

# Mini Colecovision

SPARKLETRON

November 7, 2024

Jay Convertino

# Contents

<b>1</b>	<b>Introduction</b>	<b>2</b>
1.1	Specifications . . . . .	2
1.2	Parts List . . . . .	2
<b>2</b>	<b>Building</b>	<b>3</b>
2.1	Dependencies . . . . .	4
2.1.1	Protable Coleco Glue File List . . . . .	4
2.1.2	Fusesoc . . . . .	4
2.1.3	Protable Coleco Glue Targets . . . . .	4
2.1.4	Quartus . . . . .	5
2.2	PCB . . . . .	5
2.3	3D Printed Case . . . . .	5
2.4	Programming . . . . .	5
2.4.1	ROM . . . . .	5
2.4.2	CPLD . . . . .	5
<b>3</b>	<b>Usage</b>	<b>6</b>
3.1	Directory Guide . . . . .	6
<b>4</b>	<b>Module Documentation</b>	<b>6</b>
4.1	porta_glue_coleco . . . . .	7

# 1 Introduction

This project creates a mini colecovision for a portable console. Much of the TTL and Analog Monostable circuits are emulated by a CPLD. The full PCB and CPLD code is in this repository. It emulates the original Colecovision with the additional super game module.

## 1.1 Specifications

- Z80 CPU
- 32 KiB of RAM
- 32 kiB of ROM
- SN76489 Sound Chip
- YMZ284 Sound Chip
- TMS9118 Video Display Processor with 16 KiB of VRAM

## 1.2 Parts List

Item	Qty	Reference(s)	Value
1	13	C1, C7, C8, C10 to C14, C18, C19, C23, C25, C29	100nF
2	1	C2	330uF
3	4	C3, C5, C24, C30	10uF
4	1	C4	100pF
5	1	C6	270pF
6	8	C9, C17, C22, C31 to C35	100nF
7	2	C15, C16	33pF
8	2	C20, C21	10nF
9	1	C26	0.47uF
10	1	C27	0.1uF
11	1	C28	2.2uF
12	1	D1	LED
13	5	H1, H2, H4, H6, H7	MountingHole_Pad
14	1	J1	Conn_01x07
15	3	J2, J10, J11	Conn_01x02
16	1	J3	Conn_Coaxial
17	1	J4	Cartridge Port
18	1	J5	Player 1
19	1	J6	Conn_02x05_Odd_Even
20	1	J7	Player 2
21	1	J9	SJ1-3525NG

22	3	L1, L2, L3	4.7uH
23	1	Q1	2N3904
24	1	R1	4k7
25	1	R2	470R
26	2	R3, R28	100k
27	2	R4, R27	100K
28	2	R5, R6	2k2
29	3	R7, R8, R9	3K3
30	1	R10	75R
31	1	R11	510R
32	1	R12	100R
33	1	R13	3k3
34	4	R14, R15, R16, R17	1k
35	2	R18, R19	10k
36	1	R20	1K
37	1	R21	1k
38	1	R22	220R
39	1	R23	10K
40	2	R24, R26	1K
41	1	R25	68K
42	2	RN1, RN2	10k
43	1	RV1	10K
45	1	SW1	SW_Push
46	1	SW2	SW_SPDT
47	1	SW3	SW_SPDT
48	1	U1	TPA711D
49	1	U2	SN76489AN
50	1	U3	Z84C0010AEG
51	1	U4	CY62256-55PC
52	1	U5	27C256
53	1	U6	TMS9118NL
54	2	U7, U8	TMS4416
55	1	U9	EPM7128SLC
56	1	U10	74ABT125
57	1	U11	YMZ284
58	5	U12, U13, U14, U15, U16	74AHCT1G08
59	1	Y1	10.738635 MHz

## 2 Building

Steps to build the mini Colecovision

- Create main PCB schematic/gerber/coleco\_original.zip

- Create Right Angle PCB schematic/gerber/right\_angle/right\_angle.zip
- Program ROM with BIOS
- Populate main PCB
- Populate right angle PCB
- Power up and program CPLD
- Build your own case

## 2.1 Dependencies

The following are the dependencies needed to build the firmware and PCB for the system.

