# Touchscreen Interfacing

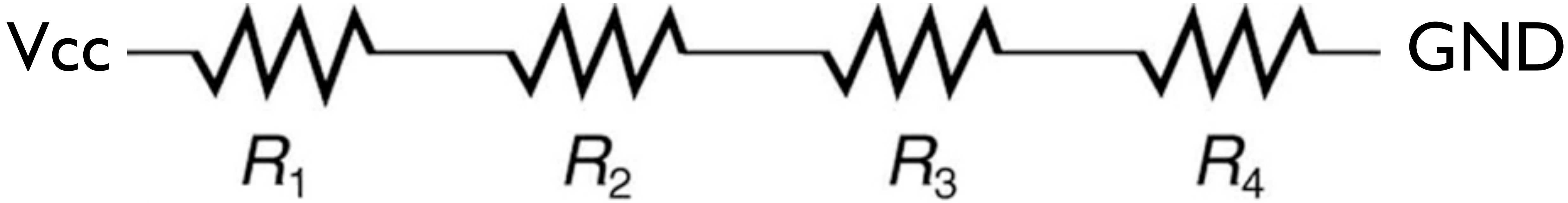
ECE 3710

I used to have an open
mind but my brains
kept falling out.

- Steven Wright

# resistive touchscreens

assuming:

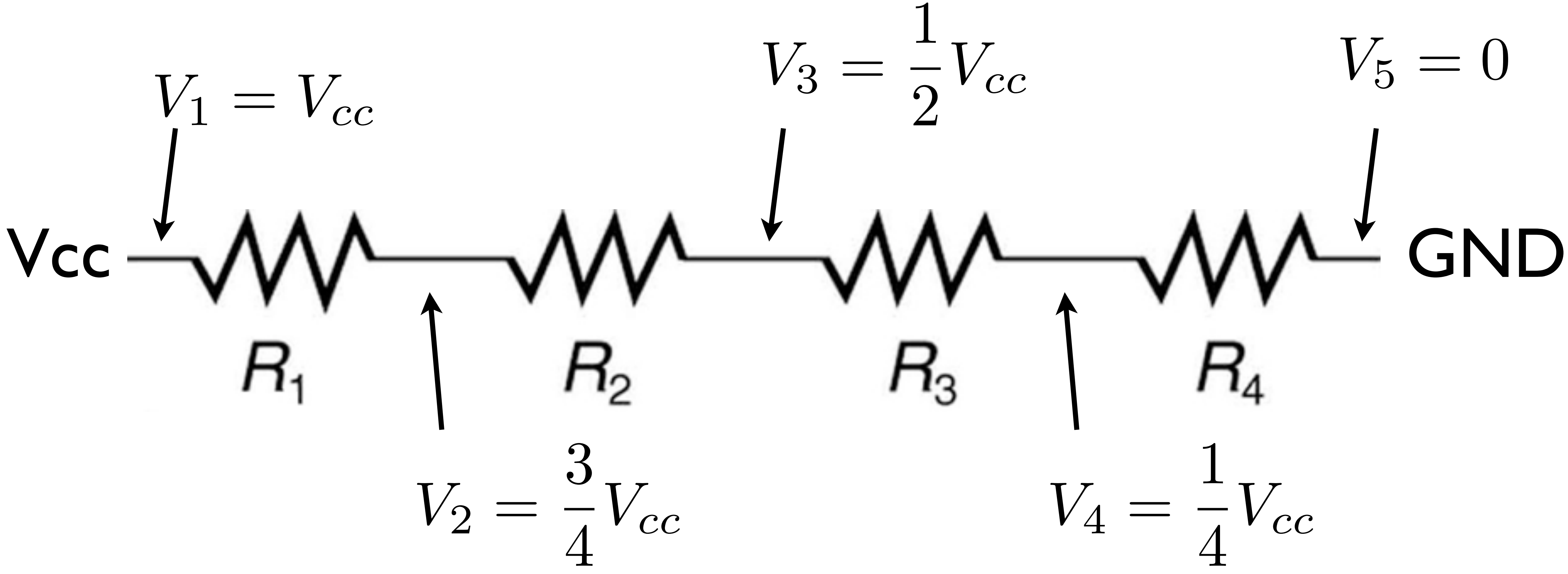


if given V_x:
can we deduce where on resistive chain the measurement is made?

$$R_1 = R_2 = R_3 = R_4$$

# resistive touchscreens

assuming:


$V_1 = V_{cc}$
$V_3 = \frac{1}{2}V_{cc}$
$V_5 = 0$
Vcc
GND
$R_1$
$R_2$
$R_3$
$R_4$
$V_2 = \frac{3}{4}V_{cc}$
$V_4 = \frac{1}{4}V_{cc}$

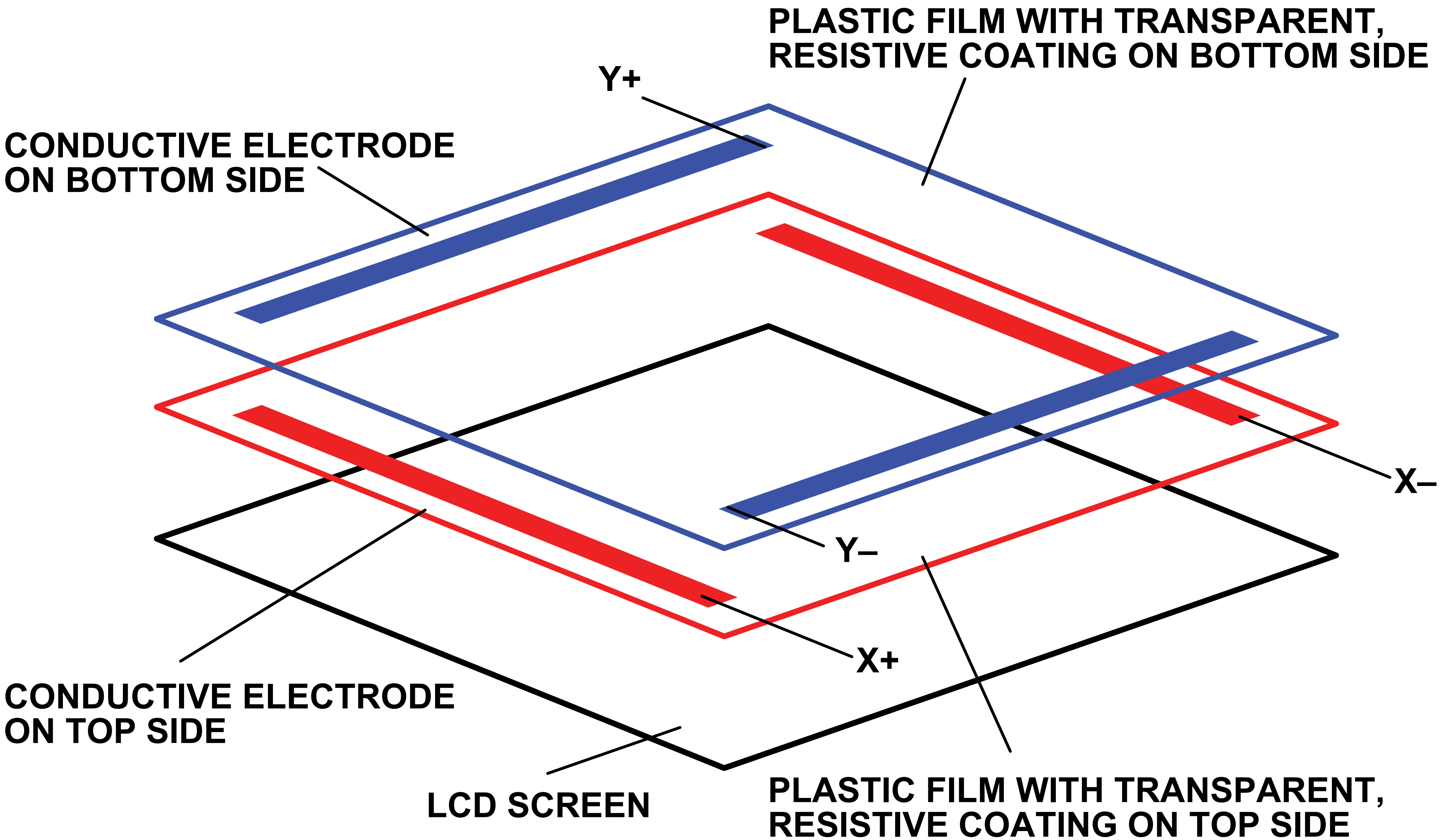
if given V_x:

we can deduce where on resistive chain the measurement is made

$$R_1 = R_2 = R_3 = R_4$$

# resistive touchscreens

if we embed resistors
in a screen overlay:

