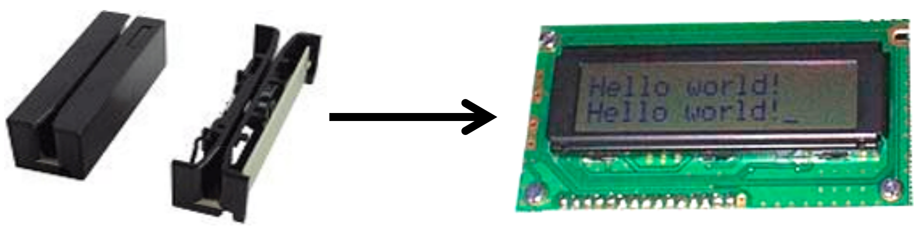
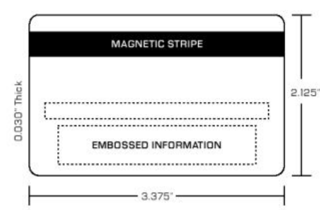
Final Lab Project

- Magnetic stripe card reader to LCD display
- Given:
  - basic schematic
  - test fixtures
- Your job:
  - design the core of the system



Overview of Magnetic Stripe Cards

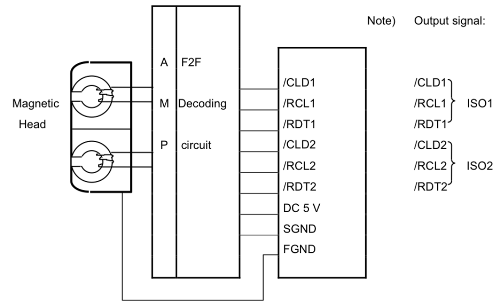
- Commonly used in credit, debit, transportation, and gift cards
- Magnetic material (iron-ion rich) is contained in a plastic-like film
  - Stripe is 5.66 mm from edge of card and is 9.52 mm wide
  - Contains three tracks, each 2.79 mm wide
    - Tracks one and three are typically recorded at 8.27 bits per mm
    - Track two typically has a recording density of 2.95 bits per mm
- Various ISO standards define format
  - 7810, 7811, 7812, 7813, and 4909
  - Defined by each industry



See http://en.wikipedia.org/wiki/Magnetic_stripe_card for details

0.223"	TRACK	Recording Density (Bits per inch)	Character Configuration (including parity bit)	Information Content (inclusing control characters)
0.110"	1 IATA	210	7 bits per character	79 alphanumeric charcters
0.110"	2 ABA	210	5 bits per character	40 numeric characters
0.110"	3 THRIFT	210	5 bits per character	107 numeric characters

Magnetic Card Interface



(1) /CLD(CARD LOAD) : The /CLD line will be Low when a Magnetic Card is running in the Magnetic Card Reader.
The /CLD line will be High when the Card is stopped or not present in the Card reader.

(2) /RCL(READ CLOCK) : This is used to sample the data line by it's falling edges. The time relationship of the clock with respect to the order signals is shown in Figure 6.4.

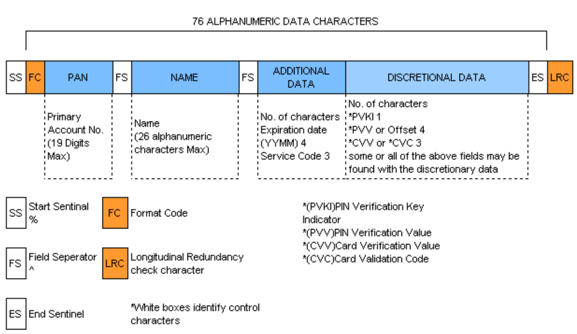
(3) /RDT(READ DATA) : The moment /RCL change from High to Low ; /RDT is "1" when the /RDT line is Low , and /RDT is "0" when the /RDT line is High.

