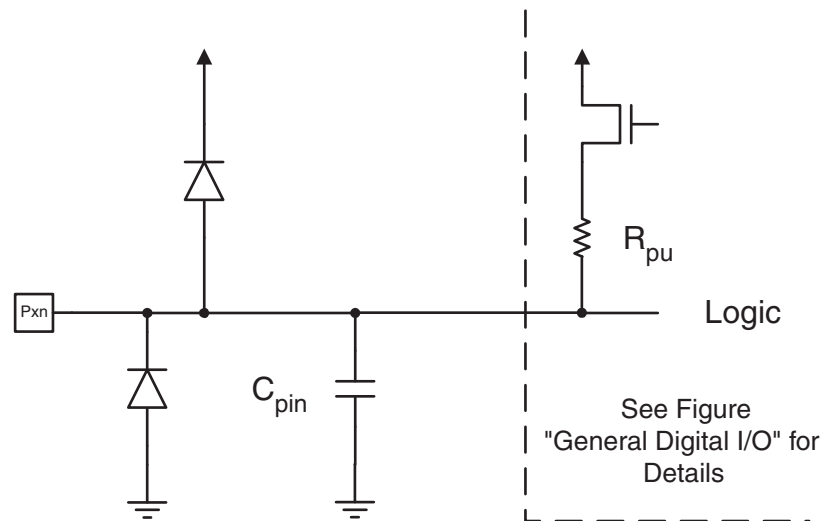


## 13. I/O-Ports

### 13.1 Introduction

All AVR ports have true Read-Modify-Write functionality when used as general digital I/O ports. This means that the direction of one port pin can be changed without unintentionally changing the direction of any other pin with the SBI and CBI instructions. The same applies when changing drive value (if configured as output) or enabling/disabling of pull-up resistors (if configured as input). Each output buffer has symmetrical drive characteristics with both high sink and source capability. The pin driver is strong enough to drive LED displays directly. All port pins have individually selectable pull-up resistors with a supply-voltage invariant resistance. All I/O pins have protection diodes to both  $V_{CC}$  and Ground as indicated in Figure 13-1. Refer to “Electrical Characteristics” on page 355 for a complete list of parameters.

**Figure 13-1.** I/O Pin Equivalent Schematic



All registers and bit references in this section are written in general form. A lower case “x” represents the numbering letter for the port, and a lower case “n” represents the bit number. However, when using the register or bit defines in a program, the precise form must be used. For example, PORTB3 for bit no. 3 in Port B, here documented generally as PORTxn. The physical I/O Registers and bit locations are listed in “Table 13-34 and Table 13-35 relates the alternate functions of Port L to the overriding signals shown in Figure 13-5 on page 73.” on page 95.

Three I/O memory address locations are allocated for each port, one each for the Data Register – PORTx, Data Direction Register – DDRx, and the Port Input Pins – PINx. The Port Input Pins I/O location is read only, while the Data Register and the Data Direction Register are read/write. However, writing a logic one to a bit in the PINx Register, will result in a toggle in the corresponding bit in the Data Register. In addition, the Pull-up Disable – PUD bit in MCUCR disables the pull-up function for all pins in all ports when set.

Using the I/O port as General Digital I/O is described in “Ports as General Digital I/O” on page 68. Most port pins are multiplexed with alternate functions for the peripheral features on the device. How each alternate function interferes with the port pin is described in “Alternate Port Functions” on page 72. Refer to the individual module sections for a full description of the alternate functions.

Note that enabling the alternate function of some of the port pins does not affect the use of the other pins in the port as general digital I/O.



### 13.2.3 Switching Between Input and Output

When switching between tri-state ( $\{DDxn, PORTxn\} = 0b00$ ) and output high ( $\{DDxn, PORTxn\} = 0b11$ ), an intermediate state with either pull-up enabled ( $\{DDxn, PORTxn\} = 0b01$ ) or output low ( $\{DDxn, PORTxn\} = 0b10$ ) must occur. Normally, the pull-up enabled state is fully acceptable, as a high-impedant environment will not notice the difference between a strong high driver and a pull-up. If this is not the case, the PUD bit in the MCUCR Register can be set to disable all pull-ups in all ports.

Switching between input with pull-up and output low generates the same problem. The user must use either the tri-state ( $\{DDxn, PORTxn\} = 0b00$ ) or the output high state ( $\{DDxn, PORTxn\} = 0b11$ ) as an intermediate step.

Table 13-1 summarizes the control signals for the pin value.

**Table 13-1.** Port Pin Configurations

DDxn	PORTxn	PUD (in MCUCR)	I/O	Pull-up	Comment
0	0	X	Input	No	Tri-state (Hi-Z)
0	1	0	Input	Yes	Pxn will source current if ext. pulled low
0	1	1	Input	No	Tri-state (Hi-Z)
1	0	X	Output	No	Output Low (Sink)
1	1	X	Output	No	Output High (Source)