- Quartus 13.0 sp1
- python 3.X
- KiCAD v7.X

### 2.1.1 Protable Coleco Glue File List

- src
  - 'src/porta\_glue\_coleco.v': 'file\_type': 'verilogSource'
- constr
  - 'constr/porta\_glue\_coleco.sdc': 'file\_type': 'SDC'
- tb
  - 'tb/tb\_porta\_glue\_coleco.v': 'file\_type': 'verilogSource'

### 2.1.2 Fusesoc

### 2.1.3 Protable Coleco Glue Targets

- default
  - Info: Default IP target for future tool intergration.
  - src
  - constr
- sim
  - Info: Simulation target for basic test bench.

- src
- tb

Fusesoc is used for the simulation target only. There are no build targets due to the use of Quartus 13.0sp1

#### **2.1.4 Quartus**

This project uses the last version that supports the MAX7000S series. The version is 13.0sp1 for quartus. The project is located at src/quartus13sp01/.

### **2.2 PCB**

The four layer PCB is fairly easy to populate. The right angle PCB is a dual layer PCB which is even easier. I recommend starting with resistors, then IC's, and then the rest. Surface mount parts should be done last.

### **2.3 3D Printed Case**

A 3D printed case model is not included. I've kept this for release in the future.

### **2.4 Programming**

There are two devices that need to be programmed.

#### **2.4.1 ROM**

A minipro TL866A+ is an excellent device for programming the ROM with a BIOS.

#### **2.4.2 CPLD**

Quartus 13.0sp1 is the easiest way to build and program the MAX7000 CPLD. You will need an altera blaster. I recommend the chinese clone blasters, they actually worked the best. While the worst was the Terasic blaster which did not work at all.

## 3 Usage

### 3.1 Directory Guide

Below highlights important folders from the root of mini\_colecovision.

1. **docs** Contains all documentation related to this project.
  - **datasheets** Contains all datasheets for components.
  - **manual** Contains user manual and github page that are generated from the latex sources.
2. **img** Contains images of the project
3. **schematic** KiCAD v7.X schematic and PCB designs
  - **gerber** Contains gerber files and archives for production.
  - **pdf** PDF schematic
4. **src** CPLD firmware source
  - **protable\_coleco** Contains verilog source code and constraints
  - **quartus13sp01** Quartus project to use to generate firmware file.

## 4 Module Documentation

# porta\_glue\_coleco.v

---

## AUTHORS

---

JAY CONVERTINO

---

## DATES

---

2024/11/06

---

## INFORMATION

---

### Brief

---

Colecovision SGM glue logic chip

### License MIT

---

Copyright 2024 Jay Convertino

Permission is hereby granted, free of charge, to any person obtaining a copy of this software and associated documentation files (the "Software"), to deal in the Software without restriction, including without limitation the rights to use, copy, modify, merge, publish, distribute, sublicense, and/or sell copies of the Software, and to permit persons to whom the Software is furnished to do so, subject to the following conditions:

The above copyright notice and this permission notice shall be included in all copies or substantial portions of the Software.

THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL THE AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING FROM, OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN THE SOFTWARE.

## CONSTANTS

---

### DEF\_RESET\_DELAY\_BIT

---

Number of bits for reset delay register

### DEF\_FB\_MONOSTABLE\_COUNT

---

delay till state is at 1 instead of 0 (its stable state) for feedback stable circuit

### DEF\_IRQ\_MONOSTABLE\_COUNT

---



delay till state is at 1 instead of 0 (its stable state) for the controller (spinner) generated interrupt.