Overview of Magnetic Stripe Cards

- Data encoded as 7-bit characters
  - 6 bits for value (least significant bit first)
  - 1 bit for parity

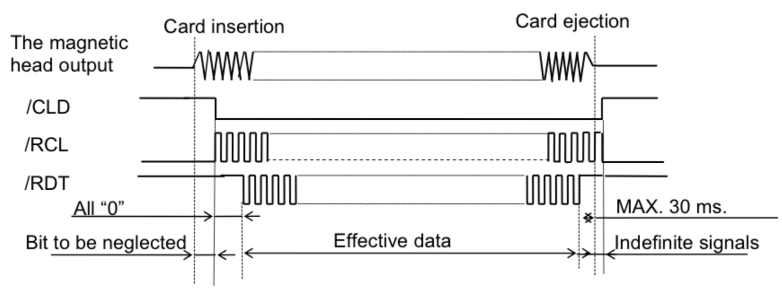
BITS			b_6	0	0	1	1
			b_5	0	1	0	1
b_4	b_3	b_2	b_1	CHARACTER SET			
0	0	0	0	SP	Ø	@	P
0	0	0	1	!	1	A	Q
0	0	1	0	"	2	B	R
0	0	1	1	#	3	C	S
0	1	0	0	$	4	D	T
0	1	0	1	%	5	E	U
0	1	1	0	&	6	F	V
0	1	1	1	'	7	G	W
1	0	0	0	(	8	H	X
1	0	0	1	)	9	I	Y
1	0	1	0	*	:	J	Z
1	0	1	1	+	;	K	[
1	1	0	0	,	<	L	\
1	1	0	1	-	=	M	]
1	1	1	0	.	>	N	^
1	1	1	1	/	?	O	-

Card Data Format - Track 1



Reader serial data format

- 3 signals
  - /RCP(RCL) – "clock"
    - RCP only oscillates if card is moving
  - /RDP(RDT) – data
  - /CLS(CLD) – card "present" indicator
    - CLS is only active if a card is present
- Decoding
  - Use RCP falling transition to sample RDP only when CLS is asserted



Clock and Data Timing

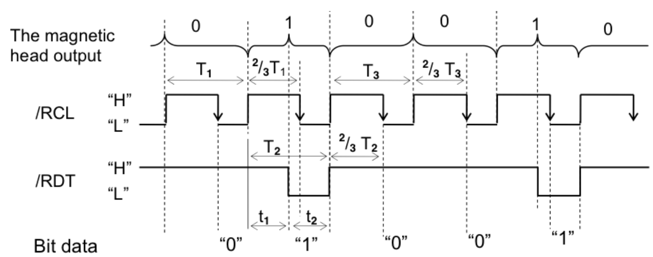
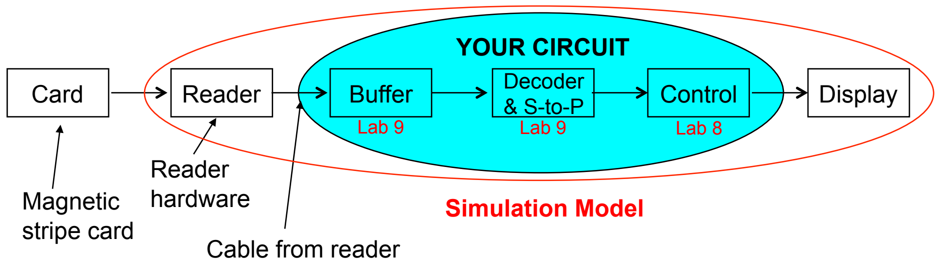


