Vending Machine Controller Specification

Integrated VLSI internship

Front-End Design/Verification Project Specification

SURE ProEd

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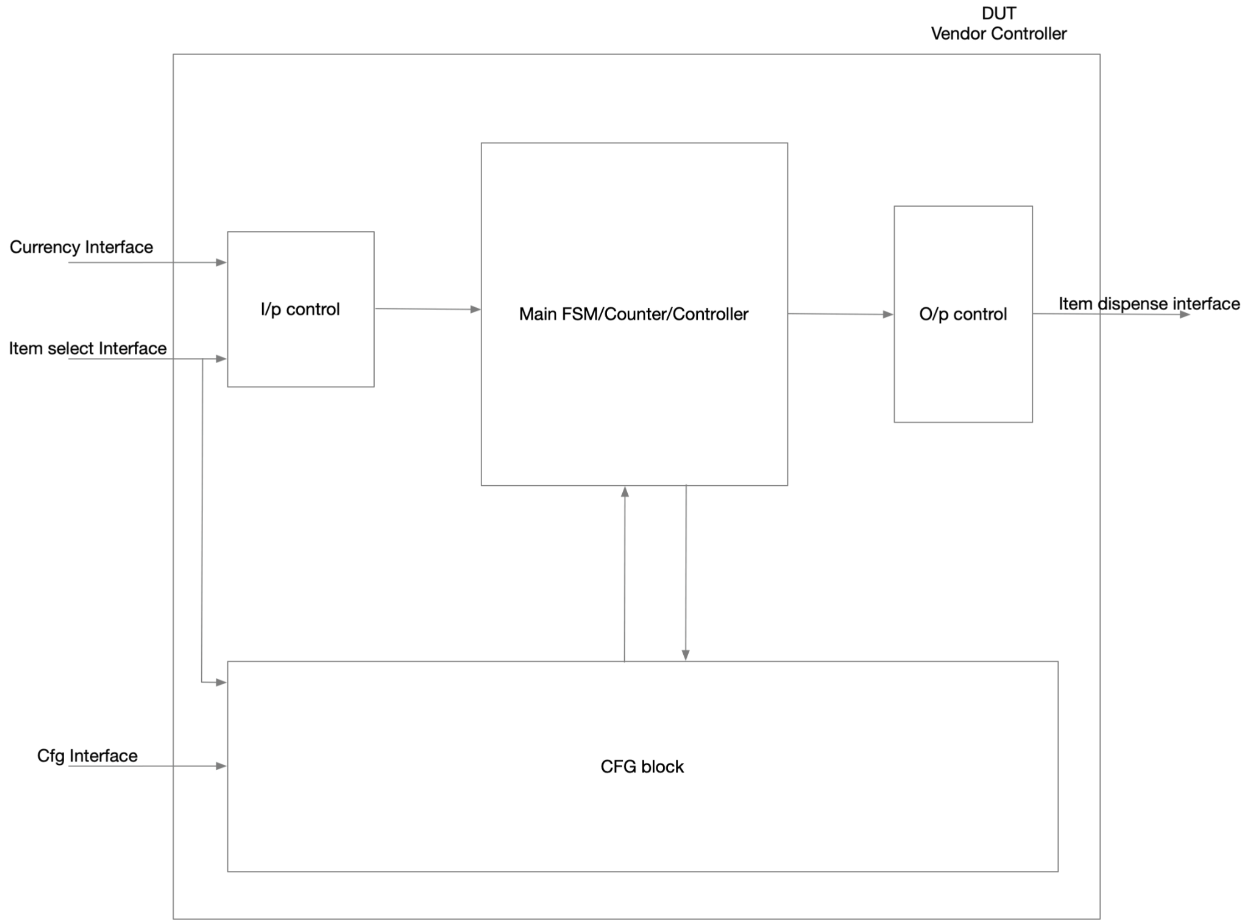
Introduction

This controller is a digital IP inside a vending machine. This IP can be used in many different vending machines with multiple items. This design offers flexibility and adaptability for various items and configurations

Block Diagram



Feature Description

- The design system clock operates at 100MHz
- No of the items supported by design are parameterized up to 1k (1024)
- The max value of the currency acceptable is parameterized and up to 100 rs
- Each item can have different values
- The design has active low reset
- The design latency should be less than 10 system clocks (from final valid currency to output item generation)
- Currency input is at a slow clock due to human insertion speed, usually ranging 10KHz to 50MHz and is asynchronous to System clock
- At any point of time the design can produce one output decision
- Currency values supported are (5, 10, 15, 20, 50, 100 rs)
- Output decision is single clock wide in System clock pulse
- Design keeps track of total dispensed and total remaining items for each item type supported
- When an item is chosen and not available
    - the change should be dispensed right away after first input inserted
    - One item number is preserved for empty_item indication sould be conveyed when dispensing empty item along with change
- Design IP has a configuration mode where the machine is loaded with the items
- During configuration mode
    - all the items supported and their values are loaded
    - Resets the dispensed items count
    - Preloads the available item count
- Configuration mode is through an APB interface and is on 10MHz clock

High-Level Architecture

The controller works in 3 different modes.

