of time and cost on system hardware and software development. The system block diagram of RA8806 as below for the reference:
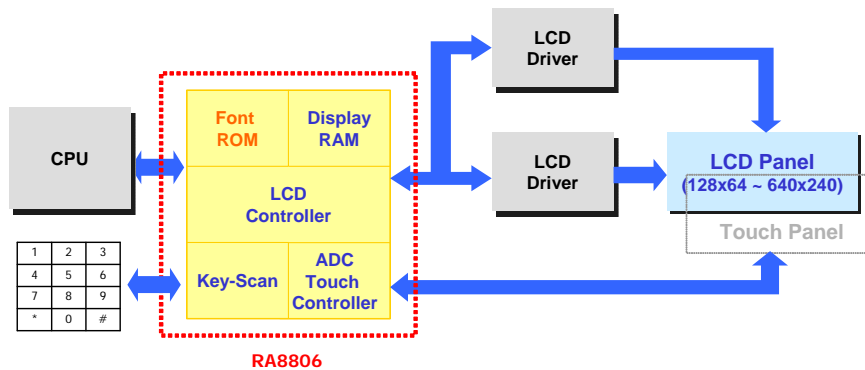
Figure 1-1

Basically RA8806 accepts commands from MCU then send the data that what RA8806 received from MCU to LCD driver and via the connection between LCD drivers and STN LCD to display texts or images on the screen. Therefore, RA8806 is the control IC between MCU and LCD driver. There are two modes in real application:One is designed RA8806 on LCD modules that become LCD modules are embedded with RA8806 controller and please refer the block diagram as below:
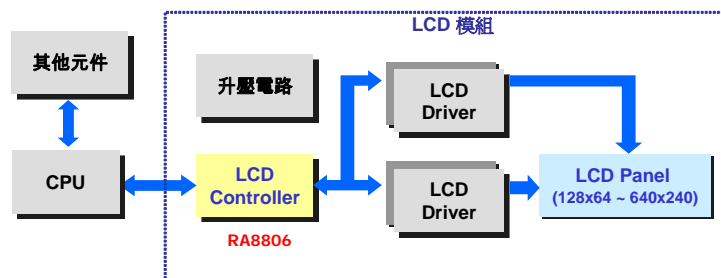
Figure 1-2

Another one is designed RA8806 on the system side to collocate various LCD modules that without controllers and please refer the block diagram as below:
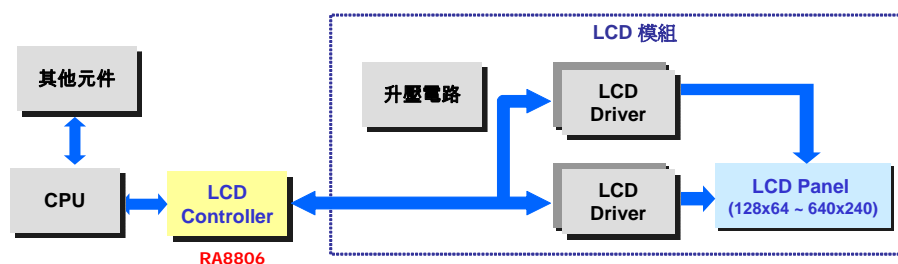
Figure 1-3

1-2 How to Design RA8806 Application Circuit on LCM ?

If you were LCM suppliers and who wants to designed RA8806 on LCD modules with LCD controller, please download the latest RA8806 datasheet first. For the complete RA8806 datasheet, you could contact with our agent or directly log on to our website (www.raio.com.tw). Before you designing your application circuit, please refer RA8806 datasheet pin definition、description of LCD driver interface in section 6-2 and the reference application circuit in appendix A. We especially highlight some common oversight points as below to be noticed:

◆ There is a bit different application circuit design between 3V LCM and 5V LCM, please refer to section 6-7 of RA8806 datasheet.

◆ When RA8806 is operating in 5V system, users must connect capacitor 1µF and 0.1µF between VDD to the ground for the VDD stability. The reference figure as below or refer to section 6-7-3 of RA8806 datasheet.
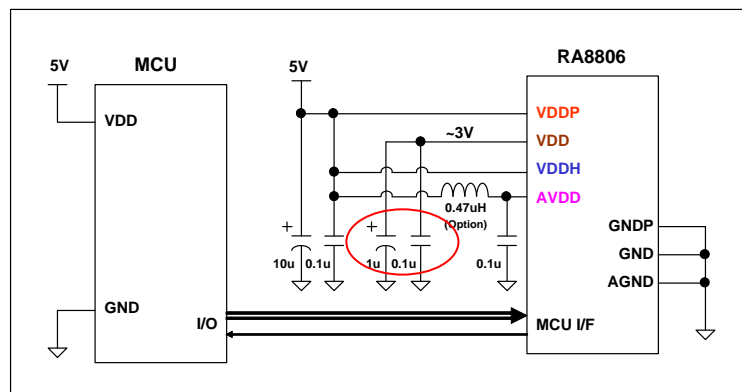
Figure 1-4

◆ RA8806 oscillator circuit is generated by external crystal and two capacitors which are between XG and XD pins. We suggest the crystal range is from 4MHz to 12MHz (even though RA8806 is pin to pin compatible with RA8803/RA8822 but the crystal of RA8803/RA8822 is fixed to 32768Hz, totally different with RA8806). The reference figure as below:
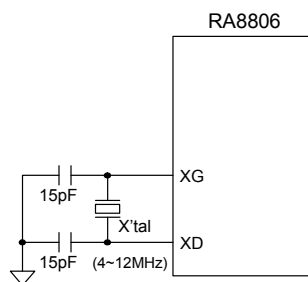
Figure 1-5

◆ RA8806 supports 8080 and 6800 interface modes and pin "MI" defines which interface is going to use (MI:0 → 8080 interface；MI:1 → 6800 interface). User's software protocol must follow the hardware setting to make sure RA8806 receive correct commands from MCU.

