



DKAN0002A

Bit-banging the SmartDisplay

09 June 2009

Features

- IS01BFRGB LCD SmartDisplay from NKK Switches
- Low cost implementation featuring the ATtiny13A from Atmel
- Complete software solution

Introduction

The IS01BFRGB SmartDisplay is NKK's standard LCD, used in every 36x24 LCD SmartSwitch. It features a 36x24 pixel monochrome LCD with red, green, and blue LED backlights. This application note describes the display's interface and provides an example implementation using bit manipulation. Complete C source code for Atmel's AVR ATtiny13A is provided.

Application

LCD

The IS01BFRGB LCD requires two supply voltages: 5VDC for logic (V_{DD}) and 7.3VDC typical for LCD contrast (V_{LC}).

Each LCD row requires that 40 data bits be serially clocked into the data-in (Din) pin on the falling edge of the serial clock pulse (SCP). The LCD only displays the last 36 data bits; the first 4 data bits are ignored. After a row of data is received, the latch pulse (LP) pin is pulsed to load the data. The LP-to-LP timing diagram in Figure 1 shows a row of data bits latched by an LP pulse.

Pulsing the LP while the first line marker (FLM) pin is high latches data into the first row. Each subsequent LP pulse latches the following row. Every 24th row, the FLM resets the display to the first row. The LP-to-LP timing determines the refresh rate. NKK recommends a maximum LP-to-LP timing of 1.2ms to avoid flicker*. The supplied code, with the ATtiny13A's 9.6MHz internal oscillator, achieves this. Figure 2 shows the timing diagram for a complete frame. Consult the datasheet for the timing specifications.

* It has been observed that a V_{LC} of more than 8VDC enables a slower refresh rate (approximately 1.8ms) without flicker. Since this requires fewer computational resources, a slower microcontroller can be used, or more tasks can be completed. Beyond 8VDC and 1.8ms, this relationship between V_{LC} and the refresh rate diminishes, and no advantage is gained.

