Programming the NS32FX200 to Drive a Stepper Motor

National Semiconductor
Application Note 820
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1.0 INTRODUCTION

The NS32FX200 is a highly integrated system chip, specially designed for fax systems based on National Semiconductor's NS32FX161, NS32FX164 or NS32FV16 embedded processors.

The NS32FX200:

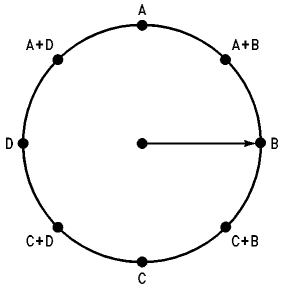
- Supports two stepper motors, one for a Thermal Print Head (TPH) printer and the other for a variety of Contact Image Sensor (CIS) and Charge Coupled Device (CCD) scanners.
- Provides special timing synchronization logic for driving the two stepper motors.
- Enables variable speeds of paper movement.
- Supports a variety of document sizes.

This document describes how to program the NS32FX200 to drive a stepper motor for a TPH printer, CIS scanner or CCD scanner.

2.0 GENERAL DESCRIPTION OF A STEPPER MOTOR

The stepper motor has four poles (A, B, C and D). Assigning an active signal to a pole, while the other poles are inactive, attracts the motor rotor. If two adjacent poles are active, while the other two are inactive, the rotor will reside between the adjacent active poles.

Step Motor Poles



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Step Motor Mask Table

#	Mask	Poles			
		A	C	B	D
0	0xa	1	0	1	0
1	0x8	1	0	0	0
2	0x9	1	0	0	1
3	0x1	0	0	0	1
4	0x5	0	1	0	1
5	0x4	0	1	0	0
6	0x6	0	1	1	0
7	0x2	0	0	1	0

FIGURE 1. Stepper Motor Poles and Mask Table

When a sequence of signals is assigned to the stepper motor poles, its rotor rotates. To change the rotor direction, change the sequence of the signals.

The stepper motor is controlled by three parameters:

motor__step, motor__mask and, **time__interval**.

- **motor__step:** This parameter may have one of the following values:
  2__2__STEP:
  This value produces steps of 90 degrees. Only masks that have two adjacent active signals and two inactive signals are used. The motor skips poles and moves as follows: A + B, B + C, C + D and D + A.
  1__2__STEP:
  This value produces steps of 45 degrees. The rotor moves through all poles as follows: A, A + B, B, B + C etc.
- **motor__mask**: The **motor__mask__array** contains sequences of signals for driving specific stepper motors. A pointer, **mask__index,** points to the last mask used by the stepper motor.
  Use of consecutive masks in the array causes the stepper motor to operate in the 1__2__STEP mode.
  Use of only even-numbered masks in the array causes the stepper motor to operate in the 2__2__STEP mode.
  Super fine mode requires one 1__2__STEP step to print a line. Fine mode requires two 1__2__STEP steps to print a line, or one 2__2__STEP step. Standard mode requires four 1__2__STEP steps, or two 2__2__STEP steps.
- **time__interval**: This parameter defines the minimum time interval that is permitted between two consecutive masks. It ensures that the next mask will be supplied only after the rotor has completed the previous move, i.e., step.

2.1 The Stepper Motor Control

The NS32FX200 has separate mechanisms for controlling the printer motor and the scanner motor. The printer motor scrolls the paper in the printer. The scanner motor drives the scanner paper-feed system.

The NS32FX200 has four dedicated external output pins for each motor.

The scanner motor and the printer motor are controlled in a similar fashion (see *Figure 2*).

Values that indicate a specific motor phase, and the time at which its pulse is activated, are written to the appropriate registers (Scanner/Printer Motor PHases register and Scanner/Printer Motor Time SLot register). Whenever the Time Slot counter (Note 1) reaches the value specified in the Motor Time Slot register, the value in the corresponding motor phase register is sent to the output pins and an interrupt is generated.

Note 1: The time-slots are generated by the NS32FX200 Timing Control Unit (TCU) by using programmable dividers on the chip's CTTL input clock, to divide each 20 ms period into 256 time-slots. The time-slots are used to synchronize the various components of the fax system, e.g., the printer and scanner with their respective motors. For further details see the NS32FX200 datasheet Section 4.2.2.2.

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After each interrupt, the values associated with the following motor phase should be computed, and written (by the motor handler) to the appropriate registers. These new values are transferred to the appropriate motor as soon as the next interrupt occurs.