**porta\_glue\_coleco**

```

module porta_glue_coleco (
input
clk,

15:0]
A,
input
C1P1,
input
C1P2,
input
C1P3,
input
C1P4,
input
C1P6,
input
C1P7,
input
C1P9,
input
C2P1,
input
C2P2,
input
C2P3,
input
C2P4,
input
C2P6,
input
C2P7,
input
C2P9,
input
MREQn,
input
IORQn,
input
RFSHn,
input
M1n,
input
WRn,
input
RESETn_SW,
input
RDn,

7:0]
D,
output
CP5_ARM,
output
CP8_FIRE,
output
CS_h8000n,
output
CS_hA000n,
output

```

```

    CS_hC000n,
    output
    CS_hE000n,
    output
    SND_ENABLEn,
    output
    ROM_ENABLEn,
    output
    RAM_CSn,
    output
    RAM_OEn,
    output
    CSWn,
    output
    CSRn,
    output
    WAITn,
    output
    RESETn,
    output
    RAM_MIRRORn,
    output
    INTn,
    output
    AS,
    output
    AY_SND_ENABLEn
)

```

Colecovision Super Game Module Glue Logic

## Ports

<b>clk</b> input	Clock for all devices in the core
<b>A</b> input[ 15: 0]	Address input bus from Z80
<b>C1P1</b> input	DB9 Controller 1 Pin 1
<b>C1P2</b> input	DB9 Controller 1 Pin 2
<b>C1P3</b> input	DB9 Controller 1 Pin 3
<b>C1P4</b> input	DB9 Controller 1 Pin 4
<b>C1P6</b> input	DB9 Controller 1 Pin 6
<b>C1P7</b> input	DB9 Controller 1 Pin 7
<b>C1P9</b> input	DB9 Controller 1 Pin 9
<b>C2P1</b> input	DB9 Controller 2 Pin 1
<b>C2P2</b> input	DB9 Controller 2 Pin 2
<b>C2P3</b> input	DB9 Controller 2 Pin 3
<b>C2P4</b> input	DB9 Controller 2 Pin 4
<b>C2P6</b>	DB9 Controller 2 Pin 6

input	
<b>C2P7</b>	DB9 Controller 2 Pin 7
input	
<b>C2P9</b>	DB9 Controller 2 Pin 9
input	
<b>MREQn</b>	Z80 memory request input, active low
input	
<b>IORQn</b>	Z80 IO request input, active low
input	
<b>RFSHn</b>	Z80 Refresh input, active low
input	
<b>M1n</b>	Z80 M1 state, active low
input	
<b>WRn</b>	Z80 Write to bus, active low
input	
<b>RESETn_SW</b>	Input for reset switch
input	
<b>RDn</b>	Z80 Read from bus, active low
input	
<b>D</b>	Z80 8 bit data bus, tristate IN/OUT
inout[ 7: 0]	
<b>CP5_ARM</b>	DB9 Controller 1&2 ARM Select
output	
<b>CP8_FIRE</b>	DB9 Controller 1&2 FIRE Select
output	
<b>CS_h8000n</b>	Select when Z80 requests memory at h8000 (GAME CART), active low
output	
<b>CS_hA000n</b>	Select when Z80 requests memory at hA000 (GAME CART), active low
output	
<b>CS_hC000n</b>	Select when Z80 requests memory at hC000 (GAME CART), active low
output	
<b>CS_hE000n</b>	Select when Z80 requests memory at hE000 (GAME CART), active low
output	
<b>SND_ENABLEn</b>	SN76489 Sound chip enable, active low
output	
<b>ROM_ENABLEn</b>	Enable BIOS ROM, active low
output	
<b>RAM_CSn</b>	RAM chip select, active low
output	
<b>RAM_OEn</b>	RAM Ouput enable, active low
output	
<b>CSWn</b>	Chip Select Write for VDP, active low
output	
<b>CSRn</b>	Chip Select Read for VDP, active low
output	
<b>WAITn</b>	Wait state generator for Z80, active low
output	
<b>RESETn</b>	Timed reset generated by Logic, active low
output	
<b>RAM_MIRRORn</b>	Extended RAM, high is extended RAM, active low is mirrored.
output	
<b>INTn</b>	Interrupt generator for Z80, active low
output	

**AS**                                      AY sound chip address(0)/data(1) select  
 output  
**AY\_SND\_ENABLEn**              AY sound enable, active low  
 output

## REGISTER INFORMATION

Core has 3 registers at the addresses that follow.