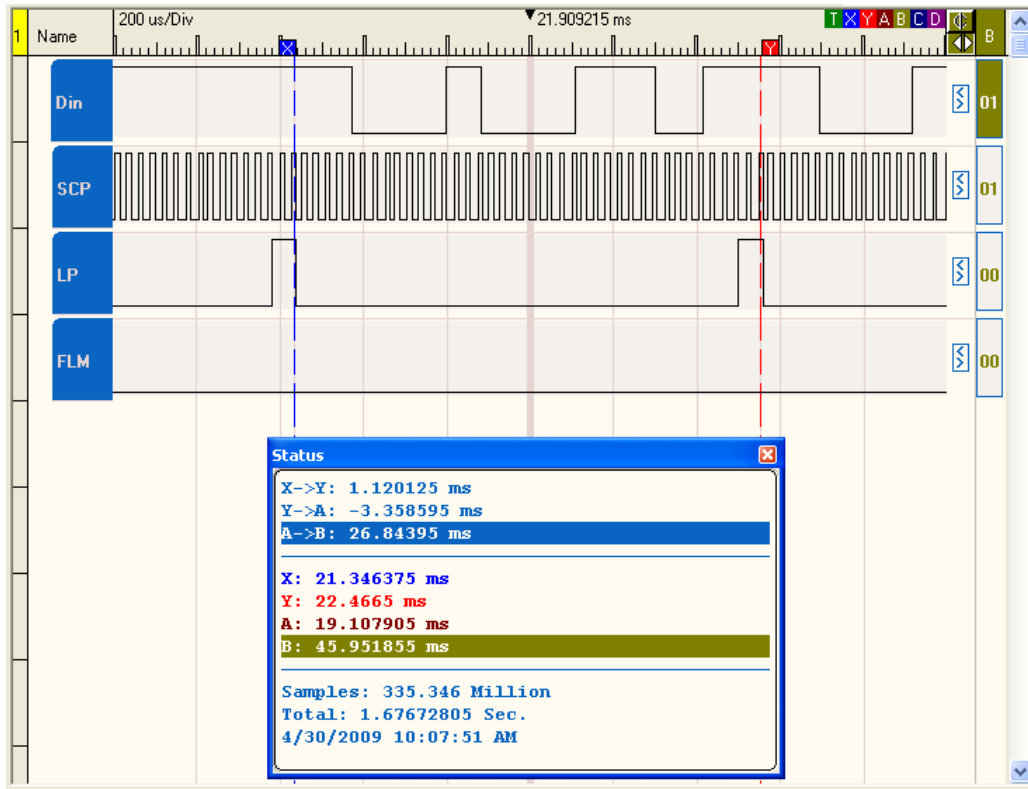


Figure 1. LP-to-LP Timing Diagram

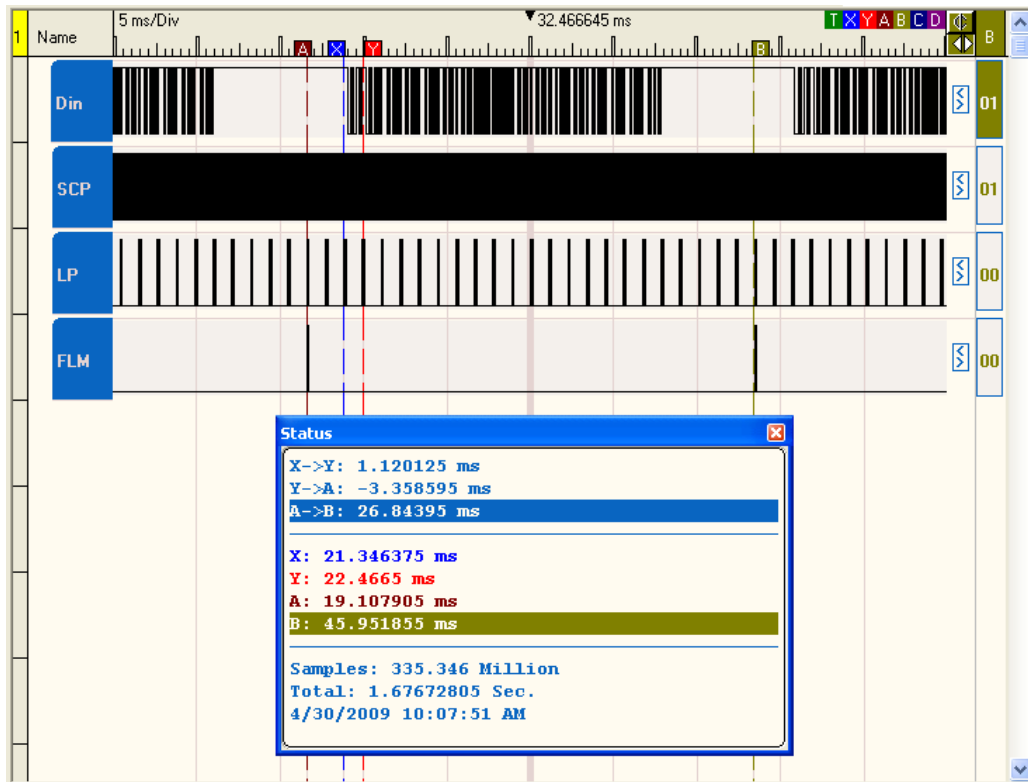


Figure 2. Frame Timing Diagram

Backlight

The LCD's backlight consists of red, green, and blue LEDs. Figure 3 shows an example circuit. The current-limiting resistors control the backlight LEDs' color and brightness. Refer to the datasheet for LED specifications.

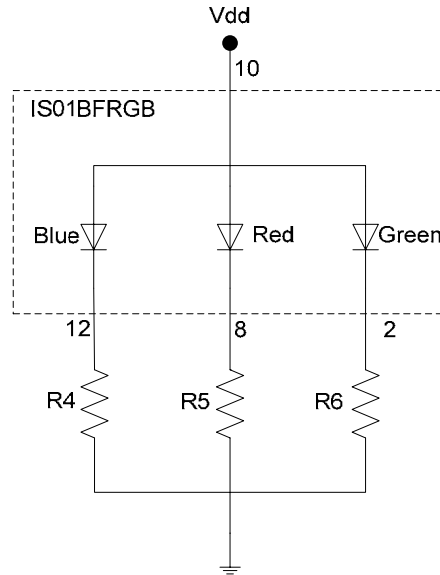


Figure 3. LED Backlight Circuit

Example Circuit

Figure 4 shows an example circuit using the ATtiny13A to control the NKK IS01BFRGB SmartDisplay. An LM2703 from National Semiconductor boosts V_{DD} to 7.3VDC for the LCD contrast (V_{LC}). The ATtiny13A controls the LM2703 shutdown pin, and the rheostat R_2 controls V_{LC} .

