EE4800-03
Embedded Systems Design

Lessons 11-12
Input/Output Interfacing Concepts

Overview - Input/Output Interfacing

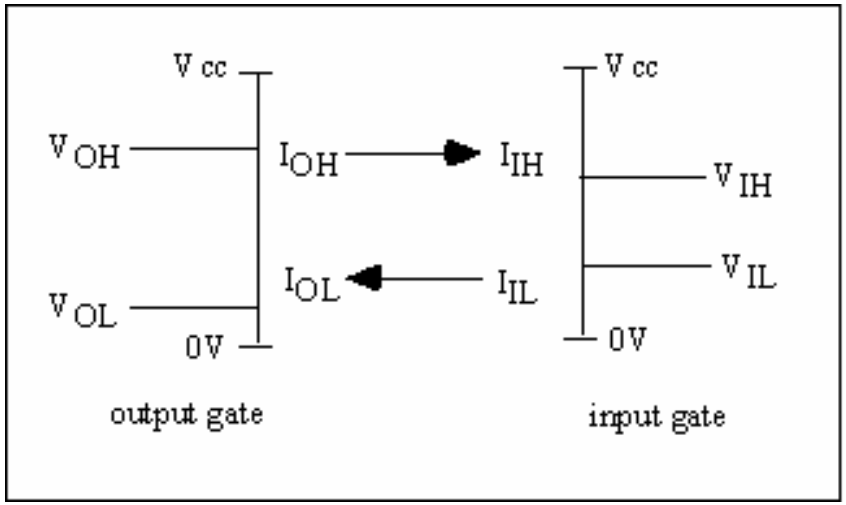
- Voltage and current characteristics
- Loading
- Input devices
- Output devices
- Fanout
- Interfacing to other devices

Voltage and Current Characteristics

- V_{OH}: lowest guaranteed output voltage for logic high
- V_{OL}: highest guaranteed output voltage for logic low
- I_{OH}: the output current for logic high (- current source)
- I_{OL}: the output current for logic low (+ current sink)
- V_{IH}: lowest input voltage guaranteed as logic high
- V_{IL}: highest input voltage guaranteed as logic low
- I_{IH}: the input current for logic high (+ current sink)
- I_{IL}: the input current for logic low (- source sink)

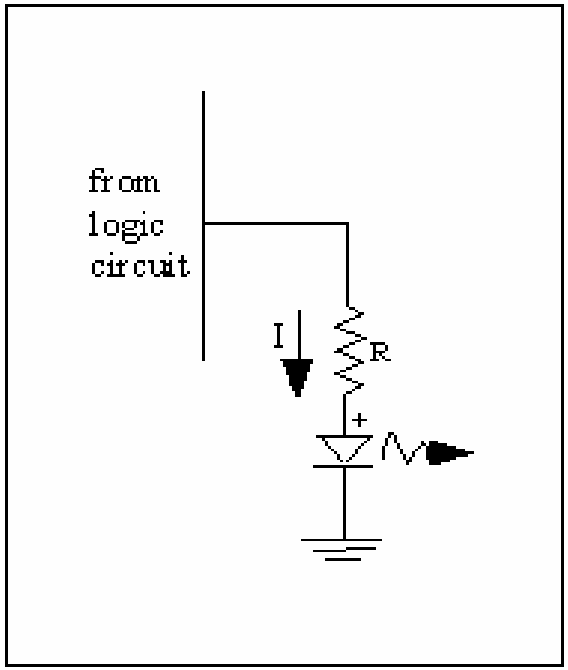
Voltage and Current Characteristics for "HC" CMOS Devices

- V_{OH}: 4.2 volts
- V_{OL}: 0.4 volts
- I_{OH}: -0.8 mA
- I_{OL}: 1.6 mA
- V_{IH}: 3.5 volts
- V_{IL}: 1.0 volt
- I_{IH}: 10 uA
- I_{IL}: -10 uA
- Fanout example