◆ Due to it is unpredictable what environment the system developer is using in, so we strongly recommend the users to connect a capacitor 50~150pF between ZCS1、ZRD and ZWR to the ground. Please refer the figure below or figure 6-1、6-2 of RA8806 datasheet.
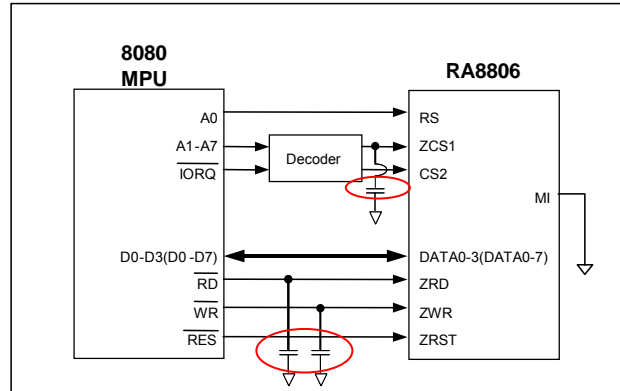
Figure 1-6

◆ To use touch panel function, users except connect XL、XR、YU and YD to RA8806 who still need to connect capacitor 0.01μF with these 4 wires to the ground and a pull-high resistor 39Kohm to pin YU. Please refer the figure below or figure 6-18 of RA8806 datasheet.
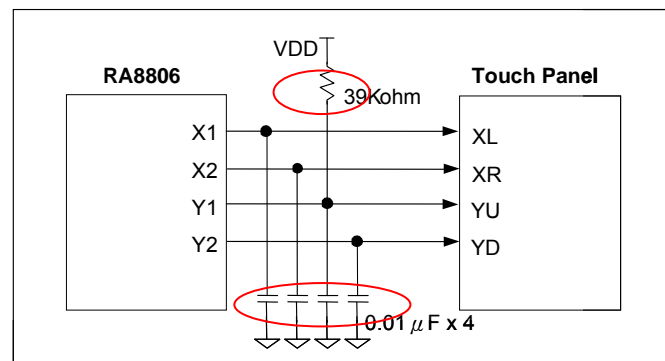
Figure 1-7

Besides RA8806, LCM designers must make sure other devices and circuits correct, like booster circuit、OP bias circuit and LCD driver circuit. For LCM designers or system developers, it is available to refer our sample program and download directly from RAiO website (www.raio.com.tw). We provide two sample programs of 320x240 and which are RA8806_320x240-EX1.rar and RA8806_320x240-EX2.rar.

1-3 Fail to Display on by RA8806

If you were LCM suppliers, below are the debug and analyze steps when fail to display on LCD by RA8806 :

1. Make sure the power(3V or 5V) is correct supplying to RA8806、booster circuit、OP bias circuit and LCD driver circuit.

2. Make sure VLCD (which is generated by booster circuit) and V0~V4(which are generated by OP bias circuit) are correct supplying to LCD driver.

3. Make sure RA8806 oscillator circuit is operating correctly. Users could measure pin XD and pin XG by oscilloscope to check the oscillating is happened or not.

4. Make sure RA8806 ZRST receive the reset signal from MCU during the power on. After reset, ZRST should keep at Hi level.

5. Make sure RA8806 hardware connection and pin definition are correctly connecting with MCU.

6. Make sure the timing is generated from MCU that matches with RA8806 requirement and hardware settings are the same with RA8806 modules. Please refer to figure 6-3、6-4 of RA8806 datasheet.

7. Make sure the commands are generated from MCU that match with RA8806 setting steps and requirement.

8. Make sure the signals (YD、FR、LP、XCK、LD[3:0]) to LCD driver are generated correctly.

Assume the signals to LCD driver are generated correctly, the LCD should be displayed on. If the LCD fails to display on, normally reason is the booster circuit. It is either no VLCD generating by booster circuit or V0~V4 from OP bias circuit are not correctly supplying to LCD driver.

If you were system developers, the modules you get that usually after the test by LCM suppliers. So if users fail to display on by RA8806, normally reasons are as item 5~7 above. If users design RA8806 on the system side to collocate various LCD modules that without controllers, then must check straight item 3~8 as above.

1-4 How to Display Text on LCD ?

For writing data into Display Memory to display texts or images on LCD screen, users need to send memory write command (0xB0) first before the display data write to avoid the failure display. The register [00h] bit-3 is defined which mode is in using : 1→ text mode ; 0 → graphic mode.

For example : show letter A on LCD screen

```
LCD_Text();              // set the Register [00h] Bit3 to 1
LCD_CmdWrite(0xB0)；
LCD_DataWrite(0x41)；    // Character Code of A (Font Code) is 41h
```

1-5 How to Use 「Continuous-Data-Writing」Function ?

