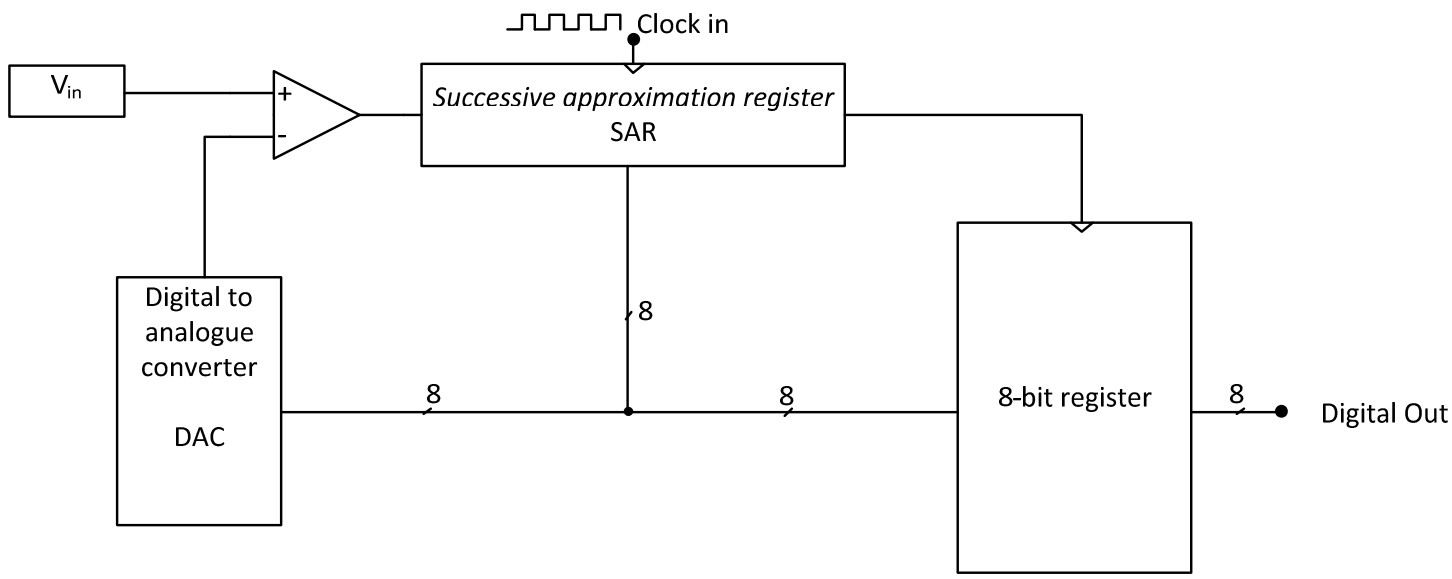
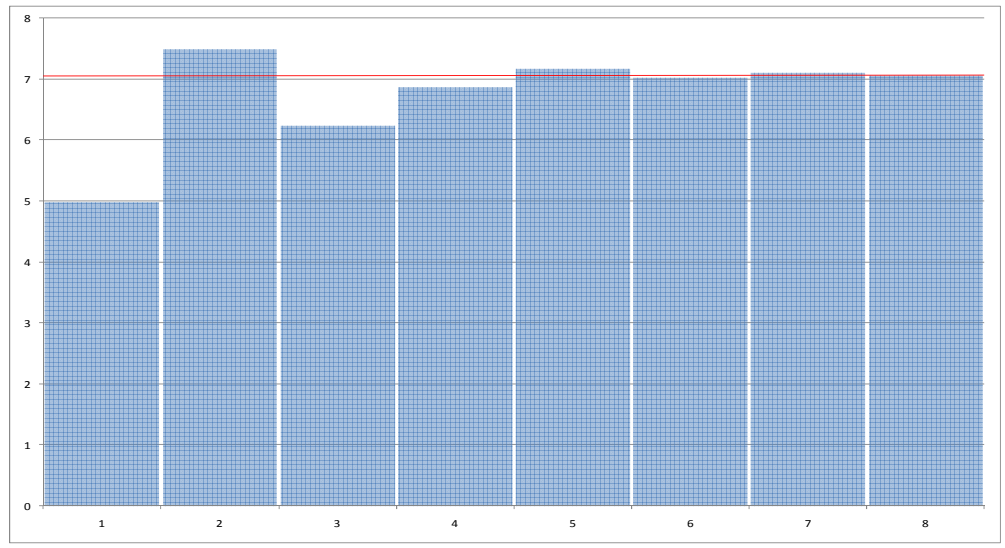
Successive approximation ADC