2.1.1 The Thermal Print Head Printer Stepper Motor Control

A Thermal Print Head (TPH) printer is composed of three main elements, a serial-in, parallel-out shift register, a thermal print head and a stepper motor.

The shift register receives the bitmap lines serially from the NS32FX200 printer controller and latches them inside the TPH. The TPH prints these image lines one at a time, using the printing strobes generated by the NS32FX200 printer controller, on the thermal paper. The stepper motor moves the thermal paper over the printing element.

A printing session may be performed during fax reception, local copy, printing from memory or report printing operations.

A printing session consists of the following stages:

1. Idle stage.
2. Initialize the NS32FX200 and printer hardware.
3. Adjust the thermal paper backward to the printing element.
4. Advance the thermal paper and print the image lines, one after the other.
5. Eject the thermal paper from the printer.
6. Return to stage 3, if there are more pages to be printed.

Printing operations are performed by the printer handlers using the NS32FX200 Printer Controller module. The printer state is set by the printer interface routines, and is modified according to the status of the printer sensors. The printer motor handler, invoked by an interrupt, moves the paper over the printing element.

The NS32FX200 Printer Controller contains the printer bitmap-shifter and the thermal print-head control block. Each block is individually enabled or disabled by the Module Configuration Register (MCFG).

The bitmap shifter can operate with either internal or external clocks. DMA channel 1 loads the data to the bitmap shifter.

The thermal print-head block includes the stepper motor controller, a strobes generator, printer interrupt generator, and temperature sensing circuit. The block is synchronized with the time-slots of the TCU module.

The stepper motor is synchronized with the time-slots of the Time Control Unit (TCU). The motor handler determines in which time-slot the motor interrupt pulse will occur.

The stepper motor control is divided into four phases. The values of the phases are stored, by the printer motor handler (Note 2) into the Printer Motor PHases (PMPH) register in the Ports module, and are latched into the phase pins (PMPH0–3) on the motor interrupt pulse rising edge. The handler controls the time-slot in which the printer motor interrupt pulse is generated via the Printer Motor Time-Slot (PMTSL) register. *Figure 3* is a timing diagram of the signals required to control the stepper motor.

Note 2: At each printer motor interrupt, the interrupt handler does the following:

- Computes the next mask of the motor and writes it to the PMPH register.
- Computes the next step activation time interval (time-slot) and writes it to the PMTSL register.

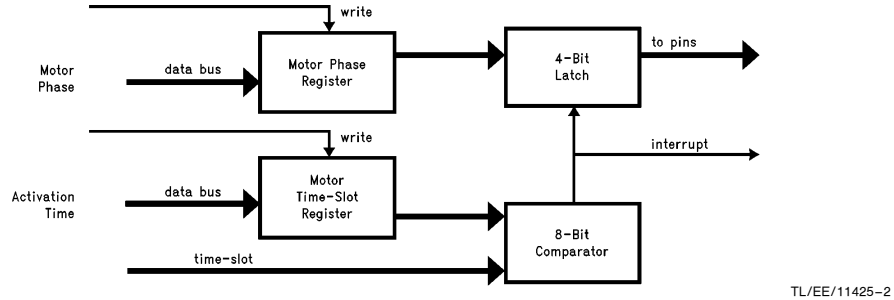

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FIGURE 2. Stepper Motor Controller Block Diagram

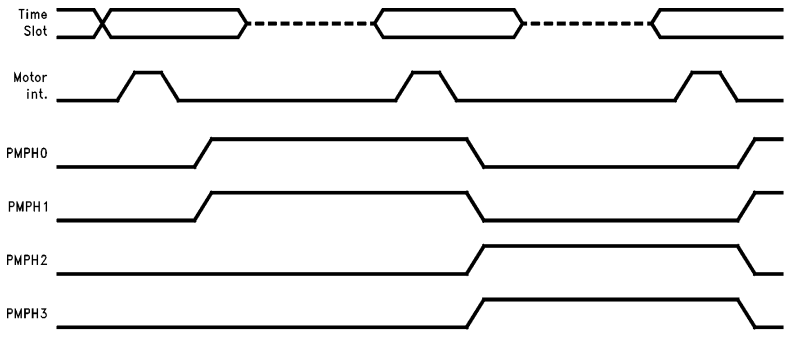

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FIGURE 3. TPH Printer Stepper Motor Control Signals (for 2—2—STEP)

2.1.2 The Scanner Stepper Motor Control

Scanning operations may be performed during fax transmission, local copy or scan to memory operations.