RA8806 supports "Continuous-data-writing" function. Users can continuous write text-data or image-data into memory after the coordinate and memory write command (0xB0) set.

For example : show letters ABC on LCD screen

```
LCD_Text();              // set the Register [00h] Bit3 to 1
LCD_SetXY(5,10)；        // set address X = 5，Y = 10
LCD_CmdWrite(0xB0)；
LCD_DataWrite(0x41)；    // Font Code A : 41h
LCD_DataWrite(0x42)；    // Font Code B : 42h
LCD_DataWrite(0x43)；    // Font Code C : 43h
```

Please note that the memory write command (0xB0) must re-send when other commands are executing during the continuous data writing. Users usually forget to re-send memory write command (0xB0) after setting display data in another coordinate. And it will cause the afterward display data fail to display.

For example: show letters ABCDE at coordinate(0,0) on LCD screen

```
A B C D E
A B C D E




```

Figure 1-8

Common incorrect setting :

```
LCD_Text();                      // set the Register [00h] Bit3 to 1
LCD_SetXY(0,0) ;                 // set address X = 0，Y = 0
LCD_CmdWrite(0xB0) ;
for(i = 0 ; i < 5 ; i++)
{
     LCD_DataWrite(0 x 41 + i) ; // data write : ABCDE
}
LCD_SetXY(0,16) ;                // set address X = 0，Y = 16
for(i = 0 ; i < 5 ; i++)
{
     LCD_DataWrite(0 x 41 + i) ; // data write : ABCDE
}
```

The incorrect setting above will cause the second line ABCDE fail to display. As the memory write command (0xB0) re-send after the coordinate set, the situation is solved.
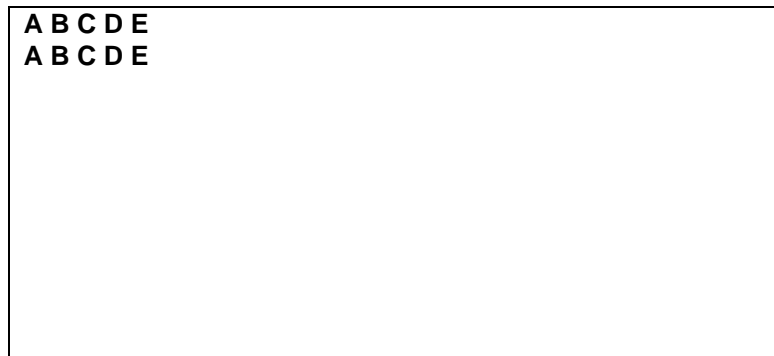
Correct setting :

```
LCD_Text();                      // set the Register [00h] Bit3 to 1
LCD_SetXY(0,16) ;                // set address X = 0，Y = 16
LCD_CmdWrite(0xB0) ;
for(i = 0 ; i < 5 ; i++)
{
     LCD_DataWrite(0x41 + i) ;  // continue write ABCDE
}
```

1-6 How to Adjust the Frame Rate ?

RA8806 provides a register ITCR (Idle Time Counter Register) for users adjusting the frame rate.The ITCR is used to determine every LCD COM scan time.Please refer the figure below :
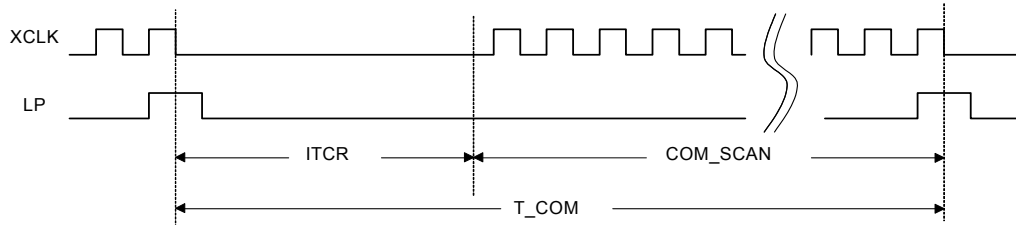
Figure 1-9

Assume the panel resolution is 320x240 and driver data bus is 4-Bit, the formulate between the frame rate and ITCR as below :

$$\text{Frame Rate} = \frac{\text{System Freq.}}{\left(\text{ITCR} + 320/4\right) \times 240}$$

For example:what ITCR will be if the system clock is 4 MHz and frame rate is 70Hz ?

$$\text{ITCR} = \frac{4 \times 10^6}{240 \times 70} - 80 = 158$$

1-7 Frame Rate Setting Between Gray Scale Mode and Monochrom Mode

The frame rate is different in gray scale mode and monochrom mode. For the best display performance, we suggest the frame rate is set to 70Hz in monochrom mode and 120Hz ~ 140Hz in gray scale mode to avoid the flickering.

1-8 Contrast Adjustment to Improve the Display Quality

After the contrast adjustment,the display quality is still poor and dark.It usually related to the frame rate.When the frame rate $>$ 90Hz in monochrom mode,the display quality is getting worst. For the similar issues, users must adjust the frame rate between 70Hz ~ 80Hz. Regarding to the frame rate in different system clock, users could refer appendix B of RA8806 datasheet.

2. Eliminating Flicker Mode

2-1 What is "Flicker"?