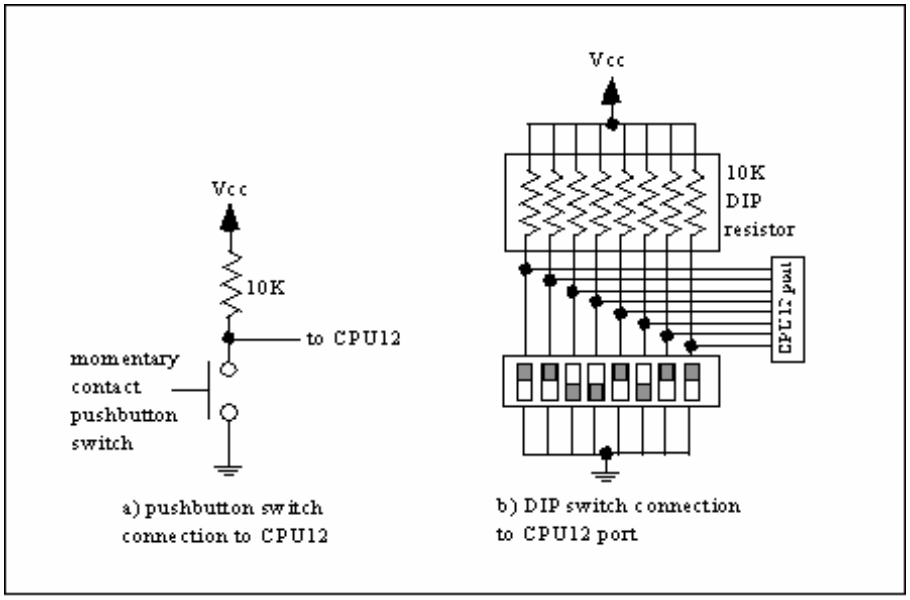
Loading

- Reference Fig 5.2
- In logic high condition, I_{OH} values greater than -0.8 mA will cause V_{OH} to decrease
- In logic low condition, I_{OL} greater than 1.6 mA will cause V_{OL} to increase
- Both may cause faulty logic levels in downstream systems



Input/Output Devices

- Momentary pushbutton
  - interrupt
- DIP switches
  - configuration
- Keypad
  - data entry
- LEDs
  - status entries
- 7 segment display
  - data display

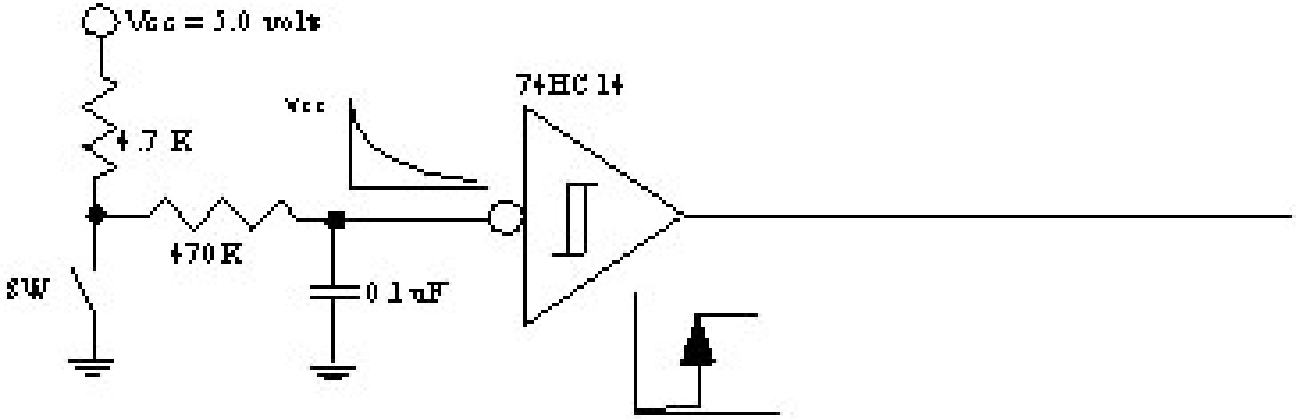


Switch debouncing

- Switches are mechanical devices
- When switch is flipped it makes/breaks contacts multiple times - called bouncing
  - processor fast enough to see each bounce as independent input
  - debounce with hardware, software, or HW/SW techniques