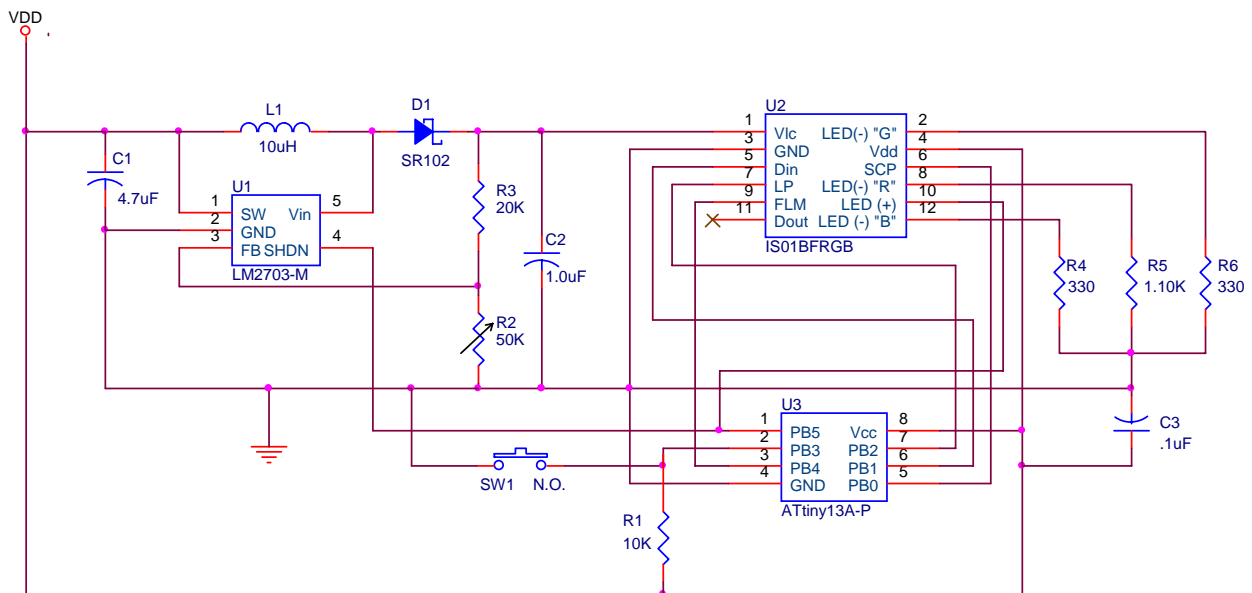


Figure 4. Example Circuit

Code

Figure 5 illustrates the program flow chart.