The flicker means when RA8806 internal logic circuit is doing the scan task, at the meantime MPU is doing the data access to RA8806 DDRAM.The error will be occurred by the interfering scan data and it will cause unexpected flicker. RA8806 embedded eliminating flicker function, users only need to set the register MISC [01h] bit-7 to 1 to enable this function.

2-2 The Limits in Eliminating Flicker Mode

◆ The eliminating flicker function is not available in text mode and memory clear mode. It is available only in graphic mode.

◆ Memory clear means the data is going to be set (ex : to clear the screen is set to 0x00) into the register PNTR[E0h], enable this function and the screen will be automatically clear by hardware.

◆ While switching the text/graphic mode, users must beware of the eliminating flicker function is active or not, because it will effect the display performance.

2-3 The Recommendations when Using Eliminating Flicker Mode

Users could have the better display performance who is following recommendations when using eliminating flicker mode.

◆ Disable eliminating flicker function in text mode.

◆ Enable eliminating flicker function in graphic mode.

◆ Disable eliminating flicker function before to active memory clear function and enable eliminating flicker function after the screen clear is done by memory clear function.

3. Touch Panel Mode

3-1 How to Use RA8806 Embedded Touch Panel Controller ?

◆ Hardware control **:**

Users only need to connect the touch panel control pins – XL、XR、YU and YD to RA8806. For the stable signal output, we suggest to connect capacitor 0.01uF between each control pins (XL、XR、YU and YD) and ground. Please refer the figure below :
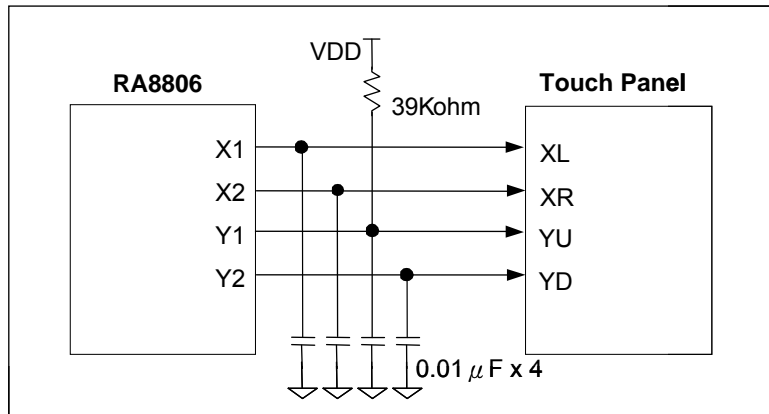
Figure 3-1

◆ Software control :

Register TPCR1 [C0h] bit-7 to enable touch panel function then users could depend on what application you need to choose the related functions :

Table 3-1

Reg.	Bit_Num	Description	Reference
TPCR1	Bit 7	Enable Touch Panel function	REG[C0h]
TPCR2	Bit 7	"Auto-Mode" or "Manual Mode" selection bit	REG[C4h]
	Bit 1~0	Mode selection for TP manual mode	
INTR	Bit 4	Touch Panel Hardware Interrupt enable bit.	REG[0Fh]
	Bit 3	Touch event detect bit (use in Manual Mode only).	
	Bit 0	Touch Panel Detect Status bit	
TPXR	Bit 7~0	Touch Panel X Data Bit [9:2] (Segment)	REG[C1h]
TPYR	Bit 7~0	Touch Panel Y Data Bit [9:2] (Common)	REG[C2h]
TPZR	Bit 3~2	Touch Panel Y Data Bit [1:0]. (Common)	REG[C3h]
	Bit 1~0	Touch Panel X Data Bit [1:0]. (Segment)	

3-2 The Difference between Manual Mode and Auto Mode

◆ The manual mode means that whole process from detect touch event to latch X、Y data and read X、Y coordinate is finished by software engineer in manual mode.

◆ When enable touch panel function in auto mode, users do not need to do anything till the touch event happen and the X、Y coordinate will be automatically read.

◆ The advantage of auto mode is easy to use and manual mode is much flexible for users.

3-3 How to Detect Touch Event ?

Users could detect the touch event by external interrupt or polling touch status. Description as below :

(一)   Detect by external interrupt :

◆ By hardware, users must connect RA8806 interrupt pin to MCU interrupt input pin.

◆ By software, users must enable register INTR[0Fh] bit-4 to detect the touch event happen.

◆ When detect the touch event happen, RA8806 will send interrupt signal to MCU.

◆ The program will jump to ISR(interrupt service routine).

◆ Executing corresponding functions.

(二)   Detect by polling touch status :

◆ Polling touch status means that keep checking register INTR[0Fh] bit-0 to detect there is touch event happened or not.

◆ When detect touch event happen, register INTR[0Fh] bit-0 will be set to 1 and after XY coordinate read、corresponding functions are finished, users must clear this bit to 0 to detect the next touch event happen.

3-4 The Settings with Flowchart in Auto Mode

(一)The required settings in auto mode as following table (symbol * means required settings, others are depend on applications)

Table 3-2

Reg.	Bit_Num	Description	Reg._Num	
TPCR1	Bit 7	Enable Touch Panel function	REG[C0h]	*
	Bit 6~4	Touch scan sampling time adjust bit		*
	Bit 2~0	Touch scan frequency conversion speed bit		*
TPCR2	Bit 7	"Auto Mode" or "Manual Mode" selection bit	REG[C4h]	*
INTR	Bit 4	Touch Panel Hardware Interrupt bit	REG[0Fh]	
	Bit 0	Touch Panel Detect Status bit		

Note: For detail descriptions, please refer to page 18 、27、28 of RA8806 datasheet.