Fig 6.4 Timing sequence

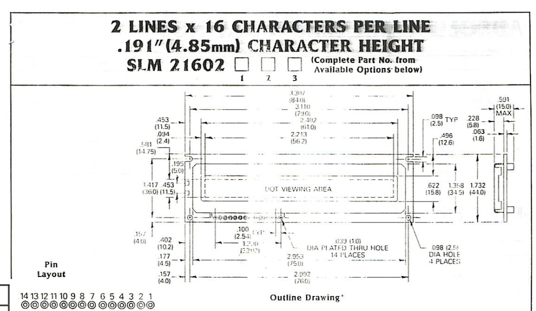
Block diagram

- Major components
  - Reader outputs (simulation test fixture)
  - **Reader buffer, decoder, and serial-to-parallel converter (Lab 9)**
  - **LCD controller (Lab 8)**
  - LCD display (simulation test fixture)

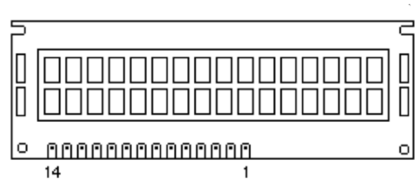


LCD interface

- Eleven signal wires plus PWR/GND/V_o
  - 1 mode input
  - 1 read/write control
  - 1 enable
  - 8 data lines (bi-directional)



Pin No	Name	I/O	Description
1	Vss	Power	GND
2	Vdd	Power	+5v
3	Vo	Analog	Contrast Control
4	RS	Input	Register Select
5	R/W	Input	Read/Write
6	E	Input	Enable *(Strobe)*
7	D0	I/O	Data *LSB*
8	D1	I/O	Data
9	D2	I/O	Data
10	D3	I/O	Data
11	D4	I/O	Data
12	D5	I/O	Data
13	D6	I/O	Data
14	D7	I/O	Data *MSB*



LCD Operations

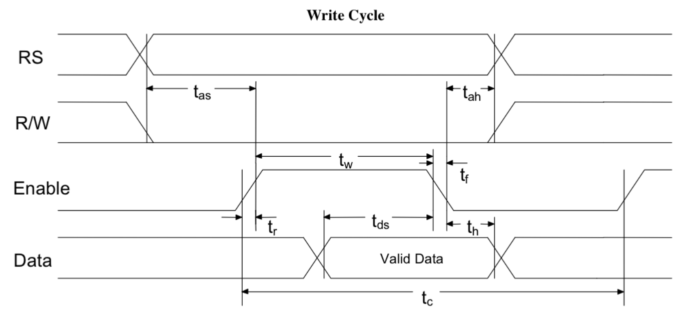
Instruction	RS	RW	D7	D6	D5	D4	D3	D2	D1	D0	Description	Clocks
NOP	0	0	0	0	0	0	0	0	0	0	No Operation	0
Clear Display	0	0	0	0	0	0	0	0	0	1	Clears display & sets address counter to zero.	165
Cursor Home	0	0	0	0	0	0	0	0	1	0	Sets address counter to zero, returns shifted display to original position. DDRAM contents remains unchanged.	3
Entry Mode Set	0	0	0	0	0	0	0	1	I/D	S	Sets cursor move direction, and specifies automatic shift.	3
Display Control	0	0	0	0	0	0	1	D	C	B	Turns display (D), cursor on/off (C) or cursor blinking(B).	3
Cursor/display shift	0	0	0	0	0	1	S/C	R/L	0	0	Moves cursor and shift display. DDRAM contents remains unchanged.	3
Function Set	0	0	0	0	1	DL	N	M	G	0	Sets interface data width(DL), number of display lines (N,M) and voltage generator control (G).	3
Set CGRAM Addr	0	0	0	1	Character Generator RAM						Sets CGRAM Address	3
Set DDRAM Addr	0	0	1	Display Data RAM Address							Sets DDRAM Address	3
Busy Flag & Addr	0	1	BF	Address Counter							Reads Busy Flag & Address Counter	0
Read Data	1	0	Read Data								Reads data from CGRAM or DDRAM	3
Write Data	1	1	Write Data								Writes data from CGRAM or DDRAM	3