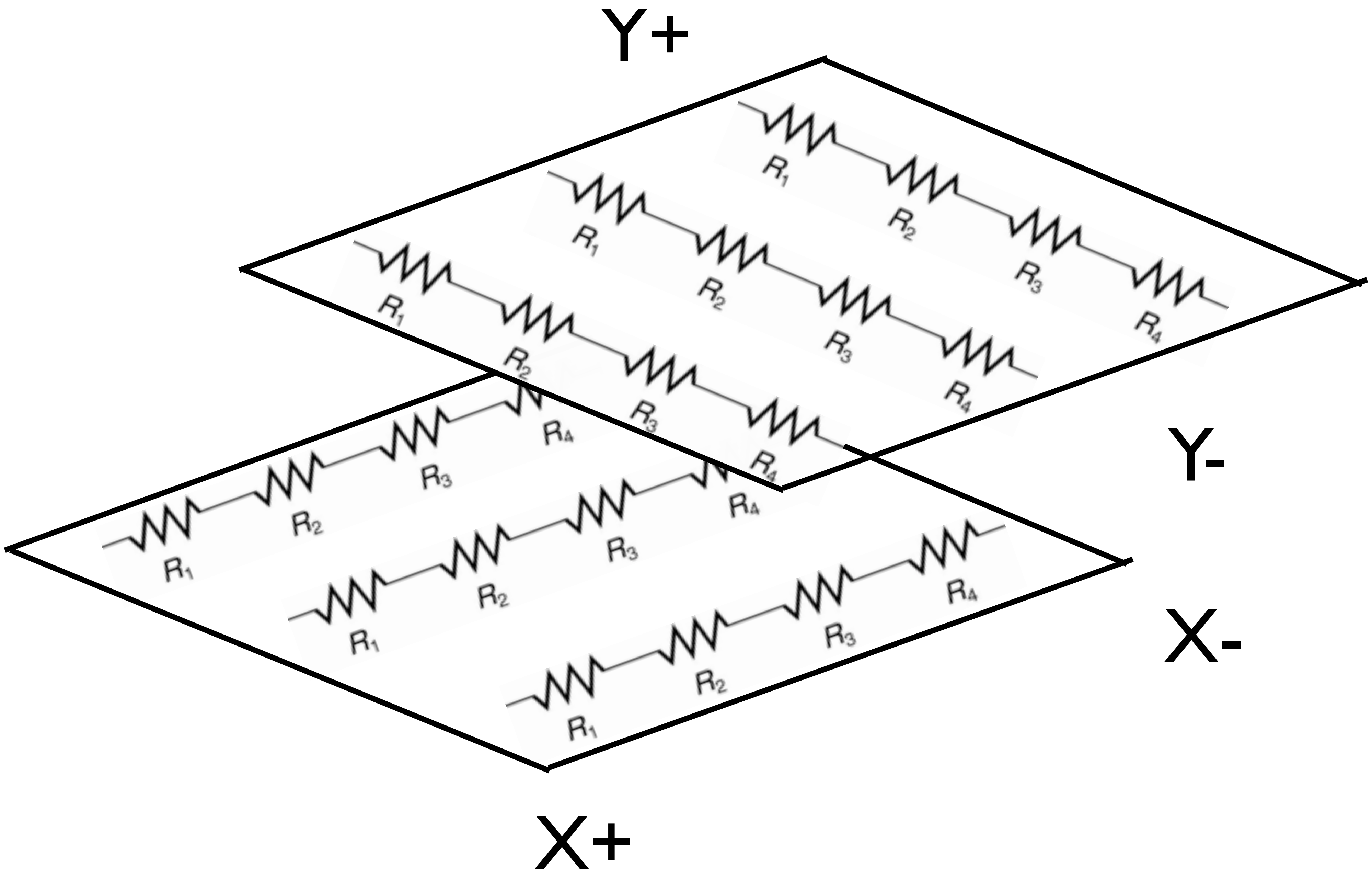

PLASTIC FILM WITH TRANSPARENT, RESISTIVE COATING ON BOTTOM SIDE
Y+
CONDUCTIVE ELECTRODE ON BOTTOM SIDE
X–
Y–
X+
CONDUCTIVE ELECTRODE ON TOP SIDE
LCD SCREEN
PLASTIC FILM WITH TRANSPARENT, RESISTIVE COATING ON TOP SIDE

resistive coating: resistance per unit length

# resistive touchscreens

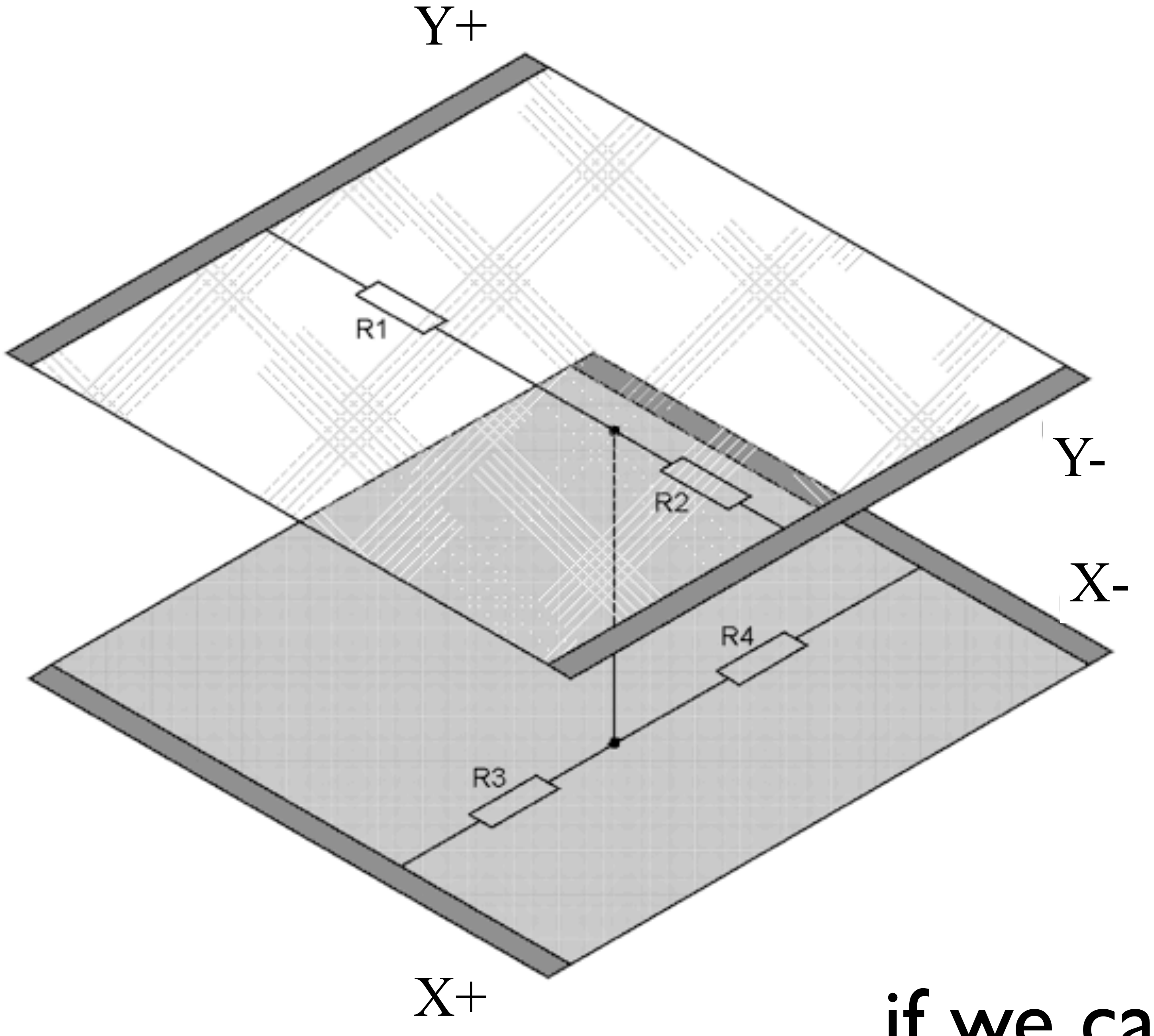
resistive coating:

resistance per unit length



# resistive touchscreens

when the screen is touched:



given:

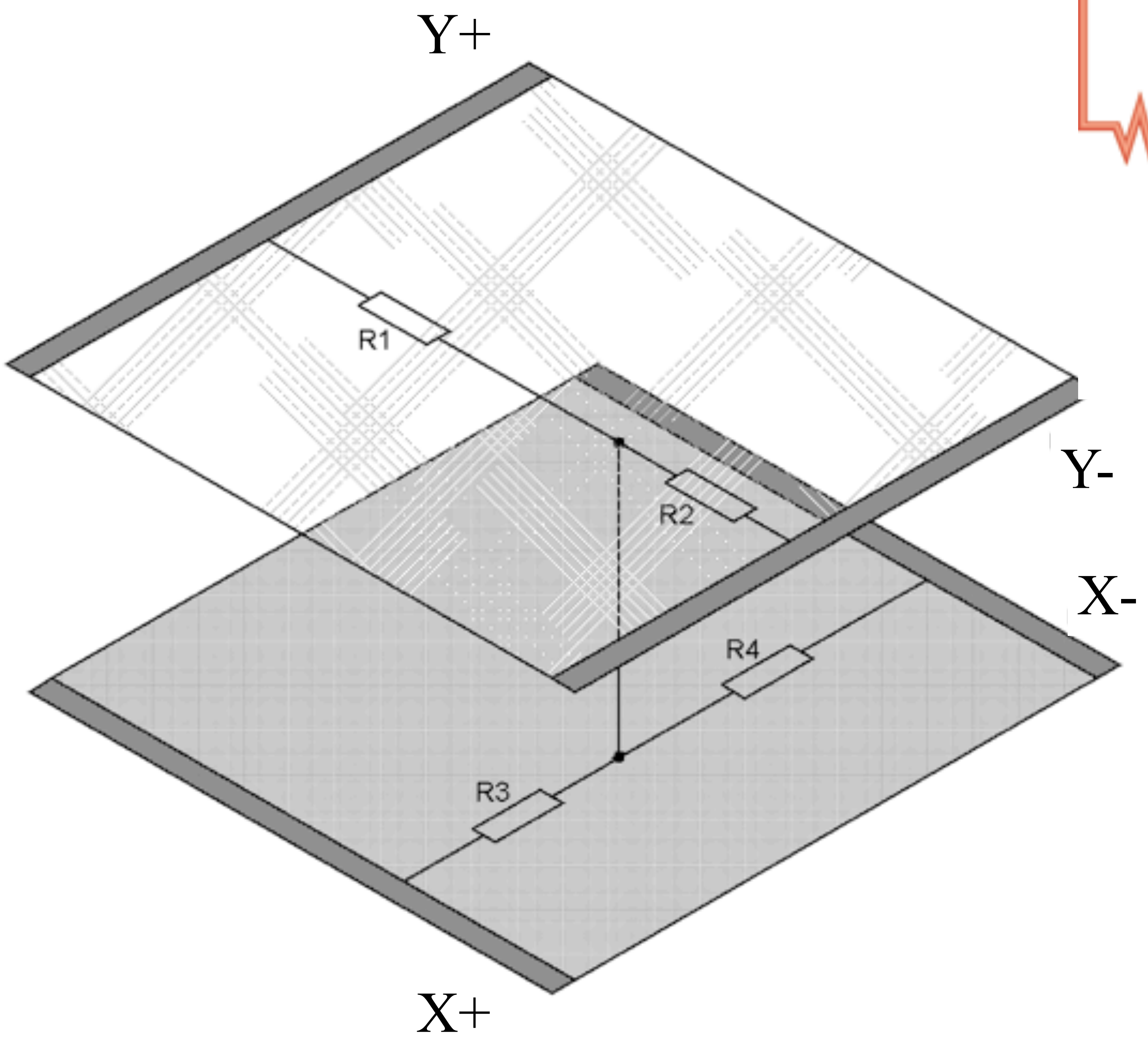
1. Y+ = Vcc & Y- = GND
2. V = voltage at point of contact
3. smaller V means closer to Y- edge; larger V means closer to Y+ edge