S No	Mode	Mode determination	Description
1	Reset Mode	rstn == 0	The rstn pin is low and other pins are dont care
2	Configure Mode	rstn == 1’b1 && Cfg_mode == 1’b1	Design is our of reset and cfg_mode is set
3	Operation Mode	rstn == 1’b1 && Cfg_mode == 1’b0	Design is our of reset and cfg_mode is not set

Reset Mode

In reset mode, the controller IP is under reset and all the HW is at reset state. The configuration registers and memories will default to reset values.

Configuration Mode

When the IP is not under reset, and the cfg_mode pin is asserted, then the design IP will enter configure mode.
This mode is visualized as a vendor stocking the vending machine and loading the stock details.
The vendor/host SW writes into the design IP through an APB interface during this mode.
The host can write into all registers the details of the value of the item, the loaded count/available count for each item, and clear the dispensed item count. Refer to the configuration section for more details.

Operation Mode

This is the primary POR mode the design IP operates in. This mode represents the controller making dispense, and/or change decisions based on the input stream of currency values.

General flow

1. Start in reset mode
2. Enter to configure mode
3. Load the item counts
4. Release from configure mode

5. Enter Operation mode
6. Do operation
    a. Select an item number on the interface with a choice of item
    b. Insert currency (as many notes as needed for the selected item’s cost value)
    c. Receive the dispense output information
7. Repeat step 6 for the next item

Interfaces

General Interfaces

Name	Direction	Width	Details
clk	Input	1-bit	100MHz System Clock
rstn	Input	1-bit	Asynchronous active Low reset
cfg_mode	Input	1-bit	Active high mode indicating config mode

Currency Interface

Name	Direction	Width	Details
currency_valid	Input	1-bit	Single clk pulse in Input frequency (10KHz - 50MHz)
currency_value	Input	N	Width is based on the Log-base-2 of Max currency value

Item Selection Interface

Name	Direction	Width	Details
item_select	Input	M bits	Width is based on log-base-2 of total items supported
item_select_valid	Input	1-bit	Single clock pulse indicating the Item selection code is valid (10KHz-50MHz)

Configuration Interface

Name	Direction	Width	Details
pclk	Input	1-bit	50MHz config clock
prstn	Input	1-bit	Synchronous Reset
paddr	Input	15-bit	Address of the configuration register/memory
psel	Input	1-bit	Selecting this block configuration
pwrite	Input	1-bit	Active high indicating write operation, else read operation
pwdata	Input	32-bit	Write data for configuration register/memory
prdata	Output	32-bit	Read data indication register/memory content
pready	Output	1-bit	Active high indicates the cfg module is ready for next config. In response to read, the prdata is valid when pready is high

Item Dispense Interface

Name	Direction	Width	Details
item_dispense_valid	Output	1-bit	Single clock pulse indicating the Item dispense is valid (system clock wide pulse)
item_dispense	Output	M bits	Width is based on log-base-2 of total items supported
currency_change	Output	X bits	Width is based on the Log-base-2 of Max possible currency change value

Configuration

Register types:
RW - Read Writeable
RO - Read Only
WO - Write Only
W1C - Clear on Writing a 1’b1

Reg Map

Address	**Reg Name**	**Description**
0x4000_0000	Vending_machine_cfg	Main configuration file describing the total no of items available
0x4000_0004 - 0x4000_xxxx	Item_cfg[0] Item_cfg[1] … Item_cfg[MAX_ITEMS-1]	An array of flops or a memory With size MAX_ITEMS supported by the design

Reg Description

Vending Mchine Config

Bits	**Field**	**Type**	**Description**
31:XX	Reserved	RO	
XX-1:0	no_of_items	RW	Store the value of No of Items available. Programmed during cfg mode. Depending on the no of items loaded in the machine the user can program this field. No_of_items <= MAX_ITEMS

Item Configuration

This register array or memory represents 31-bit wide for each item and the total elements MAX_ITEMS worth of entries.

Example: if the Vending machine can support up to 32 items then the register array is
Item_cfg[0] - 0x4000_0004
Item_cfg[1] - 0x4000_0004 + 4
Item_cfg[2] - 0x4000_0004 + 8
…
Item_cfg[31] - 0x4000_0004 + 31*4

This array lists full possible MAX_ITEMS per design, however use case can have less items based on customer programming. I.e. no_of_items <= MAX_ITEMS.
So even though the register array or memory has MAX_ITEMS worth of entries, only the no_items worth of entries are valid.

Each entry contains below:

Bits	**Field**	**Type**	**Description**
31:24	disp_items	RO	The number of items, dispensed so far
23:16	avail_items	RW	The number of items, are loaded/available as of now
15:0	item_val	RW	This field holds the value of this item