In above table, there is the specific rule between touch scan sampling time and touch scan frequency conversion speed from register TPCR1[C0h]. For the stable ADC output coordinate, please follow the recommendations as the table below :

Table 3-3

System CLK	ADC Conversion Clock Control REG[C0][2:0]	Conversion Frequency (KHz)	Touch scan Sampling wait time REG[C0][6:4]	Sampling wait time	REG[C0] Suggested data
4 MHz	000	1000	000	50	**0x80**
	001	500	000	50	**0x81**
	010	250	000	50	**0x82**
6 MHz	000	1500	000	50	**0x80**
	001	750	000	50	**0x81**
	010	375	000	50	**0x82**
	011	188	001	100	**0x93**
	100	94	010	200	**0xA4**
8 MHz	000	2000	000	50	**0x80**
	001	1000	000	50	**0x81**
	010	500	000	50	**0x82**
	011	250	001	50	**0x83**
	100	125	010	100	**0x94**
10 MHz	000	2500	000	50	**0x80**
	001	1250	000	50	**0x81**
	010	625	000	50	**0x82**
	011	313	001	50	**0x83**
	100	156	010	100	**0x94**
12 MHz	000	3000	000	50	**0x80**
	001	1500	000	50	**0x81**
	010	750	000	50	**0x82**
	011	375	001	50	**0x83**
	100	188	010	100	**0x94**

Note: The above recommendations are not 100% guarantee users will get the stable ADC output coordinate under the different touch panel modules or indefinite touch status (ex: tap). And this is still needed the users to enhance by the program.

(一) There are three steps to be followed in auto mode

(1) Define the parameters(included choosing auto mode、enable touch panel function、touch scan sampling time、touch scan frequency conversion speed and other settings)

(2) Detect touch event (included external interrupt and polling touch status, please refer to FAQ item 3-3 description)

(3) Read X,Y coordinate (there are 10-bit each of X 、 Y and which is separate in register[C1h]、[C2h] and [C3h], please refer to FAQ item 3-1 description)

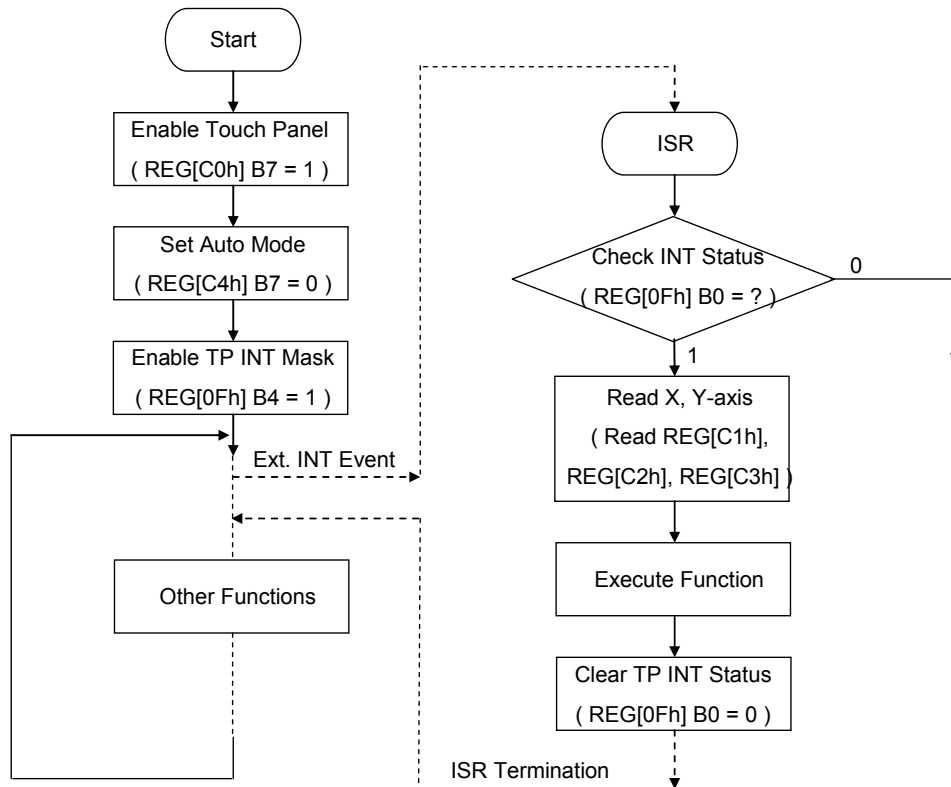The flowchart as below is using external interrupt in auto mode：

Figure 3-2

3-5 The Settings with Flowchart in Manual Mode

The required settings in manual mode as following table (symbol * means required settings, others are depend on applications)

Table 3-4

Reg.	Bit_Num	Description	Reference	
TPCR1	Bit 7	Enable Touch Panel function	REG[C0h]	∗
	Bit 6~4	Touch scan sampling time adjust bit		
	Bit 2~0	Touch scan frequency conversion speed bit		
TPCR2	Bit 7	TP Manual mode enable	REG[C4h]	∗
	Bit 1~0	Mode selection for TP manual mode		∗
INTR	Bit 4	Touch Panel Interrupt Mask	REG[0Fh]	
	Bit 3	Touch Panel Detect Status bit (use in manual mode only).		
	Bit 0	Touch Panel Detect status bit		

Note: For detail descriptions, please refer to page 18 、27、28 of RA8806 datasheet.

