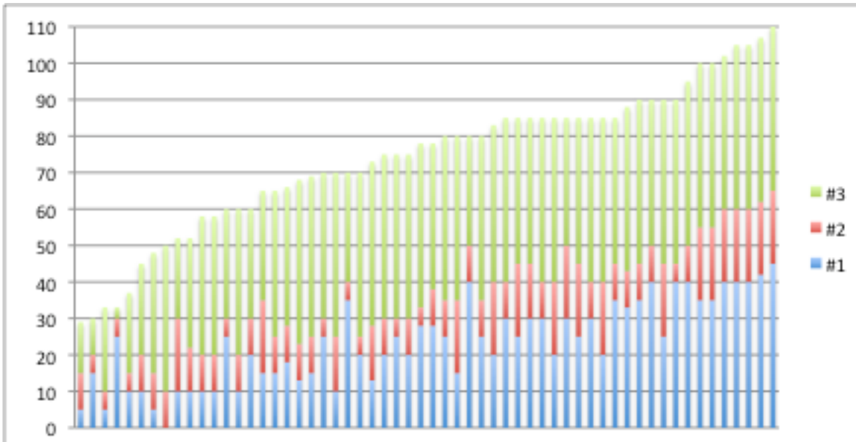
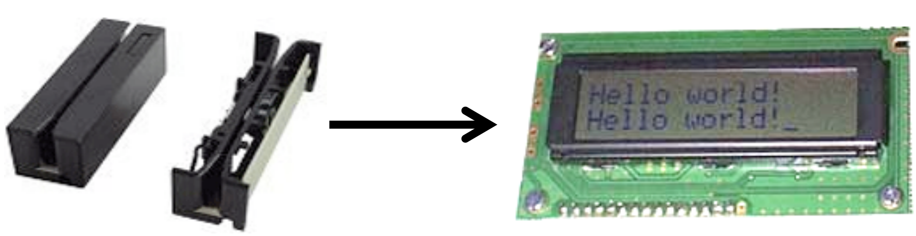
Exam 2 Results

- Average = 74; Median = 78; StDev = 20 (68% within 54 and 94)
  - Q1 avg = 23.4/45; Q2 avg = 12.3/20; Q3 avg = 38.4/45



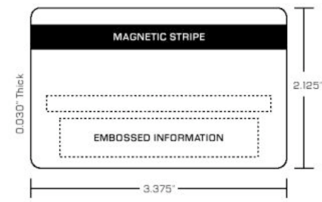
Final Lab Project

- 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



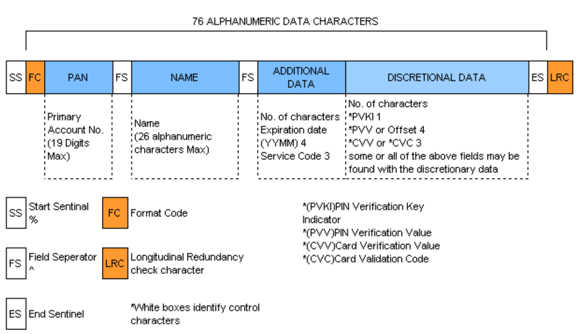
See http://en.wikipedia.org/wiki/Magnetic_stripe_card for details

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

Overview of Magnetic Stripe Cards

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

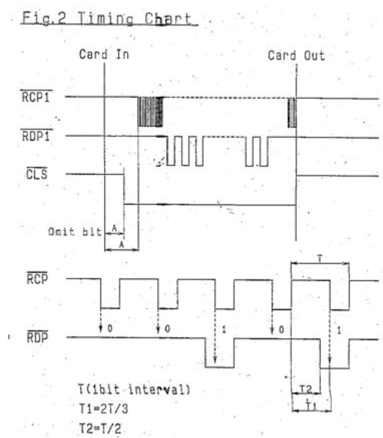
Card Data Format - Track 1



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	-

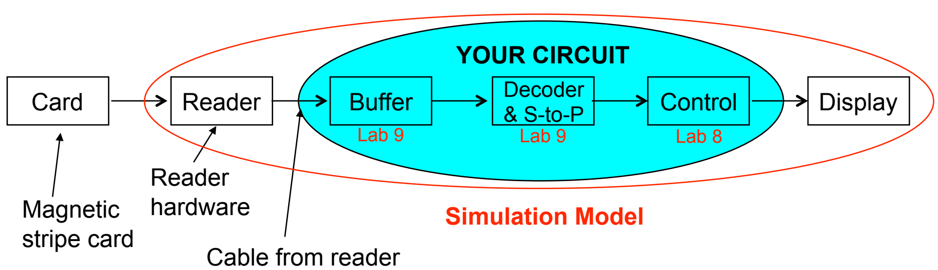
Reader serial data format

- 3 signals
  - RCP – "clock"
    - RCP only oscillates if card is moving
  - RDP – data
  - CLS – 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