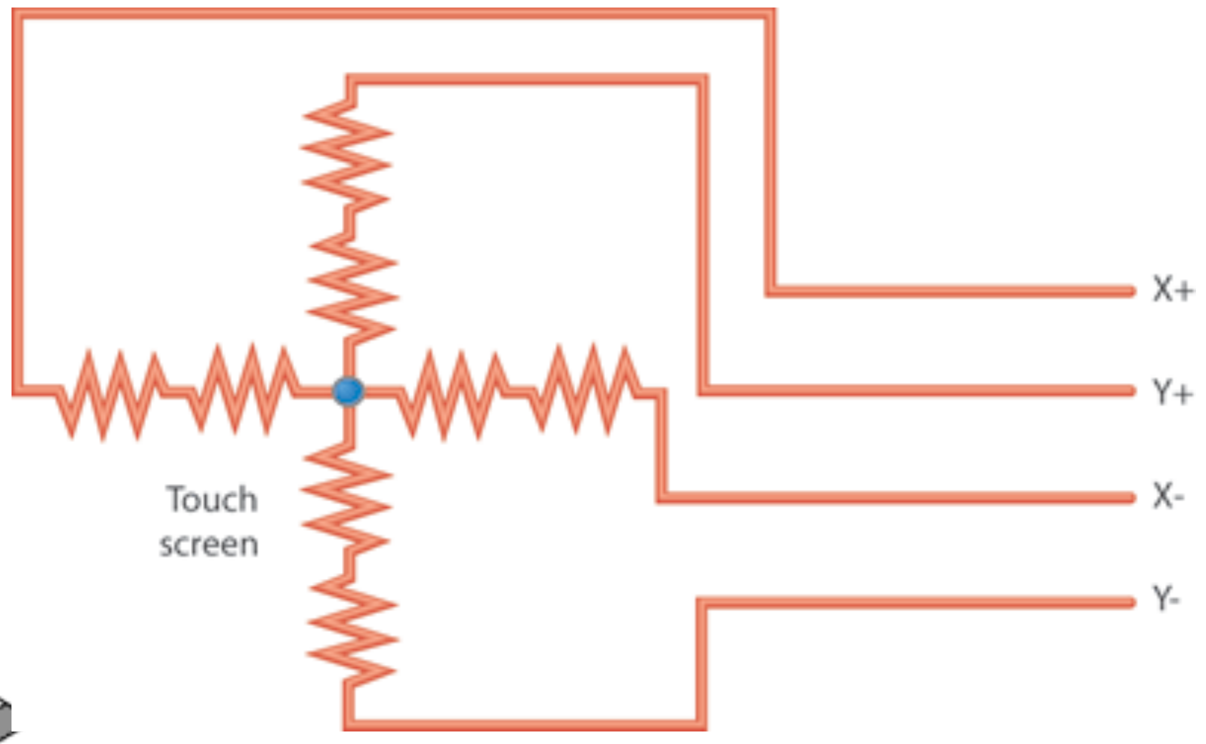
↓

can determine position if we can measure voltage at point

# resistive touchscreens

when the screen is touched:

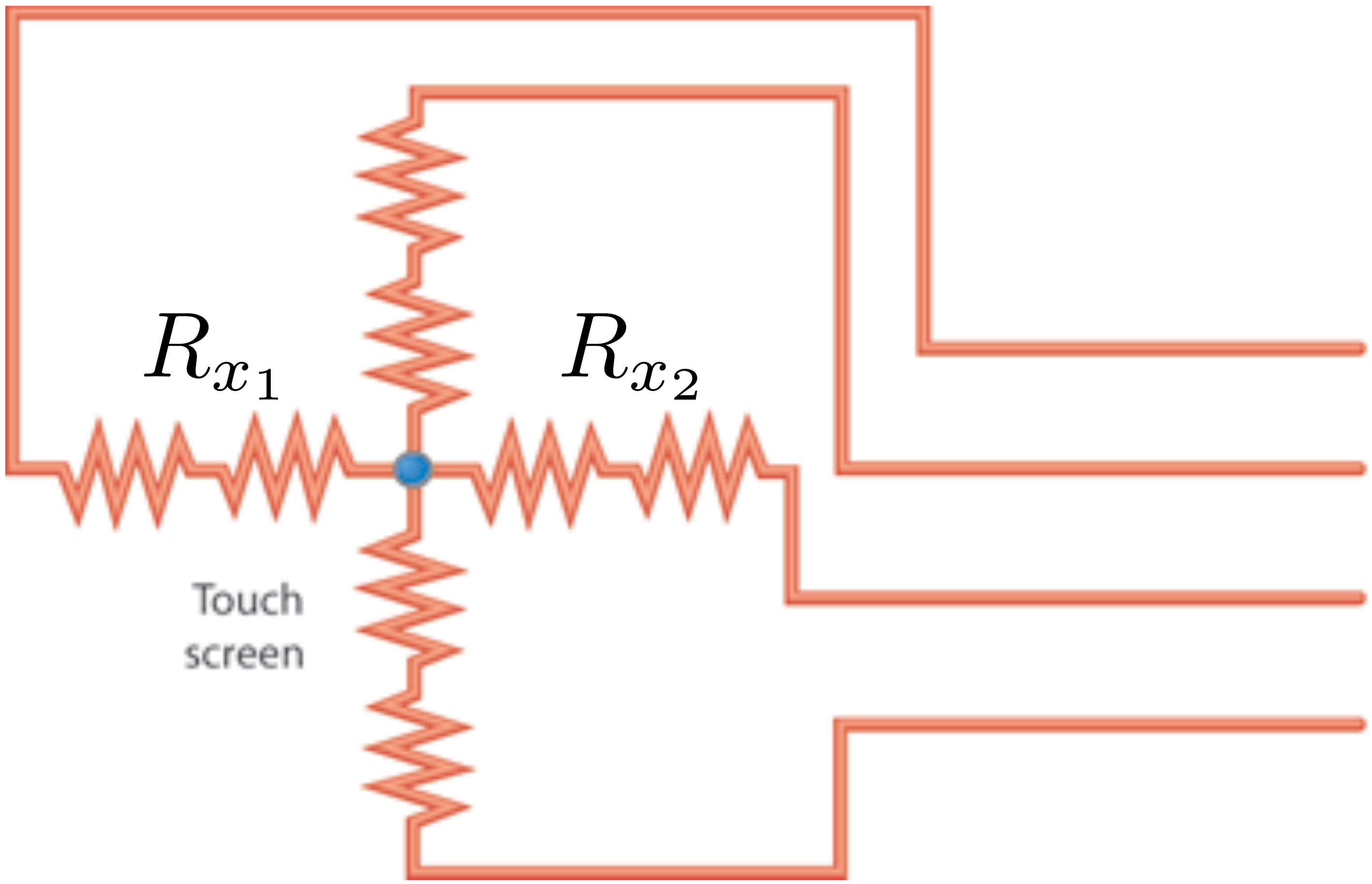




equivalent circuits

# resistive touchscreens

to determine x coordinate:



X+ = Vcc

Y+ = $V_{cc}\left(\frac{R_{x_2}}{R_{x_1}+R_{x_2}}\right)$

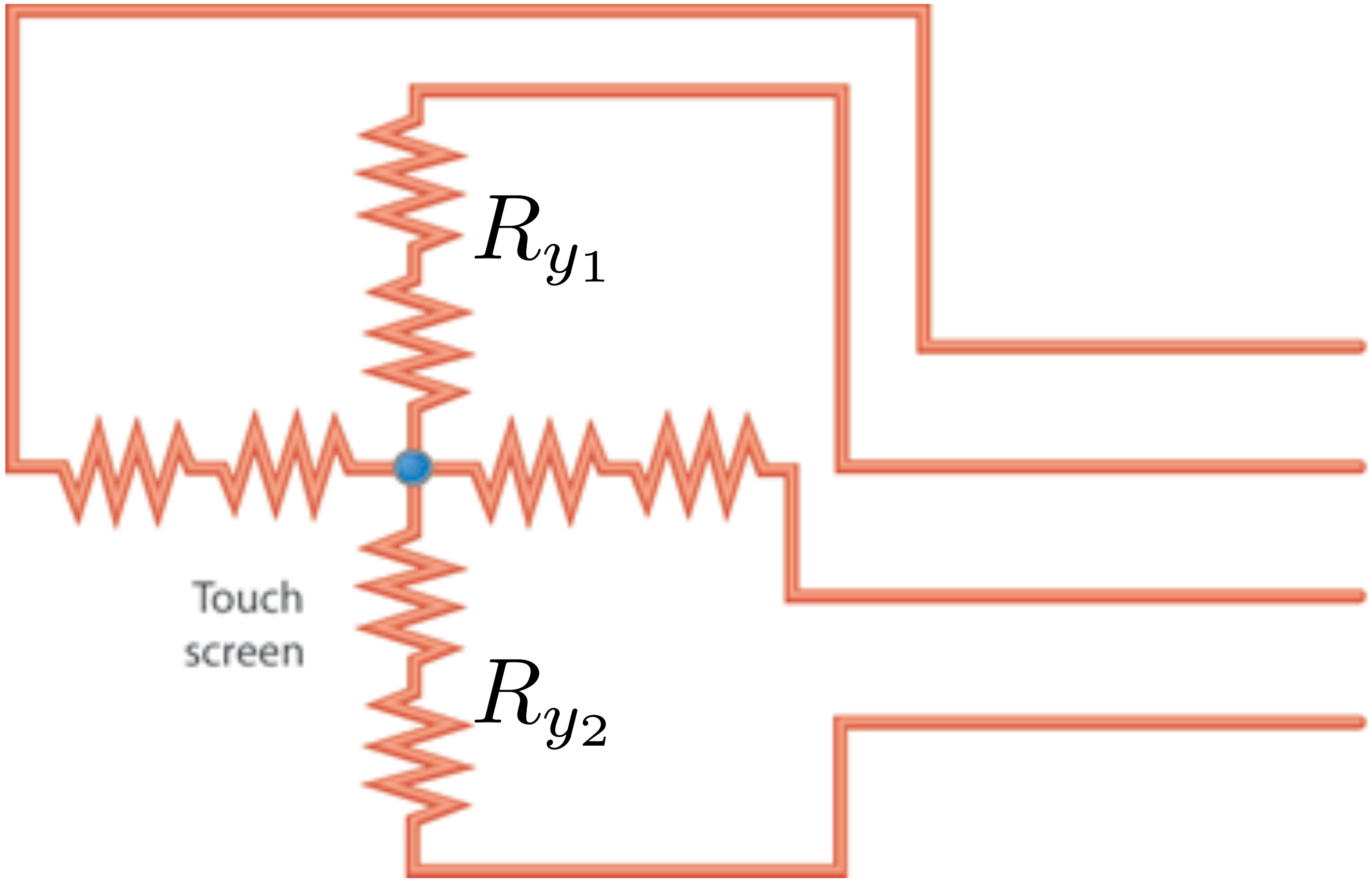
X- = GND

Y- = floating

need x,y coords:
two measurements

# resistive touchscreens

to determine y coordinate:



X+ = $V_{cc}\left(\frac{R_{y_2}}{R_{y_1}+R_{y_2}}\right)$

Y+ = Vcc

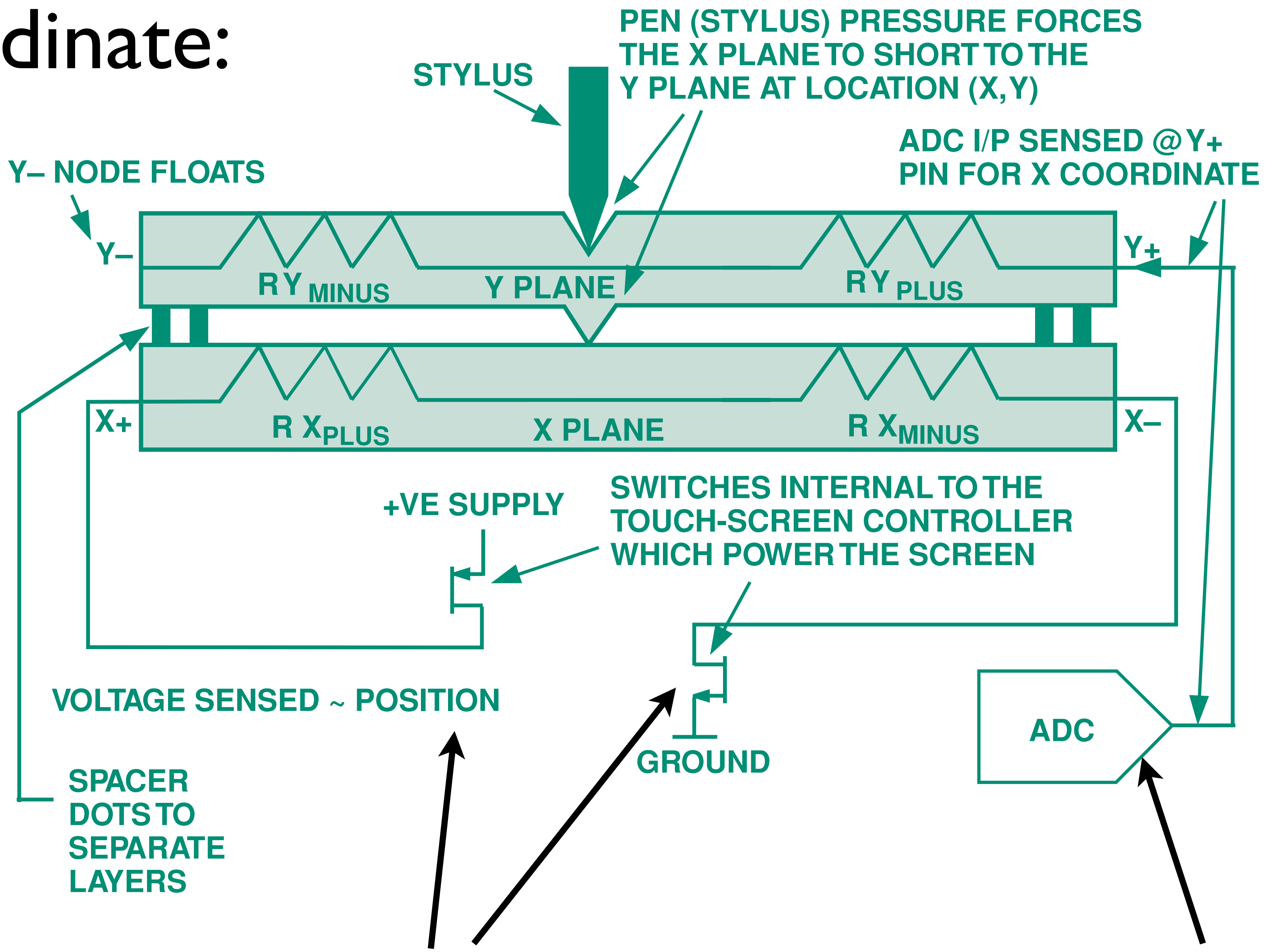
X- = floating

Y- = GND

need x,y coords: two measurements

# resistive touchscreens

to determine x coordinate:


STYLUS
PEN (STYLUS) PRESSURE FORCES THE X PLANE TO SHORT TO THE Y PLANE AT LOCATION (X,Y)
Y– NODE FLOATS
ADC I/P SENSED @ Y+ PIN FOR X COORDINATE
Y–
Y+
RY MINUS
Y PLANE
RY PLUS
X+
X–
R XPLUS
X PLANE
R XMINUS
+VE SUPPLY
SWITCHES INTERNAL TO THE TOUCH-SCREEN CONTROLLER WHICH POWER THE SCREEN
VOLTAGE SENSED ~ POSITION
GROUND
ADC
SPACER DOTS TO SEPARATE LAYERS