**SOUND\_CACHE**                      h51  
**RAM\_24K\_ENABLE**                  h53  
**SWAP\_BIOS\_TO\_RAM**              h7F

### SOUND\_CACHE

```
localparam SOUND_CACHE = 8'h51
```

Defines the address of r\_snd\_cache

SOUND CACHE REGISTER	
7:0	
CACHE LAST WRITE TO AY SOUND CHIP	

Cache Sound Chip as the SGM games read from it (Yamaha chip does not have a read like a GI does).

### RAM\_24K\_ENABLE

```
localparam RAM_24K_ENABLE = 8'h53
```

Defines the address of r\_24k\_ena

24K RAM ENABLE REGISTER	
7:1	0
ZERO	ENABLE 24K RAM, ACTIVE HIGH

Super Game Module 24K RAM enable using bit 0 (Active High)

### SWAP\_BIOS\_TO\_RAM

```
localparam SWAP_BIOS_TO_RAM = 8'h7F
```

Defines the address of r\_swap\_ena

SWAP BIOS TO RAM REGISTER			
7:4	3:2	1	0
ZERO	ONE	BIO TO RAM SWAP, ACTIVE LOW	ONE

Super Game Module BIOS to RAM swap on bit 1 (Active Low)

### r\_24k\_ena

```
reg [ 7:0] r_24k_ena = 0
```

register for RAM\_24K\_ENABLE See Also: [RAM\\_24K\\_ENABLE](#)

### r\_swap\_ena

```
reg [ 7:0] r_swap_ena = 8'h0F
```

register for 8K RAM/ROM swap See Also: [SWAP\\_BIOS\\_TO\\_RAM](#)

### r\_snd\_cache

```
reg [ 7:0] r_snd_cache = 0
```

register for SOUND\_CACHE See Also: [SOUND\\_CACHE](#)

### r\_int\_p1

```
reg r_int_p1 = 1'b0
```

Interrupt from player one control

### r\_int\_p2

```
reg r_int_p2 = 1'b0
```

Interrupt from player two control

### r\_wait

```
reg r_wait = 1'b0
```

Wait state generated register

### r\_reset\_counter

```
reg [ 9:0] r_reset_counter = 0
```

---

Timed reset counter

---

## **r\_resetn**

```
reg r_resetn = 0
```

Registered reset output, active low

---

## **r\_mono\_count\_p1**

```
reg [11:0] r_mono_count_p1 = 0
```

monostable circuit counters, player 1 AND

---

## **r\_mono\_count\_p2**

```
reg [11:0] r_mono_count_p2 = 0
```

monostable circuit counters, player 2 AND

---

## **r\_mono\_count\_int\_p1**

```
reg [ 5:0] r_mono_count_int_p1 = 0
```

monostable circuit counters, player 1 interrupt

---

## **r\_mono\_count\_int\_p2**

```
reg [ 5:0] r_mono_count_int_p2 = 0
```

monostable circuit counters, player 2 interrupt

---

## **r\_mono\_p1**

```
reg r_mono_p1 = 1'b0
```

Feedback from IRQ to controller 1 register

---

## **r\_mono\_p2**

```
reg r_mono_p2 = 1'b0
```

Feedback from IRQ to controller 2 register

---

## **r\_ctrl\_fire**

---

```
reg r_ctrl_fire = 1'b1
```

NAND Feedback Flip Flop FIRE select.

## r\_ctrl\_arm

---

```
reg r_ctrl_arm = 1'b0
```

NAND Feedback Flip Flop ARM select.