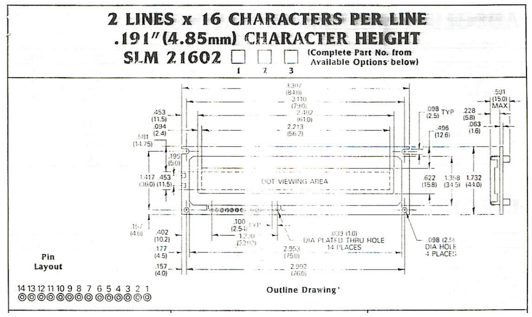


Block diagram

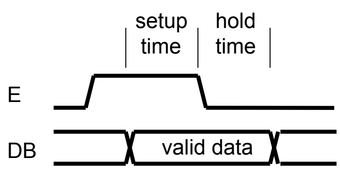
- Major components
  - Reader outputs (simulation test fixture)
  - **LCD controller (Lab 8)**
  - **Reader buffer, decoder, and serial-to-parallel converter (Lab 9)**
  - LCD display (simulation test fixture)



LCD interface



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



Interface Pin Connections

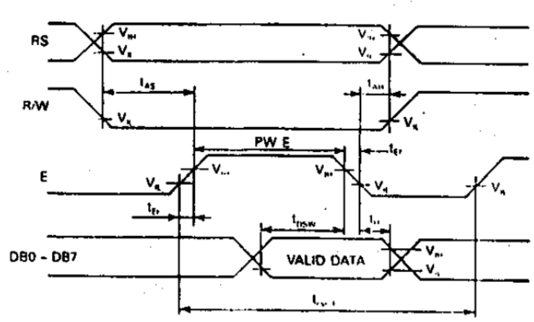
Pin No.	Symbol	Function	
1	V_{SS}	0V	Power supply
2	V_{DD}	+5V	
3	V_0	—	
4	RS	H: Data input L: Instruction input	
5	R/W	H: Read(MPU←LCM) L: Write(MPU→LCM)	
6	E	Enable signal	
7	DB0	Data bus line	
8	DB1		
9	DB2		
10	DB3		
11	DB4		
12	DB5		
13	DB6		
14	DB7		

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

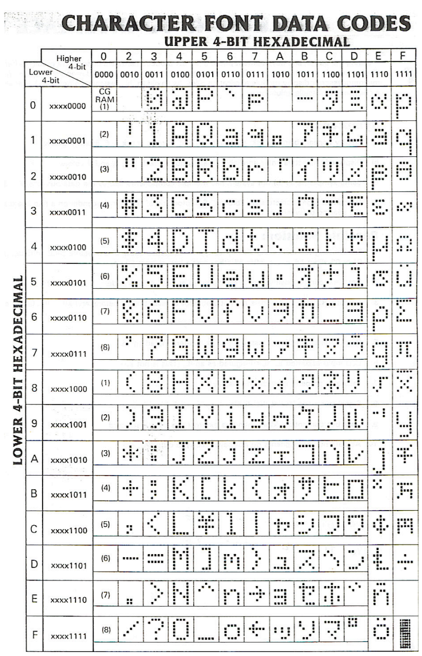
Timing details



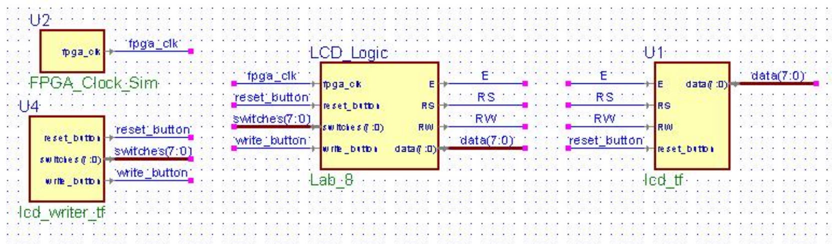
WRITE OPERATION

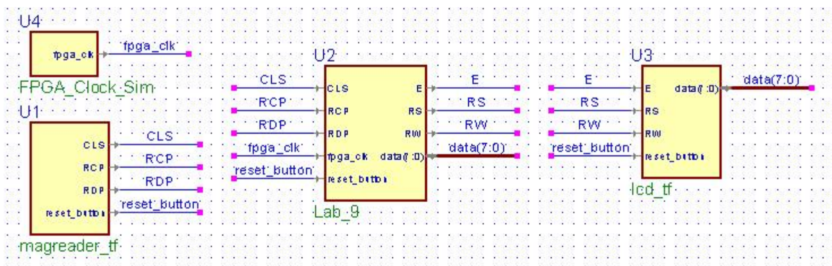
Item	Symbol	Min.	Typ.	Max.	Unit
Enable Cycle Time	$t_{cyc\ E}$	1.0	—	—	μs
Enable Pulse Width	PW E	450	—	—	ns
Enable Rise/Fall Time	t_{Er}, t_{Ef}	—	—	25	ns
Address Set-up Time	t_{AS}	140	—	—	ns
Address Hold Time	t_{AH}	10	—	—	ns
Data Start-up Time	t_{DSW}	195	—	—	ns
Data Hold Time	t_H	10	—	—	ns

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