touchscreen controller controls these switches

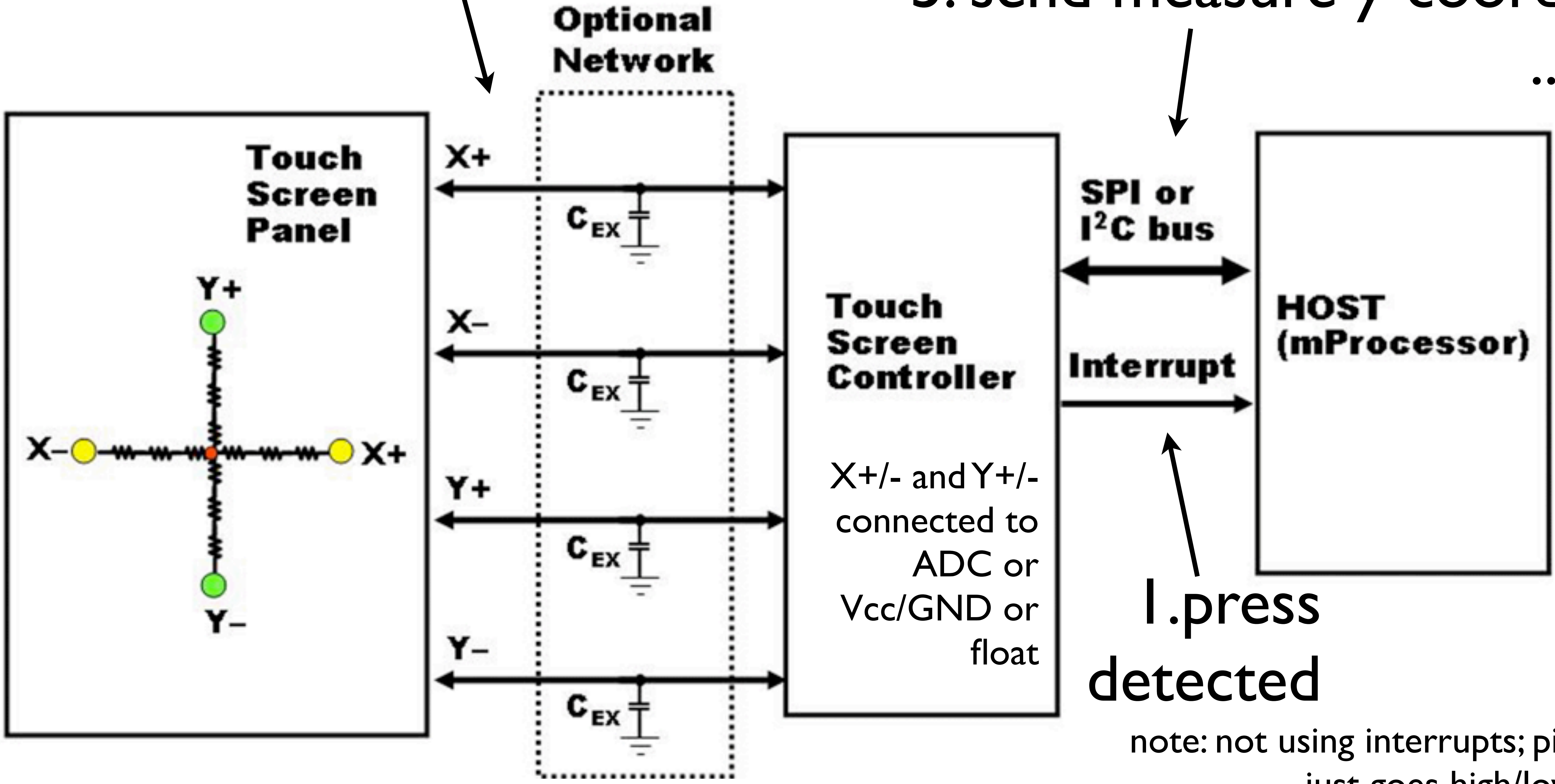
measures voltage; converts to proportional binary number you, on theory operation:

Q: how do we actually use this?

# generic touchscreen controller

3. connect Y+ to ADC; Y- is floating; X+ to VCC; X- to GND

2.send measure x-coord command
4. receive x-coord
5. send measure y-coord
...



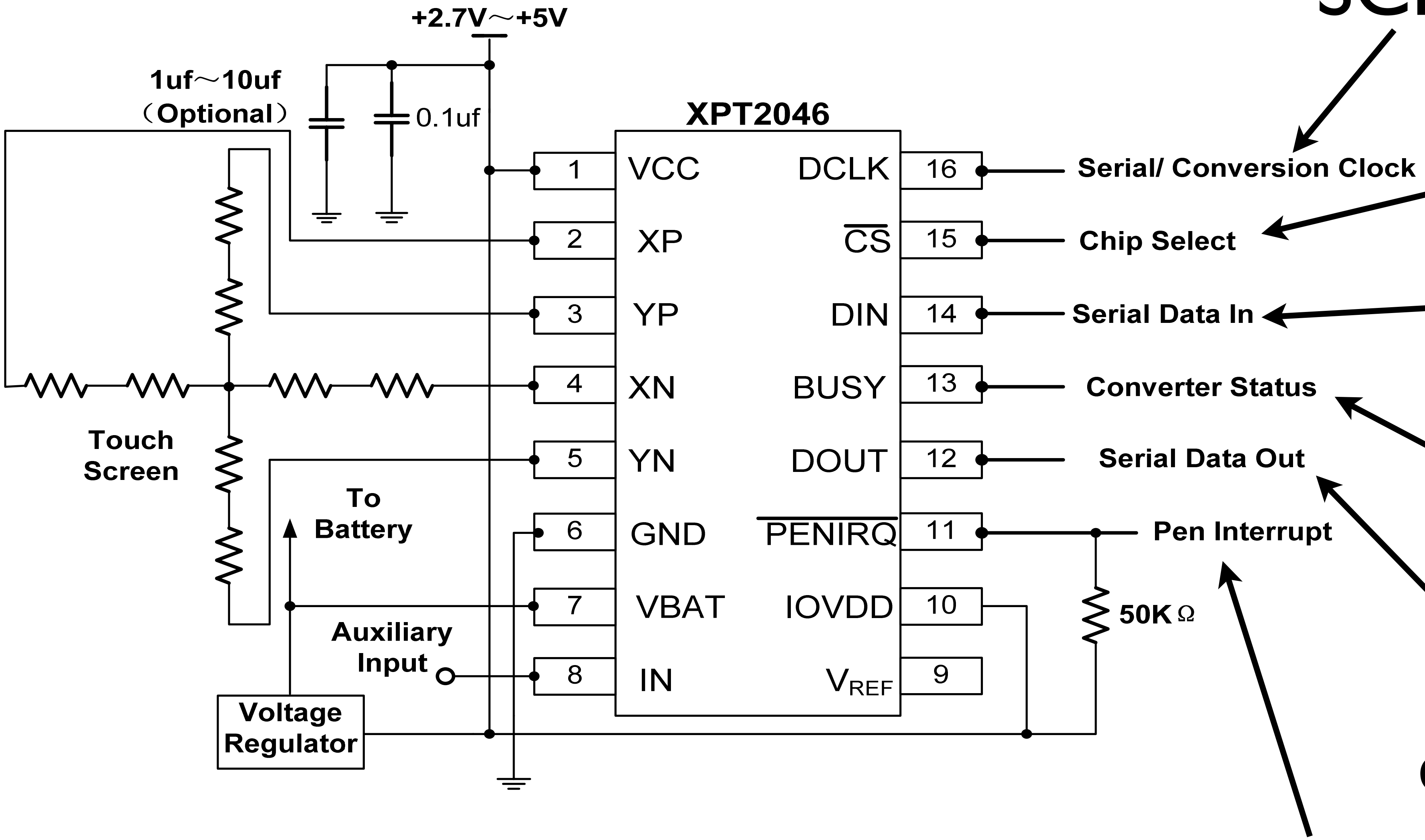
X+/- and Y+/- connected to ADC or Vcc/GND or float

1.press detected

note: not using interrupts; pin just goes high/low

# XPT2046 touchscreen

interface via SPI



SCLK

enable I/O

data latched on rising edge

high during conversion

data shifted on falling edge

low while touch is detected

note: refer to schematic
to find pins on LCD board

p13 & p9

# XPT2046 touchscreen

one command

pressure
temperature

very simple:

1. tx: get x,y, or z/t (control byte)
2. rx: requested coord

note: the control byte also contains configuration options

# XPT2046 touchscreen: control byte

what is sent to touchscreen controller

coordinate:
x: 101
y: 001

conversion resolution:
1: 8-bits
0:12-bits

| BIT7(MSB) | BIT 6 | BIT 5 | BIT 4 | BIT 3 | BIT2 | BIT 1 | BIT 0(LSB) |
|---|---|---|---|---|---|---|---|
| S | A2 | A1 | A0 | MODE | SER/$\overline{DFR}$ | PD1 | PD0 |

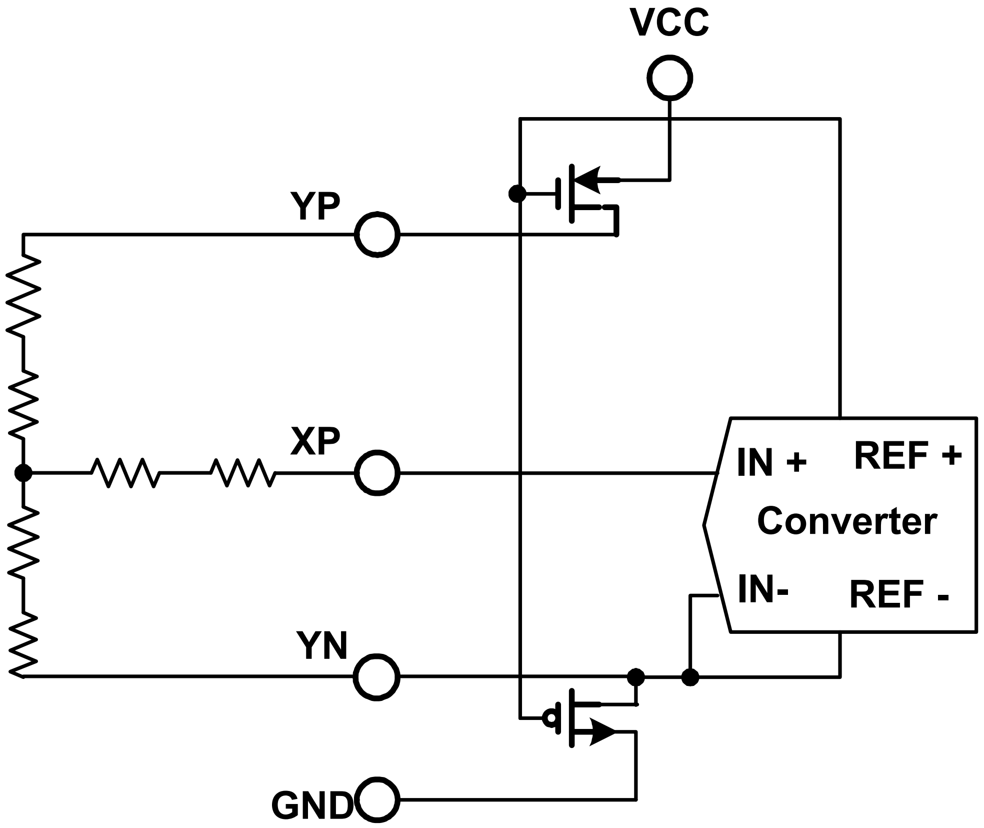
always 1

conversion reference type:
1: single
0:differential

power/interrupt pin:
0 0: unit off between conversions but /
PENIRQ active

# XPT2046 touchscreen: A[ 2 : 0 ]

(get y)