## ASSIGNMENT INFORMATION

---

How signals are created

## s\_ram\_csn

---

```
assign s_ram_csn = (
    s_y0_seln |
    r_swap_ena[1]
) & (s_ram2_csn | ~r_24k_ena[0]) & (s_ram1_csn | ~r_24k_ena[0]) & s_ram0_csn
```

RAM Chip select when address is requested (active low).

**(s\_y0\_seln | r\_swap\_ena[1])** address range starting at h0000, swap bios/rom bit is enabled (1 is disabled).

**(s\_ram1\_csn | ~r\_24k\_ena[0])** address range starting at h4000, 24k enable bit from register.

**(s\_ram2\_csn | ~r\_24k\_ena[0])** address range starting at h2000, 24k enable bit from register.

**s\_ram0\_csn** address range starting h6000, this is always an available range.

## RAM\_OEn

---

```
assign RAM_OEn = RDn | s_ram_csn
```

RAM Output enable when read is requested (active low).

**RDn** Z80 read request, active low.

**s\_ram\_csn** See Also: [s\\_ram\\_csn](#)

## RAM\_CSn

---

```
assign RAM_CSn = s_ram_csn
```

RAM Chip Select output assignment.

**s\_ram\_csn** See Also: [s\\_ram\\_csn](#)

## RAM\_MIRRORn

---

```
assign RAM_MIRRORn = (
  r_24k_ena[0] |
  r_swap_ena[1]
)
```

RAM Mirror enable. Output to AND gates that block address lines (active low)

**r\_24k\_ena[0]** If 24k ram extension is disabled, enable ram mirror

**r\_swap\_ena[1]** If ram/bios swap is disabled, enable ram mirror.

## ROM\_ENABLEn

```
assign ROM_ENABLEn = (
  s_y0_seln |
  r_swap_ena[1]
)
```

ROM enable (active low).

**s\_y0\_seln** Only select ROM when address range h0000 is enabled.

**r\_swap\_ena[1]** If ram/bios swap is disabled, enable ROM.

## DECODER INFORMATION FOR U5

How address decoder is created.

### s\_enable\_u5

```
assign s_enable_u5 = (
  RFSHn &
  MREQn
)
```

Enable the the decoder, duplicates U5 functionality from colecovision. always 1, RFSH is a double inversion on coleco (inverter + 138 internal)

**RFSHn** Z80 Refresh line, when not in refresh enable is active.

**MREQn** When the MREQn is active then encoder is enabled.

### s\_y0\_seln

```
assign s_y0_seln = ~(
  A[14] &
  A[13]
)
s_enable_u5 & ~A[15] & ~
```

Address h0000, ROM/RAM

**s\_enable\_u5** Enable decoder



**A[15:13]**      Address lines used for select lines.

## s\_ram2\_csn

---

```
assign s_ram2_csn = ~(  
    s_enable_u5 & ~A[15] & ~  
    A[14] &  
    A[13]  
)
```

Address h2000, RAM

**s\_enable\_u5**      Enable decoder

**A[15:13]**      Address lines used for select lines.

## s\_ram1\_csn

---

```
assign s_ram1_csn = ~(  
    s_enable_u5 & ~A[15] &  
    A[14] &  
    A[13]  
) ~
```

Address h4000, RAM

**s\_enable\_u5**      Enable decoder

**A[15:13]**      Address lines used for select lines.

## s\_ram0\_csn

---

```
assign s_ram0_csn = ~(  
    s_enable_u5 & ~A[15] &  
    A[14] &  
    A[13]  
)
```

Address h6000, RAM

**s\_enable\_u5**      Enable decoder

**A[15:13]**      Address lines used for select lines.

## CS\_h8000n

---

```
assign CS_h8000n = ~(  
    s_enable_u5 & A[15] & ~  
    A[14] &  
    A[13]  
) ~
```

Address h8000, Game ROM bank select.