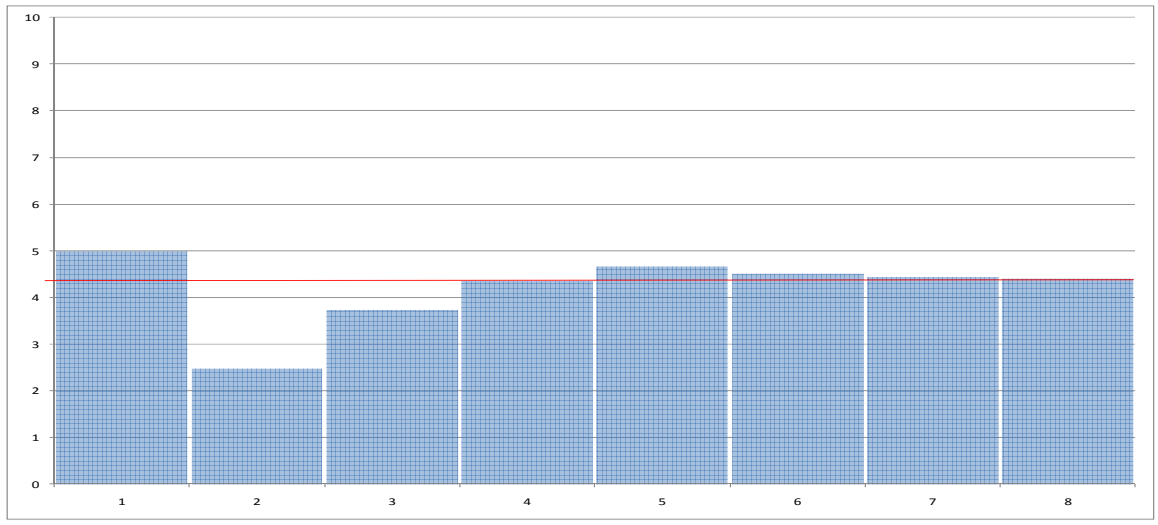


7.09V



Clock cycle	SAR Bits	Bit sum	Voltage ref
0	01111111	127	4.9804
1	10111111	127 + 64 = 191	7.4901
2	10011111	191 – 32 = 159	6.2353
3	10101111	159 +16 = 175	6.8627
4	10110111	175 + 8 = 183	7.1765
5	10110011	183 – 4 = 179	7.0196
6	10110101	179 + 2 = 181	7.0980
7	10110100	181 – 1 = 180	7.0588

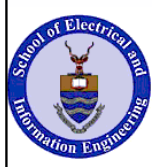
4.39V



Clock cycle	SAR Bits	Bit sum	Voltage ref
0	01111111	127	4.9804
1	00111111	127 - 64 = 63	2.4706
2	01011111	63 + 32 = 95	3.7255
3	01101111	95 +16 = 111	4.3529
4	01110111	111 + 8 = 119	4.6667
5	01110011	119 – 4 = 115	4.5098
6	01110001	115 – 2 = 113	4.4313
7	01110000	113 - 1 = 112	4.3921

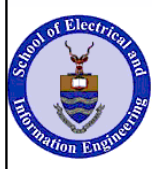
A/D module

- **ADCON0 register**
  - **Conversion clock – Frequency / time of conversion**
  - **Channel**
  - **Conversion status**
  - **A/D conversion interrupt flag**
  - **A/D module On/Off**
- **Acquisition time – Amp. Settling time, Cap charging time and temp. coefficient**



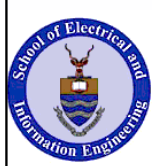
A/D module

- Conversion clock
  - 4 MHz at 2Tosc → 500 ns
  - 4 MHz at 8Tosc → 2 µs
- Time vs resolution
- Sleep mode operation

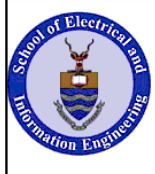


D/A converters

- **Resolution**
  - 8- bit → 2^8 = 256 values of output range → 0.4 %
- **Linearity**
  - Precision of the input-output relationship (next slide)
- **Accuracy**
  - Difference between expected vs measured output
    - 10 V full scale – accuracy of 0.2% - max error = 20 mV
- **Settling time (D/A converter)**
  - Time required to settle to within ± ½ LSB
- **Temperature sensitivity**
  - Temperature affects – V_{ref}, Resistors, Op amps, change ± ppm/℃

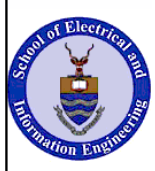


I/O of a microprocessor



I/O Ports

- Ports have two control registers
  - TRIS sets whether each pin is an input or output
  - PORT sets their output bit levels
- Most pins have 25mA source/sink (LED enabled)
- Floating input pins draw current! Tie off your pins (or set them to outputs).

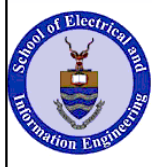


I/O

- Parallel data communications
- Serial data communications
- Data transmission
  - Synchronous
  - Asynchronous
- UART – Parallel → Serial (Baud rate)
  - Parity bit?
- RS – 232 – single data line in and out
- RS – 422 – differential signal – twisted pair

I/O → Peripheral devices

- **Application**
  - **Human**
    - Alphanumeric + special mathematical sysmbols
    - Keyboard + display
    - Slow
  - **Machine**
    - Different codes
    - High speeds



I/O → Peripherals

- A/D – transducers
- D/A – Control or level sensing
  - Frequency / digital pots
- Keyboard
- Display – LCD, 7 segment display, dot matrix
- USB, RS-232, LIN, CAN

Pitfalls in design

- **Peripheral Resource Sharing**
  Some functions require using the same resource: eg, some of the PWM modules use TMR2, which may also be used in the USART module.
- **Peripheral Pin sharing**
  Pins may share functions. eg, a GPIO will share a pin with a UART module (say the TX line). You CAN'T use one pin for two functions! You *must* choose between them.