X+ input to ADC

=> measure y coord

of course,
depends on orientation

| A2 | A1 | A0 | +REF | −REF | YN | XP | YP | Y-POSITION | X-POSITION | $Z_1$-POSITION | $Z_2$-POSITION | DRIVERS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 1 | YP | YN |  | +IN |  | M |  |  |  | YP,<br>YN |
| 0 | 1 | 1 | YP | XN |  | +IN |  |  |  | M |  | YP, |
| 1 | 0 | 0 | YP | XN | +IN |  |  |  |  |  | M | YP, |
| 1 | 0 | 1 | XP | XN |  |  | +IN |  | M |  |  | XP, |

# XPT2046 touchscreen: control byte

CB[6:4] depend on if you want x or y

recommended configuration (CB[3:0]):

1. differential reference
2. 12-bit conversion
3. power-down between conversions

recommended functions:

1. `getX()`
2. `getY()`

1. issue appropriate control byte
2. get response

need routines for SPI TX/RX

this is the tricky bit

# XPT2046 touchscreen: SPI

(12 bit)

recommended
config

24 clock cycles to get single coord:

1. TX control byte (clocks 1--8)
2. RX coord (clocks 9--24)

coord: [ 0C[11:0]000 ]

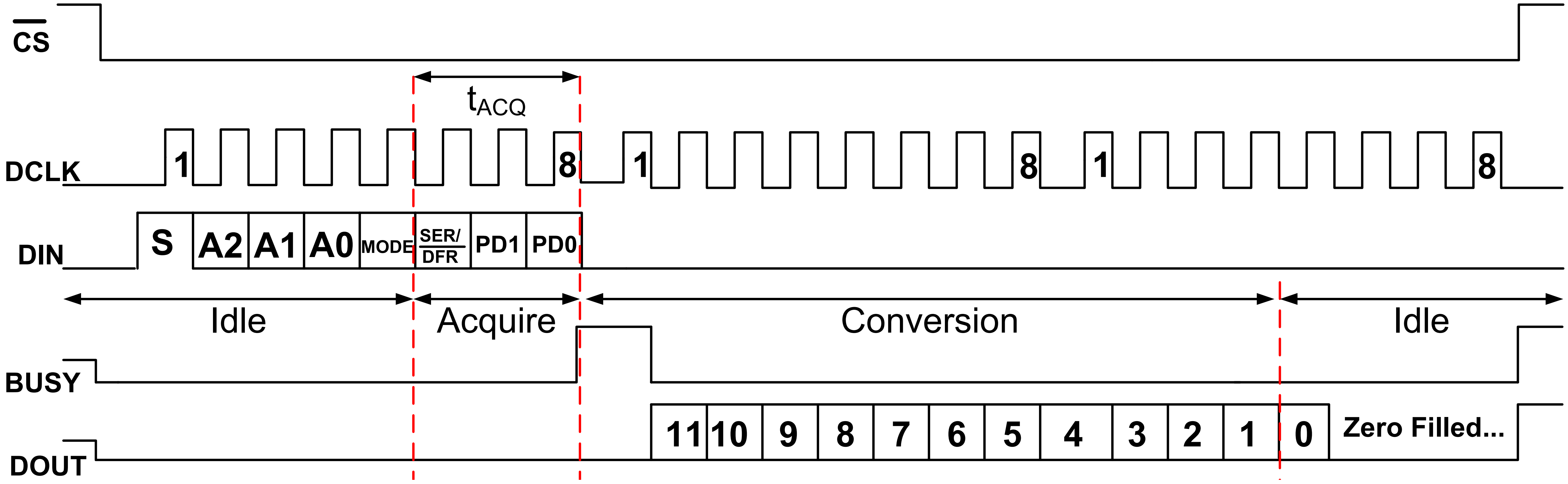
preceded by 0

followed by 000

p21 & fig 12, p23

# XPT2046 touchscreen: SPI

note: not all of these pins are
connected on your board



touchscreen RX on rising ⟶ uC change data on falling

touchscreen change data on falling ⟶ uC RX on rising

fig 12, p23

# response?

# to receive coordinate

use RX queue in SPI module:

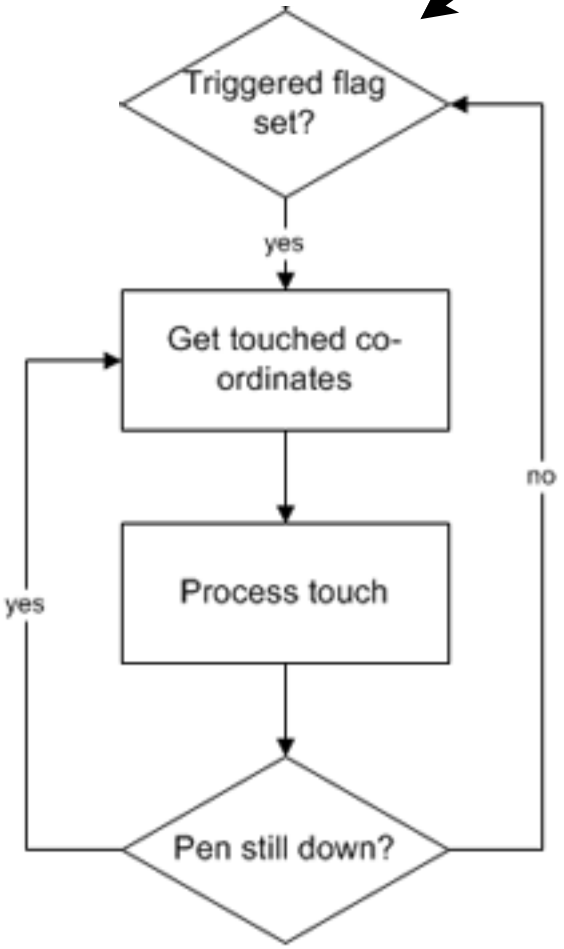
1. init conversion
2. wait
3. read DR  
   (A11--1)
4. read DR  
   (A0)
5. concatenate

# XPT2046 touchscreen: approach

basic approach:

(triggered flag is /PENIRQ)