**s\_enable\_u5**      Enable decoder

**A[15:13]** Address lines used for select lines.

## CS\_hA000n

---

```
assign CS_hA000n = ~(  
    A[14] &  
    A[13]  
    ) s_enable_u5 & A[15] & -
```

Address hA000, Game ROM bank select.

**s\_enable\_u5** Enable decoder

**A[15:13]** Address lines used for select lines.

## CS\_hC000n

---

```
assign CS_hC000n = ~(  
    A[14] &  
    A[13]  
    ) s_enable_u5 & A[15] & ~
```

Address hC000, Game ROM bank select.

**s\_enable\_u5** Enable decoder

**A[15:13]** Address lines used for select lines.

## CS\_hE000n

---

```
assign CS_hE000n = ~(  
    A[14] &  
    A[13]  
    ) s_enable_u5 & A[15] &
```

Address hE000, Game ROM bank select.

**s\_enable\_u5** Enable decoder

**A[15:13]** Address lines used for select lines.

## DECODER INFORMATION FOR U6

---

How address decoder is created

### s\_enable\_u5

---

Enable the the decoder, duplicates U6 functionality from colecovision.

**A[7]** Address IO range h80 to hFF

**IORQn** When the IORQn is active then encoder is enabled.

## s\_ctrl\_en\_2n

---

```
assign s_ctrl_en_2n = ~(  
    A[5] &                                     s_enable_u6 & ~A[6] & ~  
    WRn                                         ~  
)
```

h80 PORT IO for controller Fire Select

**s\_enable\_u6**    Enable decoder

**A[6:5]**        Address lines used for select lines.

**WRn**         Select write or read.

## CSWn

---

```
assign CSWn = ~(  
    A[5] &                                     s_enable_u6 & ~A[6] & ~  
    WRn                                         ~  
)
```

hBE PORT IO for VDP write

**s\_enable\_u6**    Enable decoder

**A[6:5]**        Address lines used for select lines.

**WRn**         Select write or read.

## CSRn

---

```
assign CSRn = ~(  
    A[5] &                                     s_enable_u6 & ~A[6] & ~  
    WRn                                         ~  
)
```

hBF PORT IO for VDP read

**s\_enable\_u6**    Enable decoder

**A[6:5]**        Address lines used for select lines.

**WRn**         Select write or read.

## s\_ctrl\_en\_1n

---

```
assign s_ctrl_en_1n = ~(  
    A[5] &                                     s_enable_u6 & A[6] & ~  
    WRn                                         ~  
)
```

hC0 PORT IO for controller ARM select

**s\_enable\_u6**    Enable decoder  
**A[6:5]**        Address lines used for select lines.  
**WRn**           Select write or read.

## SND\_ENABLEn

```
assign SND_ENABLEn = ~(
    A[5] &
    WRn
)
```

s\_enable\_u6 & A[6] & ~

hFF PORT IO for sound enable.

**s\_enable\_u6**    Enable decoder  
**A[6:5]**        Address lines used for select lines.  
**WRn**           Select write or read.

## s\_ctrl\_readn

```
assign s_ctrl_readn = ~(
    A[5] &
    WRn
)
```

s\_enable\_u6 & A[6] &

hFC/FF PORT IO for controller read

**s\_enable\_u6**    Enable decoder  
**A[6:5]**        Address lines used for select lines.  
**WRn**           Select write or read.

## DECODER INFORMATION FOR SUPER GAME MODULE

How address decoder is created for Super Game Module

**SGM IO REG**    Clocked IO decoder for Super Game Module.

## AS

```
assign AS = (
    A[7:0]
    =
    = 8'h50 & ~IORQn & ~WRn ? 1'b0 : 1'b1
)
```

h50 is the address select, when selected its in data mode

**A[7:0]**        If address matches h50, enable  
**IORQn**        Active IO request, enable  
**WRn**          Z80 write is active, enable

## AY\_SND\_ENABLEn

---

```
assign AY_SND_ENABLEn = (  
  A[7:1]  
  =  
  = 7'b0101000 & ~IORQn & ~WRn ? 1'b0 : 1'b1  
  )
```

match both h50 and h51 by ignoring bit 0. Enable AY sound chip.