Switch debouncing
- techniques -

- Hardware

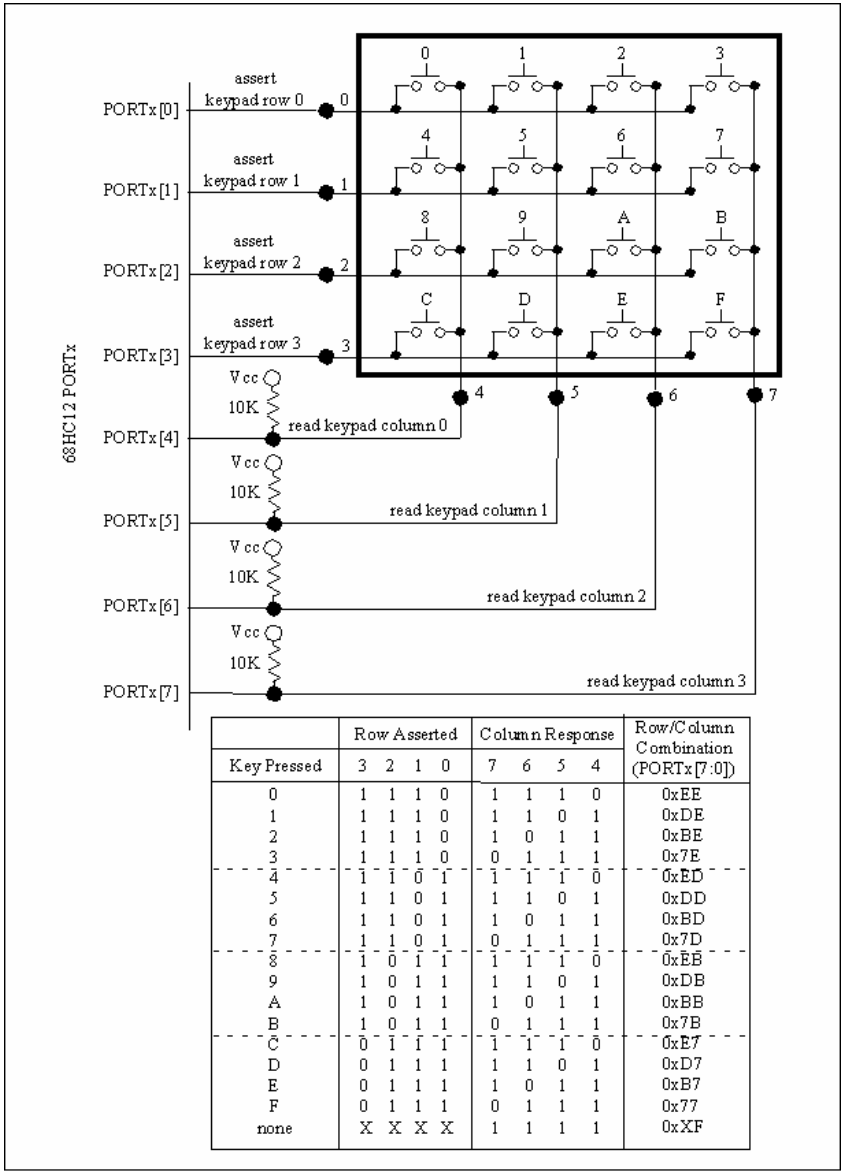


- Software
  - after first transition provide 25-50 ms delay

Terminating Unused Inputs

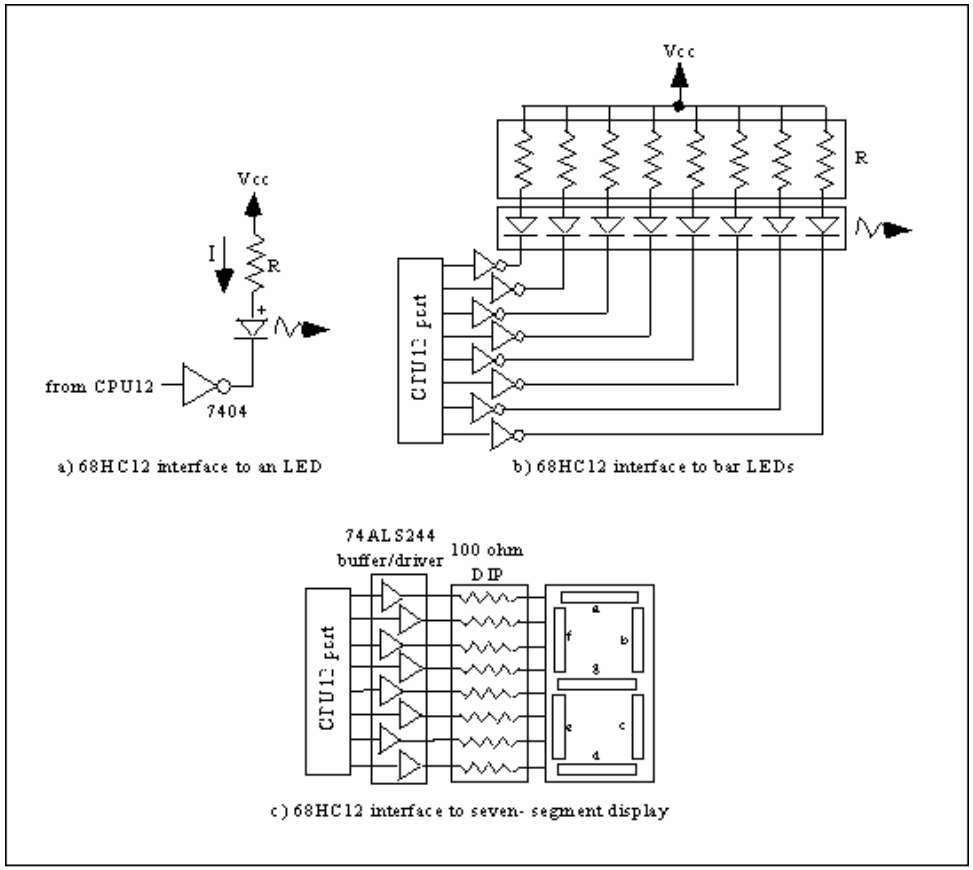
- Input impedance is very high on unused input pins
- If not connected, the input can oscillate or float to midsupply level
- Oscillation can couple noise to power supply
- Terminate unused input pins by pulling up (or down) via a resistor -- 4.7 Kohm

Keypad

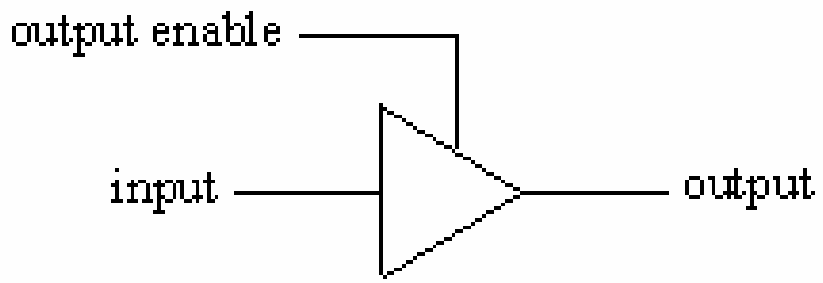


Key Pressed	Row Asserted 3	2	1	0	Column Response 7	6	5	4	Row/Column Combination (PORTx[7:0])
0	1	1	1	0	1	1	1	0	0xEE
1	1	1	1	0	1	1	0	1	0xDE
2	1	1	1	0	1	0	1	1	0xBE
3	1	1	1	0	0	1	1	1	0x7E
4	1	1	0	1	1	1	1	0	0xED
5	1	1	0	1	1	1	0	1	0xDD
6	1	1	0	1	1	0	1	1	0xBD
7	1	1	0	1	0	1	1	1	0x7D
8	1	0	1	1	1	1	1	0	0xEB
9	1	0	1	1	1	1	0	1	0xDB
A	1	0	1	1	1	0	1	1	0xBB
B	1	0	1	1	0	1	1	1	0x7B
C	0	1	1	1	1	1	1	0	0xE7
D	0	1	1	1	1	1	0	1	0xD7
E	0	1	1	1	1	0	1	1	0xB7
F	0	1	1	1	0	1	1	1	0x77
none	X	X	X	X	1	1	1	1	0xXF