polling /PENIRQ

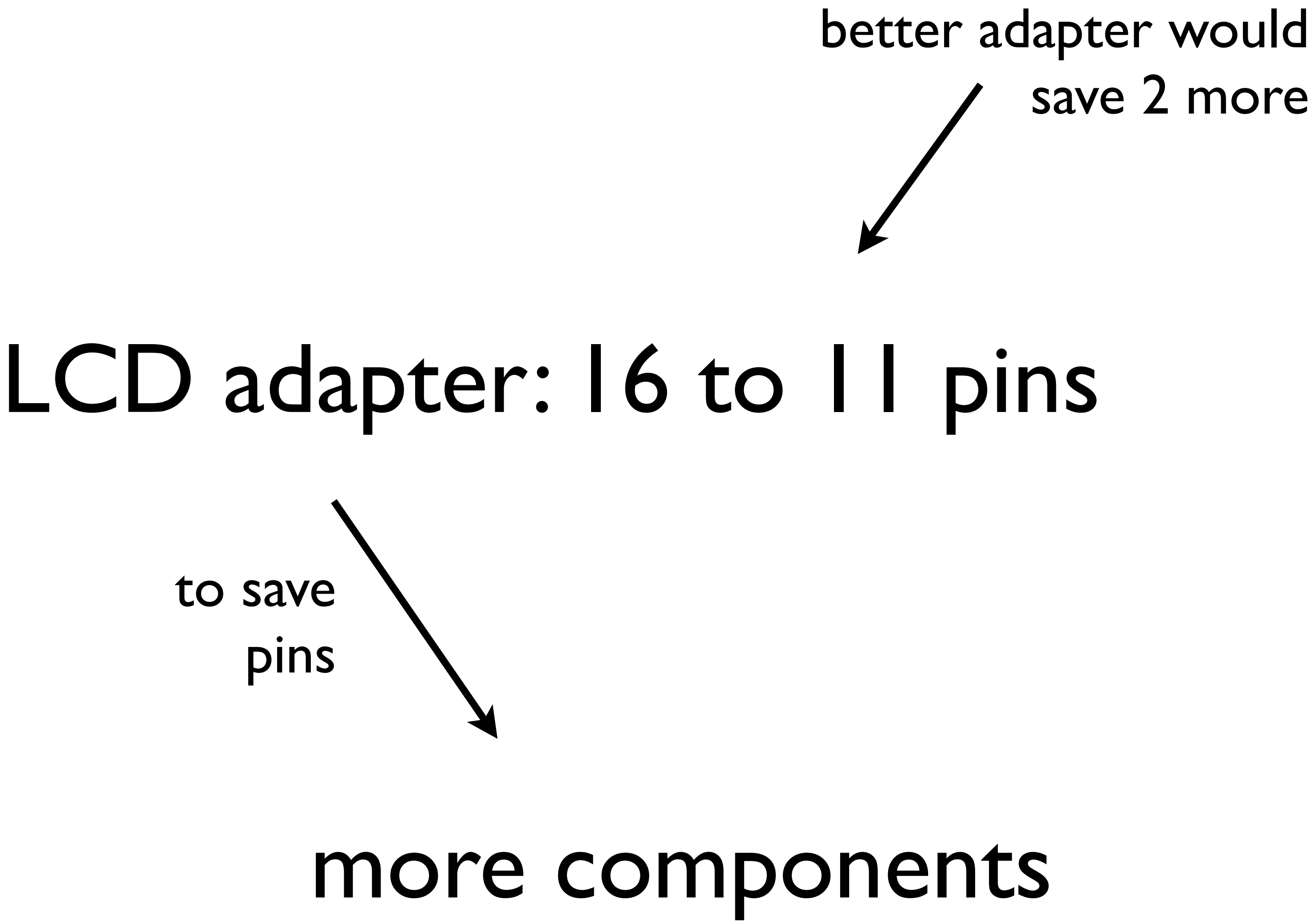


1. don't update until screen is released

2. data is noisy: average or take median of coords while pressed

# LCD Adapter

ECE 3710



better adapter would
save 2 more

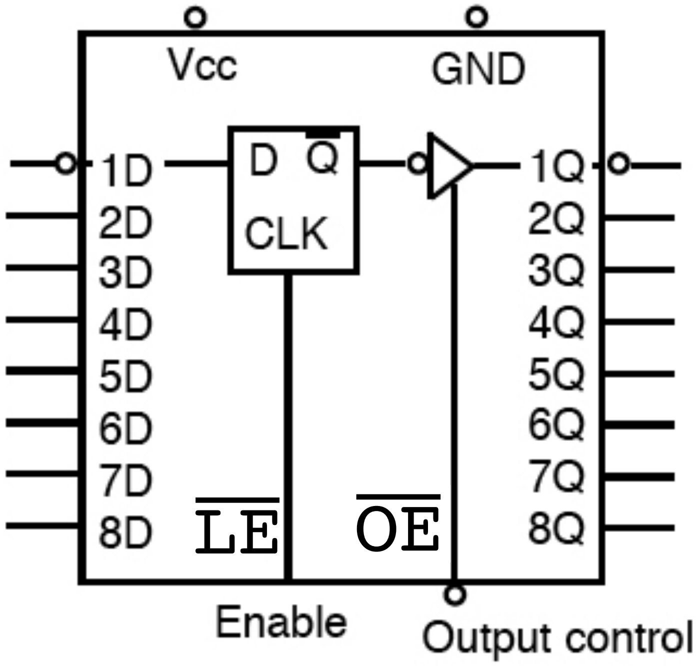
LCD adapter: 16 to 11 pins

to save
pins

more components

ah, more complexity:

# latch



**Funtion Table**

| Output control | Enable<br>$\overline{\mathtt{LE}}$ | <br>D | Output |
|---|---|---|---|
| L | H | H | H |
| L | H | L | L |
| L | L | X | Q0 |
| H | X | X | Z |

if $\overline{\mathtt{OE}}$=0

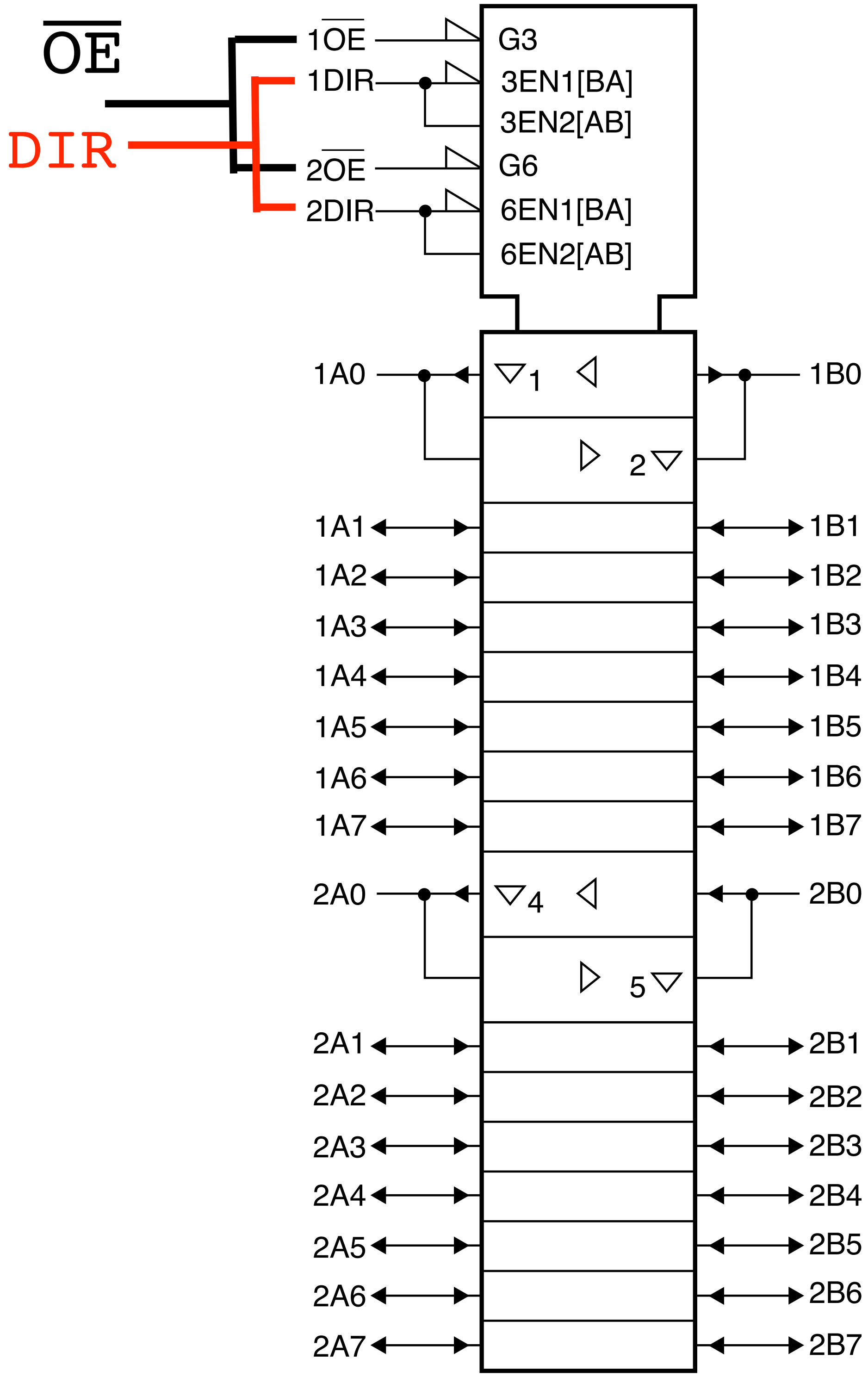
when $\overline{\mathtt{LE}}$=1  `Output=D`

when $\overline{\mathtt{LE}}$=0  `Output=Q`

stored value

# transceiver

(16-bit mode)



if $\overline{\text{OE}}$=0

data goes from A to B

when DIR=1 A=>B

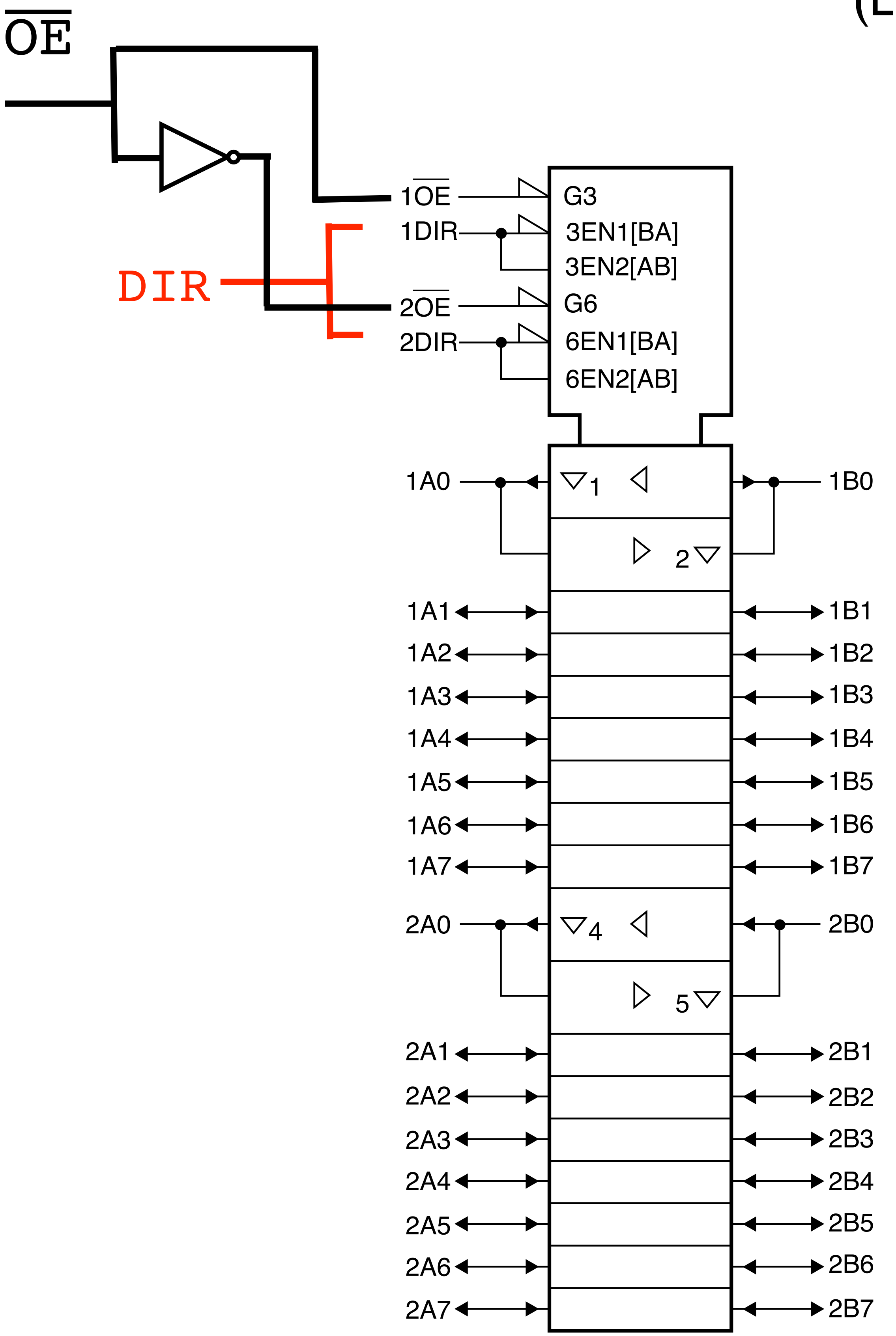
when DIR=0 A<=B

data goes from B to A

Tuesday, October 29, 13

# transceiver

(LCD adapter)



if $\overline{\text{OE}}$=0

data goes from
A to B

when DIR=1 1A=>1B

when DIR=0 1A<=1B

data goes from
B to A

if $\overline{\text{OE}}$=1

data goes from
A to B

when DIR=1 2A=>2B

when DIR=0 2A<=2B

data goes from
B to A

# to write data: first step

(lower byte)

uC does:

*1. outputs lower byte: IB[7:0]*

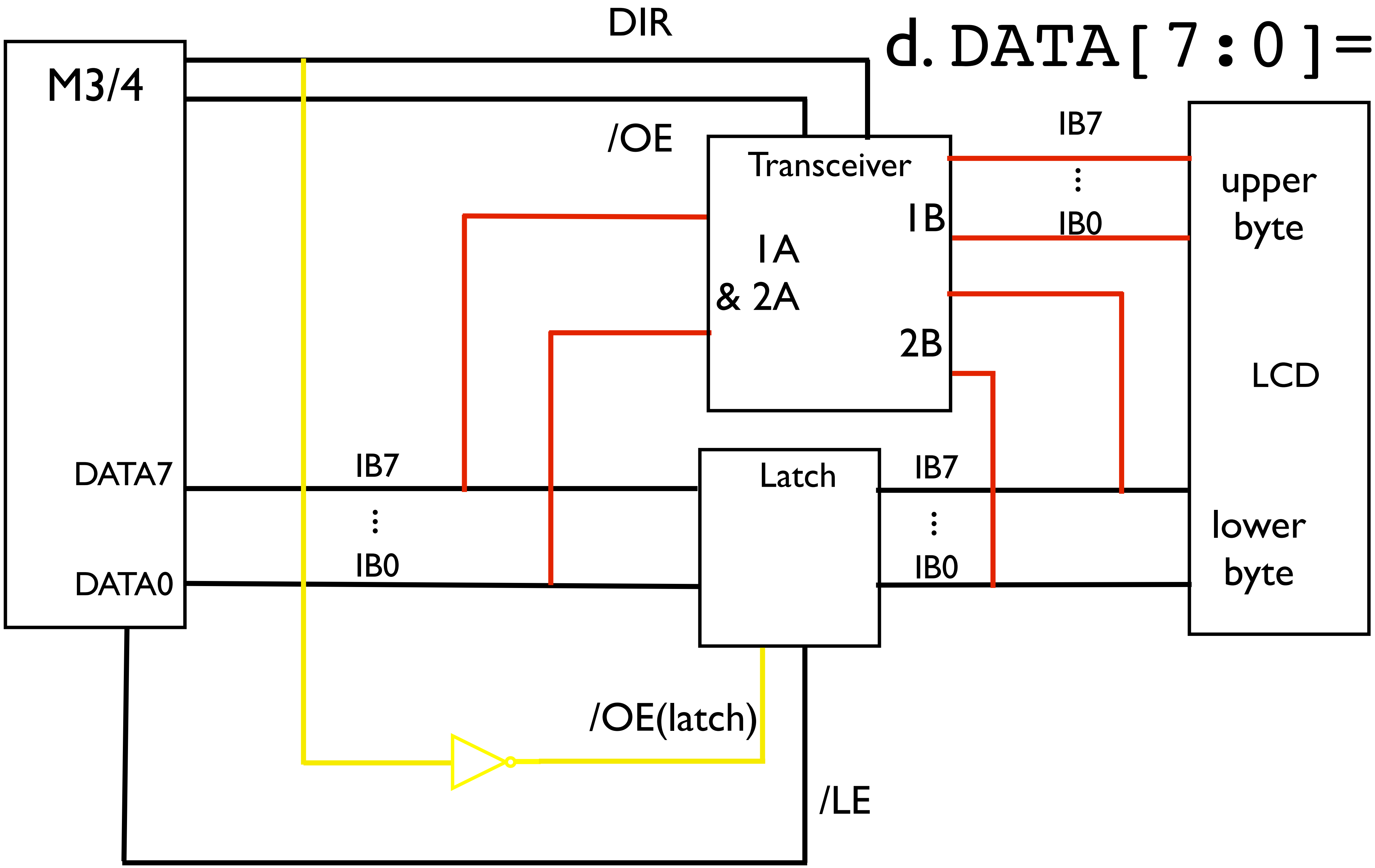
a. `/OE=0`

b. `DIR=1`

c. `/LE=1`

d. `DATA[7:0]=IB[7:0]`

e. `/LE=0`



# to write data: second step

(upper byte)

uC does:

*1. outputs upper byte: IB[15:8]*

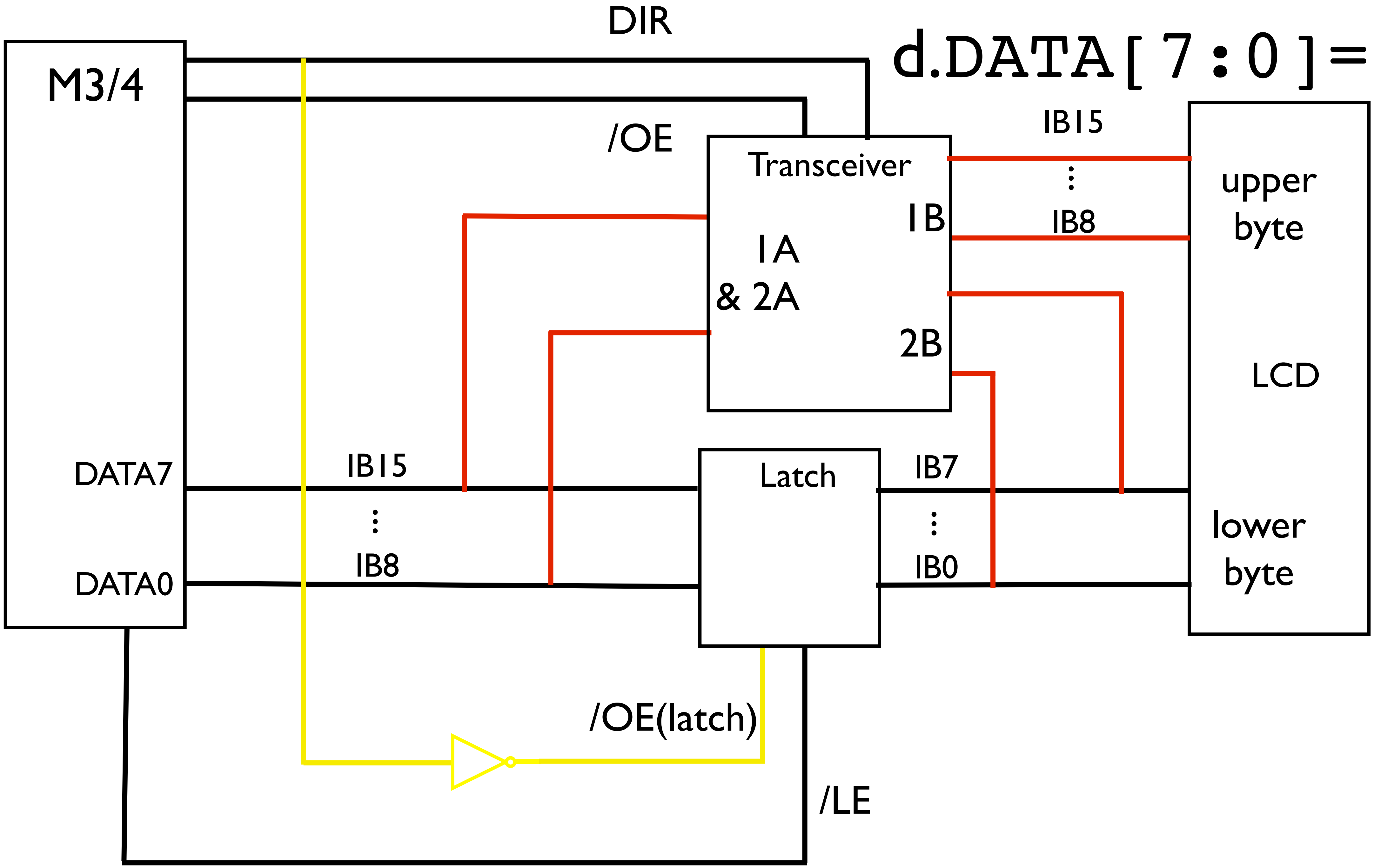
unchanged from step one

a. `/OE=0`

b. `DIR=1`

c. `/LE=0`

d.`DATA[7:0]=IB[15:8]`



for LCD adapter pins

note:

1. $/OE_{(\text{transceiver})}$ = DEN
2. $/OE_{(\text{latch})}$ = DDIR
2. /LE = DLE
3. DIR = DDIR