There are six steps to be followed by polling touch status in manual mode：

(1) Define the parameters (included choosing manual mode、enable touch panel function and other settings).

(2) Set register TPCR2[C4h] bit[1:0]=01 to wait touch event.

(3) Check the touch event is the valid touch or not (it will be treated as the valid touch if register INTR[0Fh] bit-3 always equal the same value in enough checking times).Latch X data in manual mode (it means set register TPCR2[1:0]=10b and wait enough time for the stable data latch).（＊）

(4) Latch Y data in manual mode (it means set register TPCR2[1:0]=11b and wait enough time for the stable data latch).（＊）

(5) Read X,Y coordinate (there are 10-bit each of X 、Y and which is separate in register[C1h]、[C2h] and [C3h], please refer to FAQ item 3-1 description)

（＊）We suggest the waiting time at least equal to 50 ADC clock and ADC clock conversion speed is depend on register TPCR1[C0h] bit[2:0]. Now we assume system clock is 4MHz and there is the reference table as below of register TPCR1[C0h] bit[2:0] with the different settings

Table 3-5

REG[C0h][2:0]	ADC clock conversion speed	ADC clock cycle	suggested wait time （50 ADC Clock）
000	1 MHz	1 µs	50 µs
001	500 KHz	2 µs	100 µs
010	250 KHz	4 µs	200 µs
011	125 KHz	8 µs	400 µs

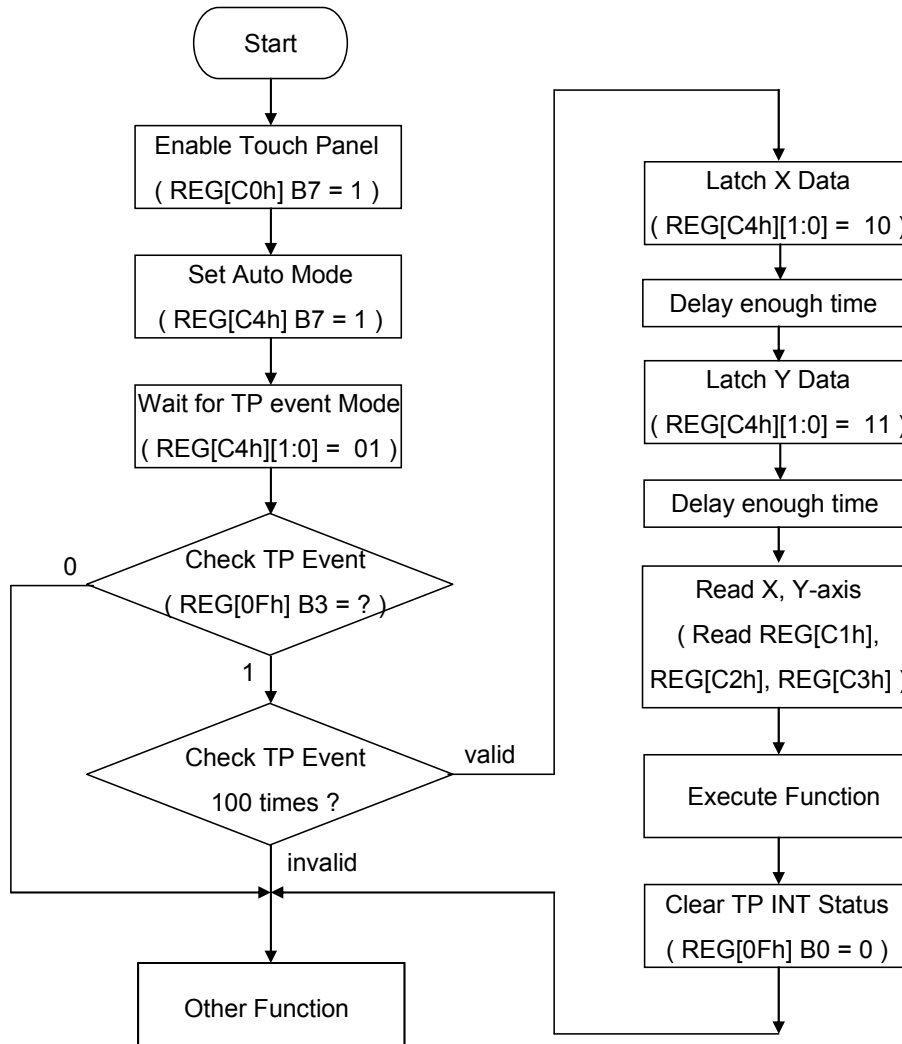The flowchart as below is using polling touch status in manual mode :

Figure 3-3

4. Gray Scale Mode

4-1 RA8806 Gray Scale Application and Characteristic

◆ RA8806 supports 4-gray-scale display.

◆ To perform the gray scale that the users only need to set register MAMR[12h] bit[6:4] to 000b.

◆ RA8806 supports 4-gray-scale function in images display and texts display. Regarding the texts display，please refer to FAQ item 4-5 description.

4-2 The Required Memory in 320x240 Gray Scale Image

In gray scale mode, each display pixel needs 2 bits memory space to save into. For example: How many display memory spaces are going to use if the display image is 320x240 ?