Indicators


Vcc
I
R
from CPU12
7404
a) 68HC12 interface to an LED
Vcc
R
CPU12 port
b) 68HC12 interface to bar LEDs
74ALS244
buffer/driver
100 ohm
DIP
CPU12 port
a
b
c
d
e
f
g
c) 68HC12 interface to seven- segment display

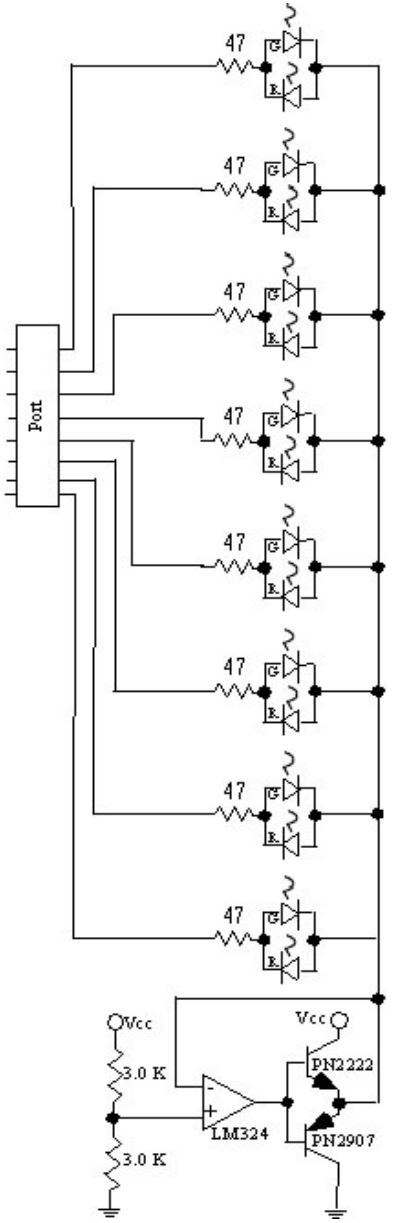
Tri-state Logic