Basic LCD operations

- Requires sequence of 4 instructions/commands on initialization (RS = 0)
  - Command write (RW = 0) – data bus pins carry command code
- Many more instructions/commands (RS = 0)
  - E.g., backup cursor, blink, etc. (look up appropriate DB values)
- Printing a character to the display (RS = 1)
  - Data write (RW = 0) – data bus pins carry character to display
- Read busy signal (on DB7)
  - LCD uses it to force a wait
  - RW = 1
  - Need to make sure not driving data lines (DB = 8'bzzzzzzzz)
  - Use DB7 as input, check if 0 (not busy) or 1 (busy)

Operation	RS	DB7...DB0
Clear Display	0	0000 0001
Function Set	0	0011 0011
Display On	0	0000 1100
Entry Mode Set	0	0000 0110
Write Character	1	DDDD DDDD

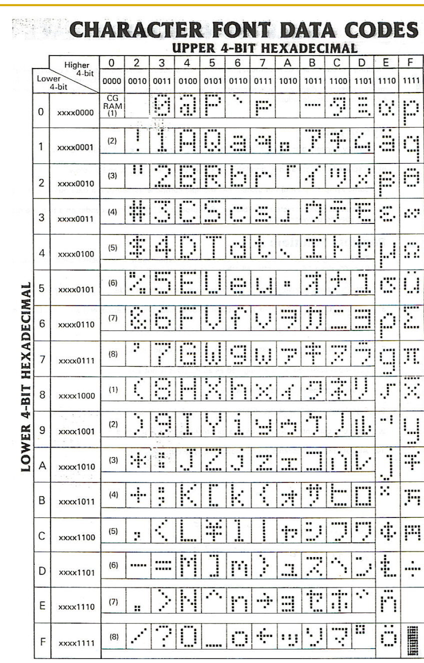
Timing details



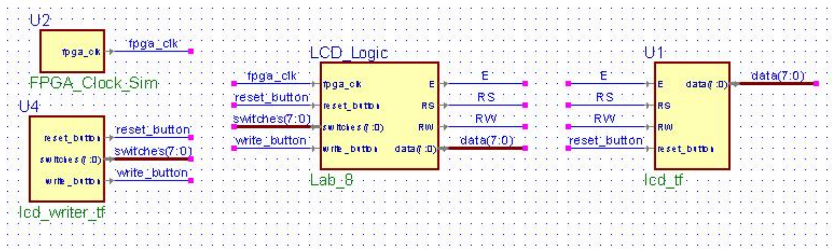
WRITE OPERATION

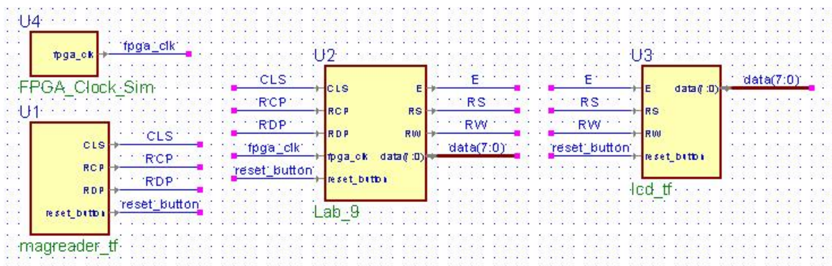
Item	Symbol	Min.	Typ.	Max.	Unit
Enable Cycle Time	$t_{CYC\,E}$	1.0	—	—	μs
Enable Pulse Width	PW E	450	—	—	ns
Enable Rise/Fall Time	t_{Er}, t_{Ef}	—	—	25	ns
Address Set-up Time	t_{AS}	140	—	—	ns
Address Hold Time	t_{AH}	10	—	—	ns
Data Start-up Time	t_{DSW}	195	—	—	ns
Data Hold Time	t_{H}	10	—	—	ns

ASCII codes



Block Diagrams for Labs 8 and 9





Purpose of the project

- Learn how to build a complete system that does something useful
- Read data sheets
- Use communicating state machines
- Use test fixtures and read some more complex Verilog code