320 x 240 x 2 = 153600 bits = 19200 bytes (about 19K bytes)

4-3 How to Display a 320x240 Gray Scale Image?

Users must enable gray scale mode first (it means to set register MAMR[12h] bit[6:4] to 000b) then write the image data into display memory from coordinate(0,0). Below is the sample program for the reference :

```
LCD_GrayScale_Mode()；          // enable gray scale function
LCD_SetXY(0,0)；               // set coordinate at X = 0，Y = 0
LCD_CmdWrite(0xB0)；            // memory write command
for(i = 0 ; i < 19200 ; i ++)       // write data 19200 bytes
{
     LCD_DataWrite(320x240_Gray_pic[ i ])；
}
```

4-4 How to Display a 240x160 Gray Scale Image at Coordinate (5,5) ?

Now if the active window is setting to 320x240；users need to write total 160 rows and 60 bytes per row(240*2/8) data into display memory by the program in double loop method. Due to it is unable to change row automatically, users must re-send coordinate before per row starting to write data. Sample program as below for the reference :

```
for(i = 0 ; i < 160 ; i ++)         // 160 rows
{
     LCD_SetXY(5, 5 + i)；          // set coordinate at X = 5，Y = 5
     LCD_CmdWrite(0xB0)；          // memory write command
     for(j = 0 ; j < 60 ; j ++)        // 60 bytes per row data
     {
          LCD_DataWrite(240x160_Gray_pic[ j + i ∗ 60 ])；
     }
}
```

4-5 How to Display Text or Symbol in Gray Scale Mode?

We provide two program codes for customer reference and which are rotate 90 degrees display and normal(non-rotate) display applications. If the users want to perform the GB/BIG-5 fonts under the gray scale mode, all you need is only to set related parameters in what program code you are using of two program codes.

◆   XX : X coordinate value of the text who want to display, the data length is 8 bits.
◆   YY : Y coordinate value of the text who want to display, the data length is 8 bits.
◆   *ptr : text strings pointer address, the data length is 8 bits.
◆   gray_level : define the text gray scale.
◆   font_inverse : font inverse function.

Users must note that there are two steps need to set befor using the program code :

◆   Switch the display mode into gray scale mode.
◆   Set Register WCCR[10h] bit-3 to 1 in rotate 90 degrees display application.
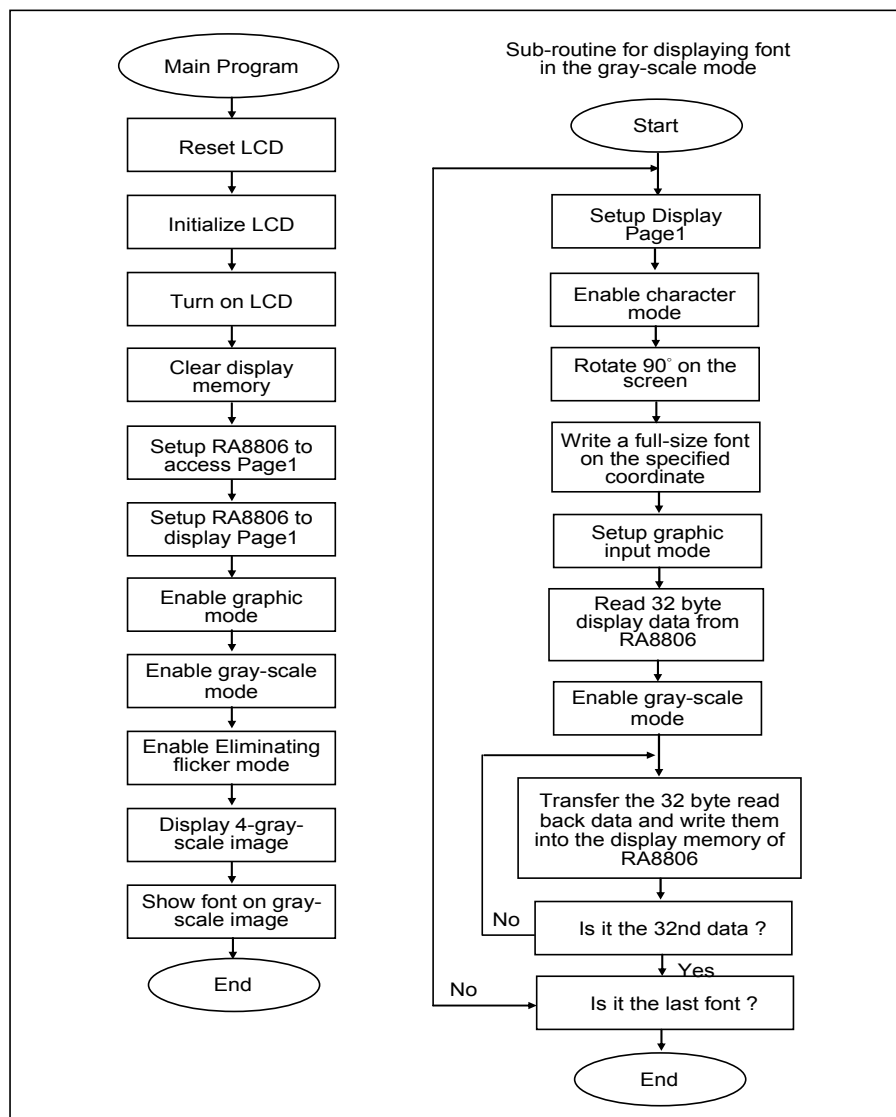
5. Other Technical Questions

5-1 Missing Display Dot when Display Text or Image

There are two possibilities:

1. Unstable DC-DC from RA8806 → When RA8806 operates in 5V system (VDDP=5V), VDD should connect a capacitor ＞1μF to the ground. Please refer section 6-7-3 of RA8806 datasheet.