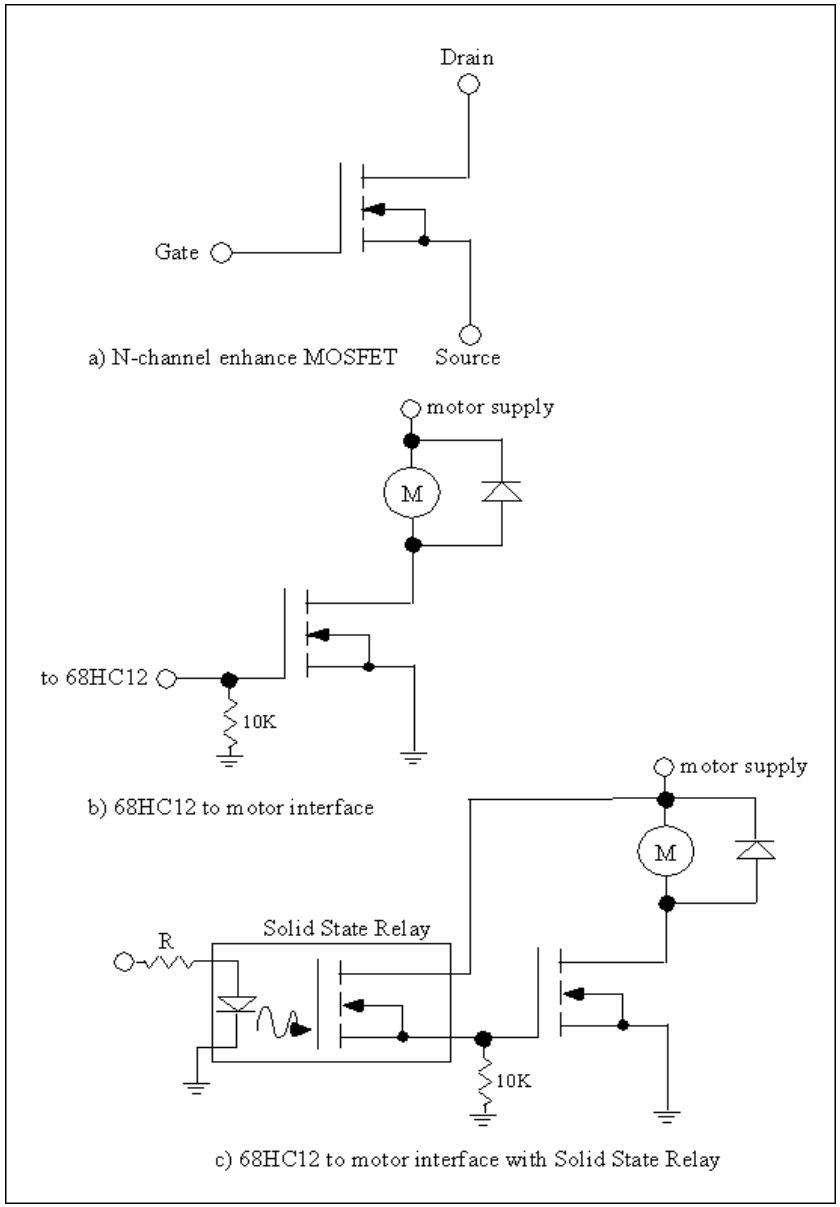
output enable	input	output
L	L	High-Z
L	H	High-Z
H	L	L
H	H	H

Tri-state indicator circuit

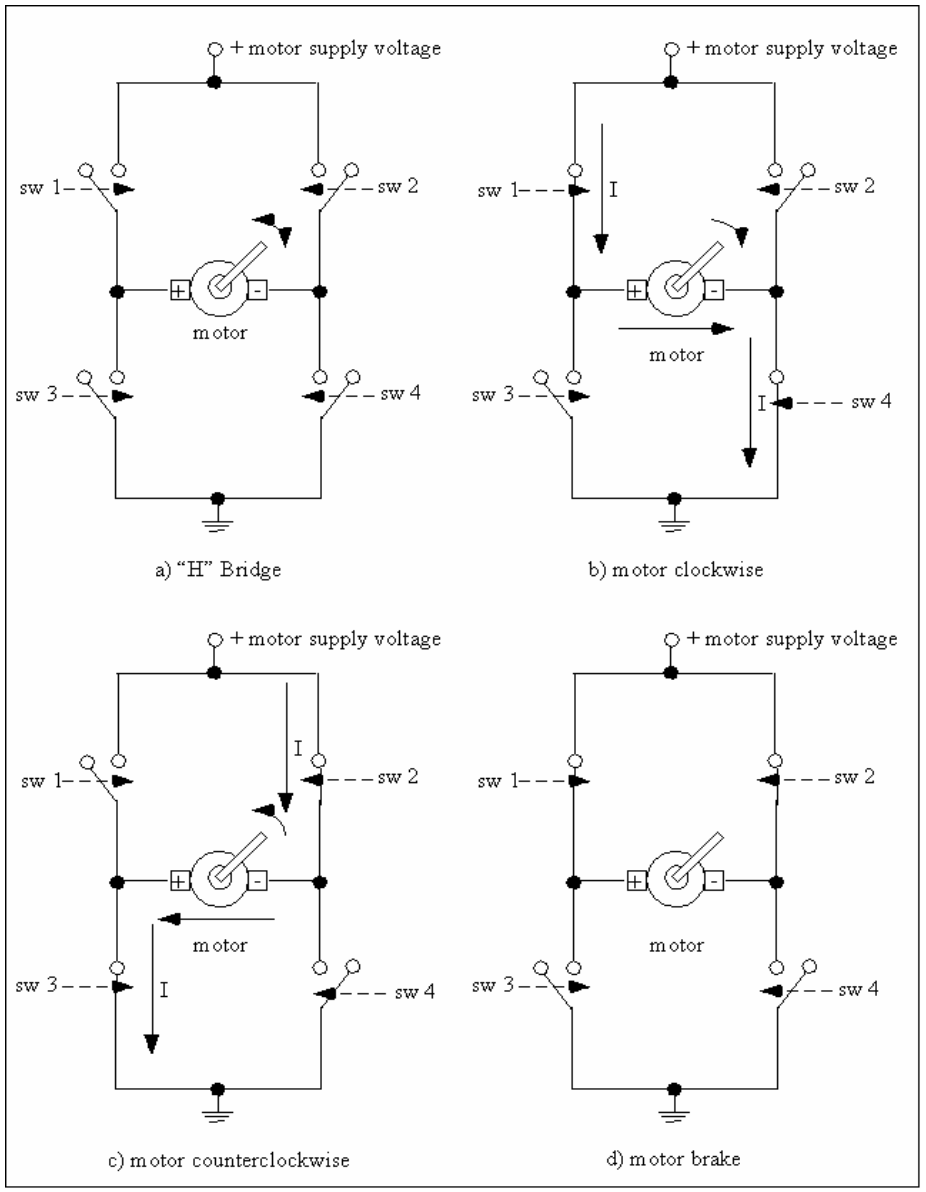
- Tri-state indicator:
  - Green: logic high
  - Red: logic low
  - None: high impedance