**A[7:0]** If address matches h50 or h51, enable

**IORQn** Active IO request, enable

**WRn** Z80 write is active, enable

## AY\_SND\_ENABLEn

---

read cached register from previous write (AY emulation).

**A[7:0]** If address matches h52, enable

**IORQn** Active IO request, enable

**RDn** Z80 read is active, enable

## CONTROLLER REGISTER READ

---

How to read controller inputs for player 1 and 2, works with roller and standard gamepads.

## CP5\_ARM

---

```
assign CP5_ARM = r_ctrl_arm
```

Activate ARM portion of controllers.

**r\_ctrl\_arm** See Also: [r\\_ctrl\\_arm](#)

## CP8\_FIRE

---

```
assign CP8_FIRE = r_ctrl_fire
```

Activate FIRE portion of controllers.

**r\_ctrl\_fire** See Also: [r\\_ctrl\\_fire](#)

## D[0]

---

```
assign D[0] = (  
  C1P1  
  :  
  1'bz  
  )  
  ~s_ctrl_readn & ~A[1] ?
```

Data bit zero for P1

**s\_ctrl\_readn**    See Also: **s\_ctrl\_readn**, read when active low  
**A[1]**            Address bit 1 is 0, read

## D[1]

---

```
assign D[1] = (
C1P4
:
1'bz
)
                                -s_ctrl_readn & ~A[1] ?
```

Data bit one for P1

**s\_ctrl\_readn**    See Also: **s\_ctrl\_readn**, read when active low  
**A[1]**            Address bit 1 is 0, read

## D[2]

---

```
assign D[2] = (
C1P2
:
1'bz
)
                                -s_ctrl_readn & ~A[1] ?
```

Data bit two for P1

**s\_ctrl\_readn**    See Also: **s\_ctrl\_readn**, read when active low  
**A[1]**            Address bit 1 is 0, read

## D[3]

---

```
assign D[3] = (
C1P3
:
1'bz
)
                                -s_ctrl_readn & ~A[1] ?
```

Data bit three for P1

**s\_ctrl\_readn**    See Also: **s\_ctrl\_readn**, read when active low  
**A[1]**            Address bit 1 is 0, read

## D[4]

---

```
assign D[4] = (
r_mono_p1
:
1'bz
)
                                -s_ctrl_readn & ~A[1] ?
```

Data bit one for P1

**s\_ctrl\_readn** See Also: **s\_ctrl\_readn**, read when active low

**A[1]** Address bit 1 is 0, read

## D[5]

---

```
assign D[5] = (
    C1P7
    :
    1'bz
)
```

~s\_ctrl\_readn & ~A[1] ?

Data bit five for P1

**s\_ctrl\_readn** See Also: **s\_ctrl\_readn**, read when active low

**A[1]** Address bit 1 is 0, read

## D[6]

---

```
assign D[6] = (
    C1P6
    :
    1'bz
)
```

~s\_ctrl\_readn & ~A[1] ?

Data bit six for P1

**s\_ctrl\_readn** See Also: **s\_ctrl\_readn**, read when active low

**A[1]** Address bit 1 is 0, read

## D[7]

---

```
assign D[7] = (
    s_int_p1
    :
    1'bz
)
```

~s\_ctrl\_readn & ~A[1] ?