2. MCU data access is too faster than RA8806 data process → Please add Delay into the program or by check Busy to make sure RA8806 has already finished processing the last data.

5-2 Text Shift or Image Shift

Here are four possibilities:

1. RA8806 display window setting and active window setting are different with LCD resolution. The table below is listing the common LCD resolution with the related register settings for the reference:

Table 5-1

Panel Resolution	Segment	Common	REG[21h] DWWR	REG[31h] DWHR
160*80	160	80	13h	4Fh
160*128	160	128	13h	7Fh
160*160	160	160	13h	9Fh
240*64	240	64	1Dh	3Fh
240*128	240	128	1Dh	7Fh
240*160	240	160	1Dh	9Fh
320*240	320	240	27h	EFh

2. MCU data transfer is too faster than RA8806 data process → Please add Delay into the program or by check Busy to make sure RA8806 has already finished processing the last data.

3. The timing is generated from MCU that not matches RA8806 requirement → To avoid insufficient Set-up time or Hold time, please refer to figure 6-3、6-4 of RA8806 datasheet.

4. The text shift or image shift phenomenon could be caused by the bad system environment 、serious noise effect or the long connection between module and system → Even though RA8806 is using Schmitt Trigger on MCU input interface to avoid the noise effect, but RA8806 still might work incorrectly by the serious noise effect. To reduce connections between MCU and RA8806 effect or system environment effect, users could connect a capacitor 50~150pF between ZCS1、ZRD and ZWR to the ground. If it is caused by the MCU weak signal or the heavy loading, users could connect a pull-high resistor 1K~4.7Kohm on ZCS1、ZRD 、ZWR and DATA[7:0].

5-3 How to Prevent the Crash Occurred ?

The possible reasons are because the bad system environment and serious noise effect → Please refer to item 4 of the previous section 5-2. Besides, please avoid the long connection between module and system.

5-4 How to Prevent the IC Damage ?

RA8806 ESD protection could reach to ±8KV, it is much higher than industrial standard 4KV requirement. But users still must especially notice the PCB layout and add the protection devices to avoid the IC damage for the special and bad system environment usage.

And the too high sudden power pulse or supply over 5.5V voltage for a long time will cause the IC damage as well → Users could connect a capacitor 470µF or the surge absorber between VDD to the ground to avoid the IC or LCM damage.
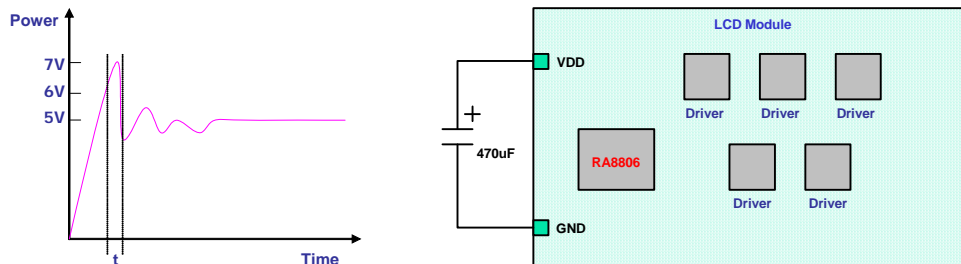

Figure 5-1

Another reason will cause the IC damage is because the EOS(Electrically Over Stress). The better way to avoid it is to reduce the cable length as short as possible or connect a resistor 200ohm~1Kohm between the system and LCMs.
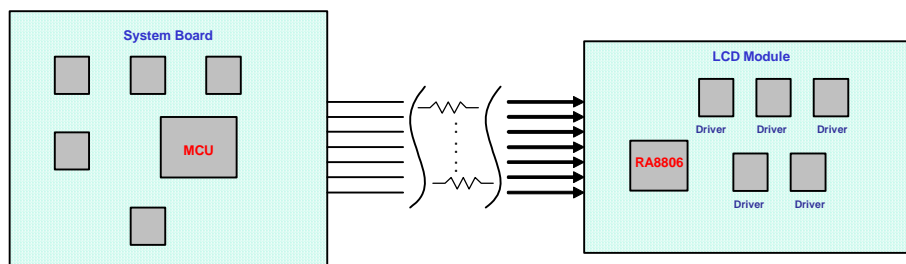

Figure 5-2

5-5 Display Performance with"Crosstalk"or Bad Quality

There are four possibilities:

1. LC quality or polarizer is poor.
2. Booster ability (VLCD) or driving ability is insufficient.
3. Incorrect bias (V0~V4).

RA8806 frame rate setting is too high to cause the crosstalk or bad display quality. Please refer to frame rate setting table in appendix B of RA8806 datasheet. The ITCR[90h] setting is defined by what LCD resolution in using and system clock. Too high frame rate will cause the driver with the high power consumption and then effect the booster ability (VLCD) or driving ability is insufficient.