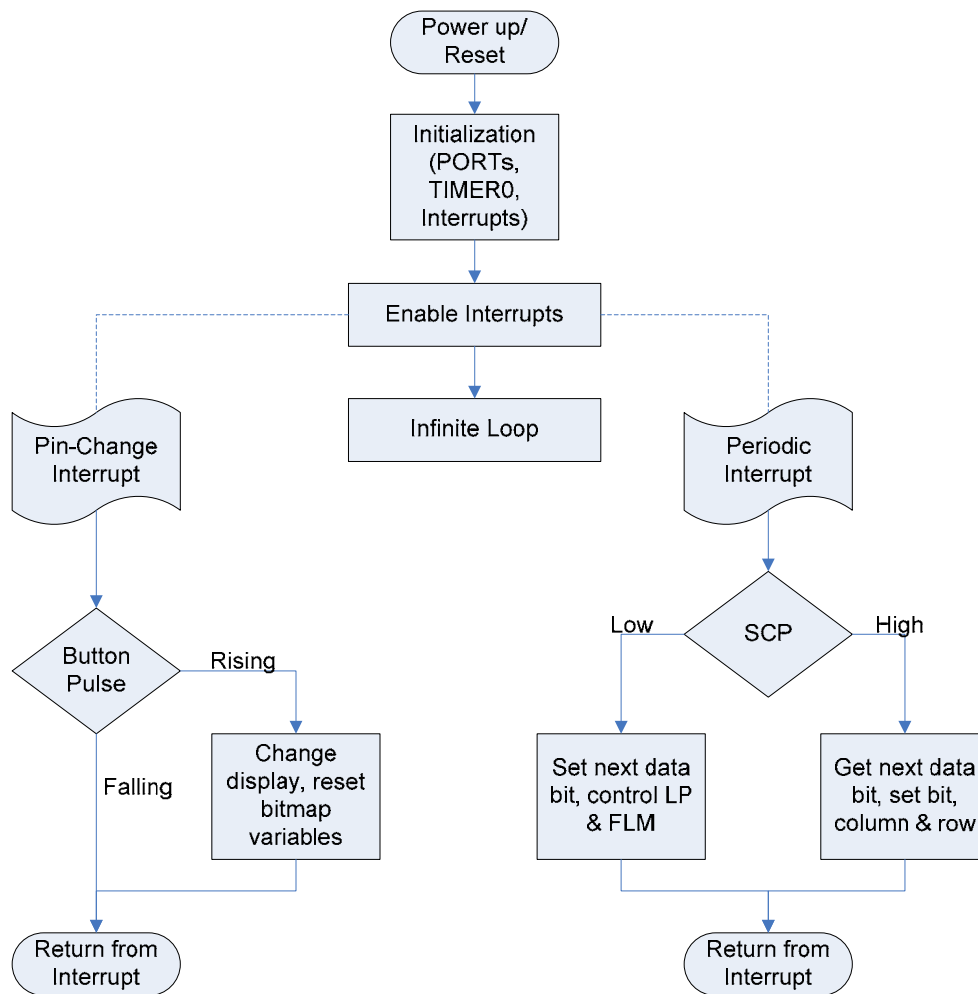


Figure 5. Program Flow Chart

Initialization

The program begins with the initialization of the GPIO pins, Timer0, and the interrupts. PB4 is configured as an input; the remaining GPIO pins are configured as outputs. Timer0 is configured to use the output compare register A (OC0A). A pin change interrupt is enabled on PB4, and the global interrupts are enabled. Table 1 shows port IO configuration.

Table 1. Port IO

ATtiny13A		IS01BFRGB	LM2703
Pin	Direction		
PB0	Output	SCP	---
PB1	Output	Din	---
PB2	Output	LP	---
PB3	Input	---	---
PB4	Output	FLM	---
PB5	Output	BL-LED+	SHDN

Pin Change Interrupt

An interrupt is generated on both a button press and a button release. After a button release, the interrupt service routine switches to the alternate bitmap and resets the bit, column, and row pointers to start a new image.

Periodic Interrupt

Timer0 is set up to interrupt every 14 μ s. The interrupt toggles SCP to generate the clock. If SCP is HIGH, the next pixel of bitmap data is retrieved from memory. If SCP is LOW, the pixel data bit is set on Din, and the LP and FLM pins are controlled appropriately.