Data bit seven for P1

**s\_ctrl\_readn** See Also: **s\_ctrl\_readn**, read when active low

**A[1]** Address bit 1 is 0, read

## s\_int\_p1

---

```
assign s_int_p1 = ~(
    r_mono_p1 &
    C1P9
)
```

generate interrupt for player one

**r\_mono\_p1** See Also: **r\_mono\_p1**, RC TL emulation

**C1P9** Input from controller port. Roller controller only.

## D[0]

---

```
assign D[0] = (
    C2P1                                     ~s_ctrl_readn & A[1] ?
    :
    1'bz
)
```

Data bit zero for P1

**s\_ctrl\_readn** See Also: **s\_ctrl\_readn**, read when active low

**A[1]** Address bit 1 is 1, read

## D[1]

---

```
assign D[1] = (
    C2P4                                     ~s_ctrl_readn & A[1] ?
    :
    1'bz
)
```

Data bit one for P1

**s\_ctrl\_readn** See Also: **s\_ctrl\_readn**, read when active low

**A[1]** Address bit 1 is 1, read

## D[2]

---

```
assign D[2] = (
    C2P2                                     ~s_ctrl_readn & A[1] ?
    :
    1'bz
)
```

Data bit two for P1

**s\_ctrl\_readn** See Also: **s\_ctrl\_readn**, read when active low

**A[1]** Address bit 1 is 1, read

## D[3]

---

```
assign D[3] = (
    C2P3                                     ~s_ctrl_readn & A[1] ?
    :
    1'bz
)
```



---

Data bit three for P1

**s\_ctrl\_readn**      See Also: **s\_ctrl\_readn**, read when active low

**A[1]**                Address bit 1 is 1, read

## D[4]

---

```
assign D[4] = (
    r_mono_p2
    :
    1'bz
)
```

~s\_ctrl\_readn & A[1] ?

Data bit four for P1

**s\_ctrl\_readn**      See Also: **s\_ctrl\_readn**, read when active low

**A[1]**                Address bit 1 is 1, read

## D[5]

---

```
assign D[5] = (
    C2P7
    :
    1'bz
)
```

~s\_ctrl\_readn & A[1] ?

Data bit five for P1

**s\_ctrl\_readn**      See Also: **s\_ctrl\_readn**, read when active low

**A[1]**                Address bit 1 is 1, read

## D[6]

---

```
assign D[6] = (
    C2P6
    :
    1'bz
)
```

~s\_ctrl\_readn & A[1] ?

Data bit six for P1

**s\_ctrl\_readn**      See Also: **s\_ctrl\_readn**, read when active low

**A[1]**                Address bit 1 is 1, read

## D[7]

---

```
assign D[7] = (
    s_int_p2
    :
```

~s\_ctrl\_readn & A[1] ?

```
1'bz  
)
```

Data bit seven for P1

**s\_ctrl\_readn** See Also: **s\_ctrl\_readn**, read when active low

**A[1]** Address bit 1 is 1, read

## s\_int\_p2

```
assign s_int_p2 = ~(  
  r_mono_p2 &  
  C2P9  
)
```

generate interrupt for player one

**r\_mono\_p1** See Also: **r\_mono\_p1**, RC TL emulation

**C2P9** Input from controller port. Roller controller only.

## INTn

```
assign INTn = ~(  
  r_int_p1 |  
  r_int_p2  
)
```

INTn is generated by monostable circuit based on NAND outputs.

**r\_int\_p1** See Also: **r\_int\_p1**, RC TL emulation

**r\_int\_p2** See Also: **r\_int\_p2**, RC TL emulation

## CIRCUIT EMULATION

Everything below emulates a part of the circuit that uses some sort of linear/non-linear components to perform its task. Things such as RC reset circuits, RC interrupts, IRQ and others. See this source file for details.

<b>WAIT GENERATE</b>	Generate wait states for the Z80 proccessor
<b>RESET GENERATE</b>	Generate a timed reset for the CPU/VDP/ETC.
<b>TL RC RESET</b>	Generate a interrupt for a monostable circuit that will trigger a 1 for a short duration.
<b>CONTROLLER NAND</b>	Controller NAND Latch FIRE/ARM emulation.
<b>NAND IRQ PULSE</b>	Controller bit 4 is a pulse that represents the spinner state.