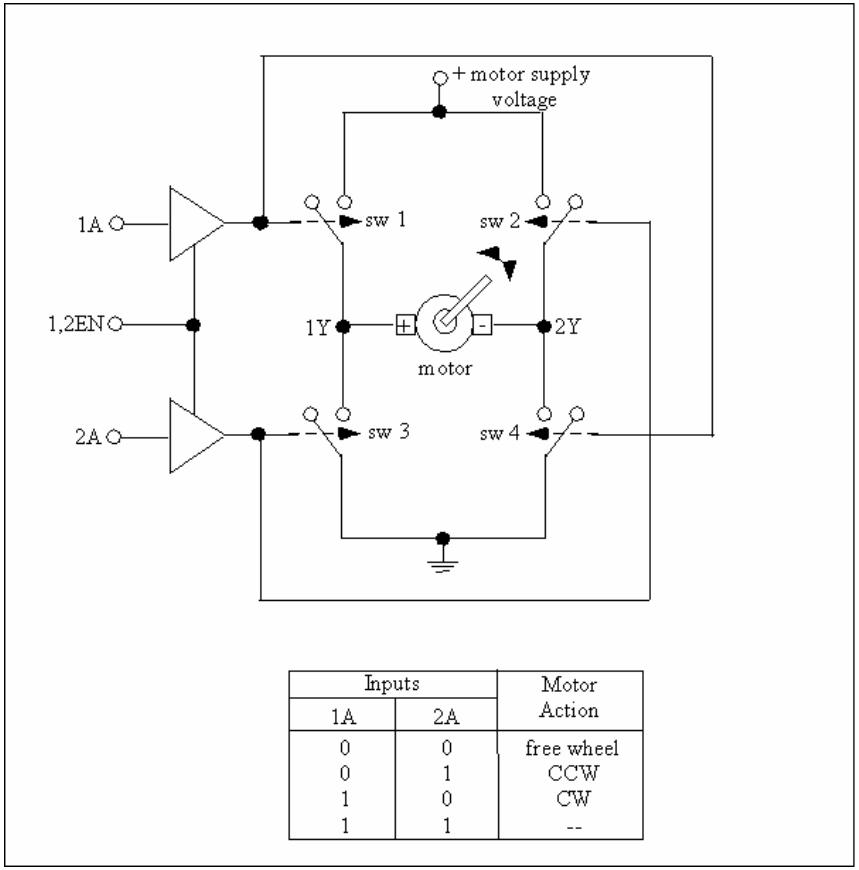
Interfacing to other Devices - Motor Control