Bitmap

The display is a 36x24 pixel format, but the bitmaps have a 40x24 format to incorporate the ignored bits. Each bit sets a pixel state (1=on, 0=off). In this example, each 120-byte bitmap is stored in internal Flash. (Note: the program inverts the OFF bitmap for visual differentiation.) Figure 6 illustrates the bitmap format.

```

unsigned char IS01BFRGB_bitmap_1[24][5] PROGMEM =
{
  {0b00000000, 0b00000000, 0b00000000, 0b00000000, 0b00000000 } // Line #1
  {0b00000000, 0b00000000, 0b00000000, 0b00000000, 0b00000000 } // Line #2
  {0b00000000, 0b00000000, 0b00000000, 0b00000000, 0b00000000 } // Line #3
  {0b00000000, 0b01111000, 0b00000110, 0b00000110, 0b00000000 } // Line #4
  {0b00000000, 0b11111100, 0b00000110, 0b00000110, 0b00000000 } // Line #5
  {0b00000001, 0b10000110, 0b00000111, 0b00000110, 0b00000000 } // Line #6
  {0b00000011, 0b00000011, 0b00000111, 0b10000110, 0b00000000 } // Line #7
  {0b00000110, 0b00000001, 0b10000111, 0b10000110, 0b00000000 } // Line #8
  {0b00000110, 0b00000001, 0b10000111, 0b11000110, 0b00000000 } // Line #9
  {0b00000110, 0b00000001, 0b10000110, 0b11000110, 0b00000000 } // Line #10
  {0b00000110, 0b00000001, 0b10000110, 0b1100110, 0b00000000 } // Line #11
  {0b00000110, 0b00000001, 0b10000110, 0b01100110, 0b00000000 } // Line #12
  {0b00000110, 0b00000001, 0b10000110, 0b01110110, 0b00000000 } // Line #13
  {0b00000110, 0b00000001, 0b10000110, 0b00110110, 0b00000000 } // Line #14
  {0b00000110, 0b00000001, 0b10000110, 0b00111110, 0b00000000 } // Line #15
  {0b00000110, 0b00000001, 0b10000110, 0b00011110, 0b00000000 } // Line #16
  {0b00000011, 0b00000011, 0b00000110, 0b00011110, 0b00000000 } // Line #17
  {0b00000001, 0b10000110, 0b00000110, 0b00001110, 0b00000000 } // Line #18
  {0b00000000, 0b11111100, 0b00000110, 0b00000110, 0b00000000 } // Line #19
  {0b00000000, 0b01111000, 0b00000110, 0b00000110, 0b00000000 } // Line #20
  {0b00000000, 0b00000000, 0b00000000, 0b00000000, 0b00000000 } // Line #21
  {0b00000000, 0b00000000, 0b00000000, 0b00000000, 0b00000000 } // Line #22
  {0b00000000, 0b00000000, 0b00000000, 0b00000000, 0b00000000 } // Line #23
  {0b00000000, 0b00000000, 0b00000000, 0b00000000, 0b00000000 } // Line #24
};

```

Figure 6. Example Bitmap

Conclusion

This application note presents a bit-bang methodology to interface with the NKK SmartDisplay. It provides a complete software solution utilizing an ATtiny13A.

Additional Information

[DKAN0003A: Controlling the SmartDisplay with a SPI Peripheral](#). Digi-Key Corporation. 09 June 2009.

Appendix: Parts List

Part	DK Part Number	Description	Mfg Part Number
R1	10KQBK-ND	RES 10K OHM 1/4W 5% CARBON FILM	CFR-25JB-10K
R2	3352H-503LF-ND	POT 50K OHM THUMBWHEEL CERM ST	3352H-1-503LF
R3	20KQBK-ND	RES 20K OHM 1/4W 5% CARBON FILM	CFR-25JB-20K
R4	330QBK-ND	RES 330 OHM 1/4W 5% CARBON FILM	CFR-25JB-330R
R5	1.1KQBK-ND	RES 1.10K OHM 1/4W 5% CARBON FILM	CFR-25JB-1K1
R6	330QBK-ND	RES 20K OHM 1/4W 5% CARBON FILM	CFR-25JB-330R
L1	811-1309-ND	INDUCTOR RADIAL 10UH 1.62A	22R103C
C1	445-2867-ND	CAP CER 4.7UF 16V Y5V RAD	FK24Y5V1C475Z
C2	445-2852-ND	CAP CER 1UF 16V Y5V RAD	FK28Y5V1C105Z
C3	445-4802-ND	CAP CER .10UF 50V Y5V RAD	FK28Y5V1H104Z
D1	SR102DICT-ND	DIODE SCHOTTKY 20V 1.0A DO-41	SR102-T
U1	LM2703MF-ADJCT-ND	IC CONV DC/DC MICPWR SOT23-5	LM2703MF-ADJ/NOPB
U3	ATTINY13A-PU-ND	IC MCU AVR 1K FLASH 2MHZ 8PDIP	ATtiny13A-PU
U2	360-2334-ND	SMARTDISPLAY RED/GREEN/BLUE	IS01BFRGB
SW1	P8014S-ND	6MM LIGHT TOUCH SW W/GND H=5	EVQ-PBC05R
or			
SW1/U2	360-2332-ND	SMARTSWITCH STANDARD RGB	IS15ABFP4RGB

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