They are performed in the following stages:

1. Initialize the NS32FX200 and scanner hardware.
2. Advance a page of the document to the scanning element.
3. Scan the page, line by line.
4. Eject a page from the scanner.
5. Return to stage 2, if there are more pages to be scanned.
6. Eject a document and end a scanning session.

Scanning operations are performed by the scanner handlers using the NS32FX200 Scanner Controller module. The scanner motor handler, invoked by an interrupt, advances the paper over the scanning element.

The Scanner Controller module contains the scanner signals generator block, the video handling block and the stepper motor control block.

The stepper motor is synchronized with the time-slots of the Time Control Unit (TCU). The motor handler determines in which time-slot the motor interrupt pulse will occur.

The stepper motor is controlled by four phases. The phases values are stored, by the scanner motor handler (Note 3) into the Ports module, in the Scanner Motor PHases (SMPH), and are latched into the phase pins (SMPH0–3) on the motor interrupt rising edge. The motor handler controls the time-slot in which the scanner motor interrupt pulse is generated via the Scanner Motor Time-SLot (SMTSL) register.

Figure 4 is a timing diagram of the signals required to control the stepper motor.

Note 3: At each scanner motor interrupt, the interrupt handler does the following:

- Computes the next mark of the motor and writes it to the SMPH register;
- Computes the next step activation time interval (time-slot) and writes it to the SMTSL register.

3.0 PROGRAMMING THE NS32FX200 CONTROLLER

To use the NS32FX200 to drive stepper motors for a thermal print head printer and a CIS, or CCD, scanner at 20 MHz (19.6608 MHz to be exact), program the NS32FX200 registers as described in this section.

3.1 The Configuration Register (MCFG)

MCFG = Logical OR between MCFG and $1f_{16}$

When the MCFG register is programmed as shown, it enables the following:

TCU module
Thermal Print-Head Control
Printer bitmap shifter block
Scanner Controller (SCANC) module
Usage of DMA channel 0 by the Scanner Controller.

3.2 The Printer Controller Registers

PMTSL: Printer Motor Time Slot register. Holds the time-slot in which the Printer Motor Interrupt Pulse is generated. The interrupt pulse occurs at the beginning of the specified time-slot.

3.3 The Scanner Controller Registers

SMTSL: Scanner Motor Time Slot register. Holds the time-slot in which the Scanner Motor Interrupt Pulse is generated. The interrupt pulse occurs at the beginning of the specified time-slot.

3.4 The TCU Frequency Controller Registers

The MCLON register, together with the MCLOFF register, is used to generate a 1.2288 MHz internal MCLK. Program them as shown for a CTTL frequency of 19.6608 MHz.

MCLON = 7_{16}

MCLK On register. Defines the on time.

MCLOFF = 7_{16}

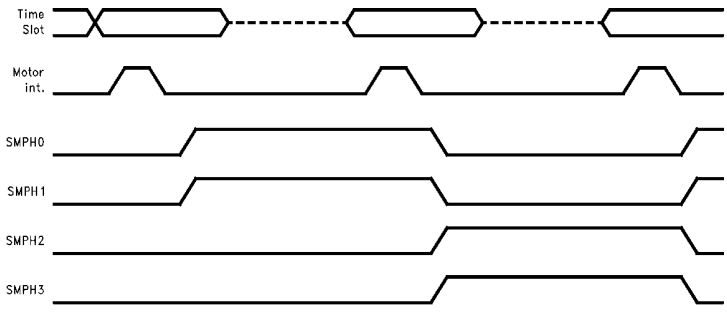
MCKL Off register. Defines the off time.

3.5 The I/O Ports Registers

PMPH: Printer Motor Phase register. The register holds the PMPH0–3 pins, next value, changed on printer motor interrupt rising edge. Bits 0–3 control the four phases. Bits 4–7 are reserved. A double buffer is used to latch the next values and to drive the pins. The PMPH0–3 pins are non TRI-STATE® outputs only. Upon reset the pins are driven low.

SMPH: Scanner Motor Phase register. The register holds the SMPH0–3 pins, next value, changed on scanner motor interrupt rising edge. Bits 0–3 control the four phases. Bits 4–7 are reserved. A double buffer is used to latch the next values and to drive the pins. The SMPH0–3 pins are non TRI-STATE outputs only. Upon reset the pins are driven low.

For a complete description and listing of the stepper motor handlers for the NS32FX200 based fax system please refer to the National Semiconductor Series 32000® Embedded Processors *NSFAX Software Reference Manual* revision P4.0.



TL/EE/11425–4

Figure 4. Scanner Stepper Motor Control Signals (for 2__2__STEP)

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