Interfacing to Other Devices - Bi-directional motor control

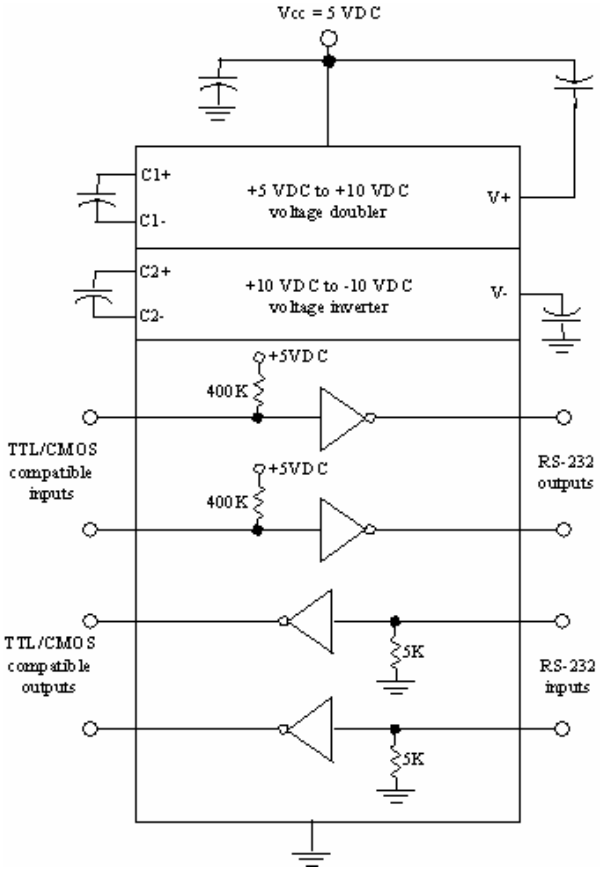


Interfacing to Other Devices
- Bi-directional motor control

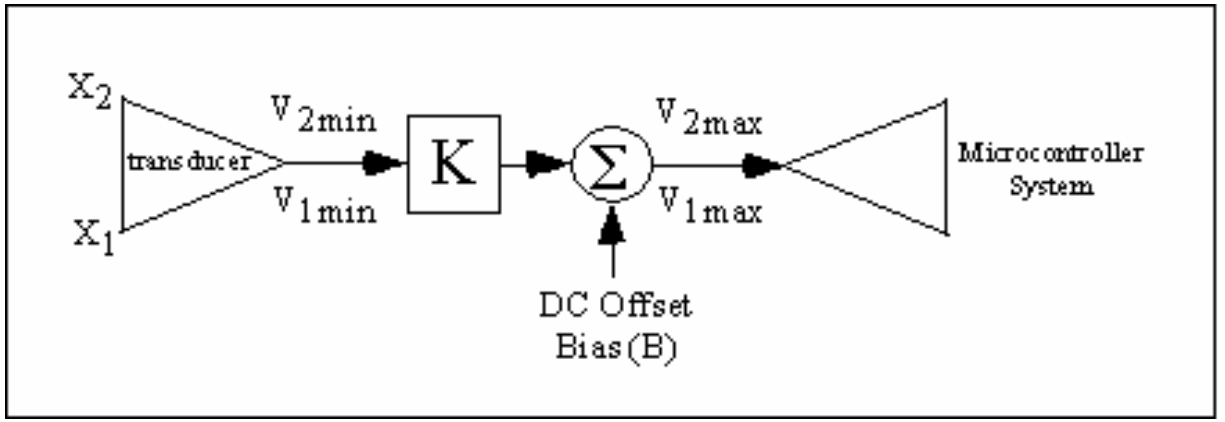


Inputs		Motor Action
1A	2A	
0	0	free wheel
0	1	CCW
1	0	CW
1	1	--

Interfacing to Other Devices - RS-232 Interface



Interfacing to Other Devices - Transducer Interface Design



$$V_{2max} = V_{2min} * K + B$$

$$V_{1max} = V_{1min} * K + B$$