Fixed-point FIR filter Implementation with ATmega32

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Files -> FIR filter, 2025 -> Fixed-point FIR filter Implementation.pptx

Basics of FIR Filter

Equation,

$$y[n] = h_0 x[n] + h_1 x[n-1] + ...h_N x[n-N]$$
$$= \sum_{i=0}^{N} h_i x[n-i]$$

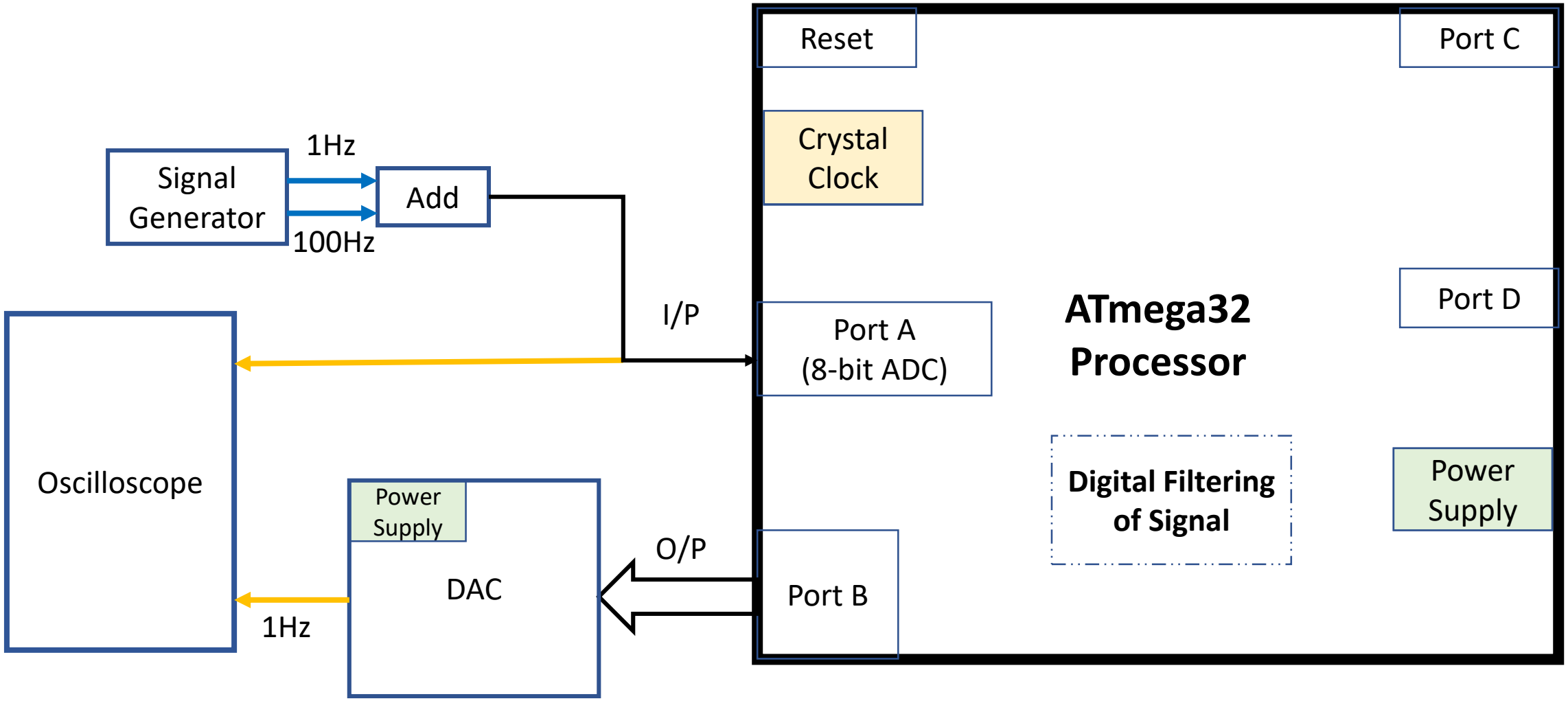
$x[n]$: Input signal $y[n]$: Output signal

N : Filter order $h_0, h_1, .., h_N$: Filter coefficients

I/P and O/P Specifications

- 10-bit ADC -> I/P
- 8-bit DAC -> O/P

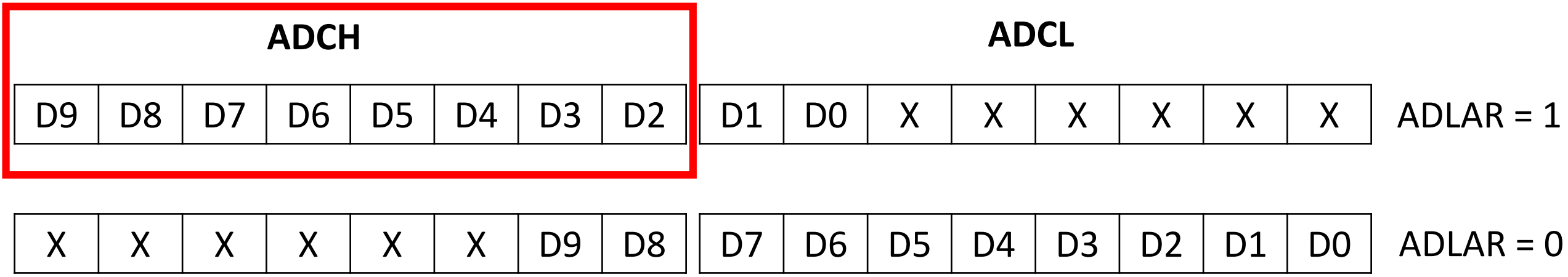
Block Diagram



FIR Filter Implementation with ATmega32

- 32 numbers of 8-bit general-purpose registers
- 8-bit FIR filter implementation
- Filter coefficients are 8-bit fixed point
- We will take 8 bits of input data (High data)

8 bits of I/P Data



FIR filter with 8-bit I/P, 8-bit coefficients and 8-bit O/P

- 8-bit I/P, take the value of ADCH register from the ADC channel

- 8-bit O/P, take only the upper 8 bits of 16 bits multiplication result

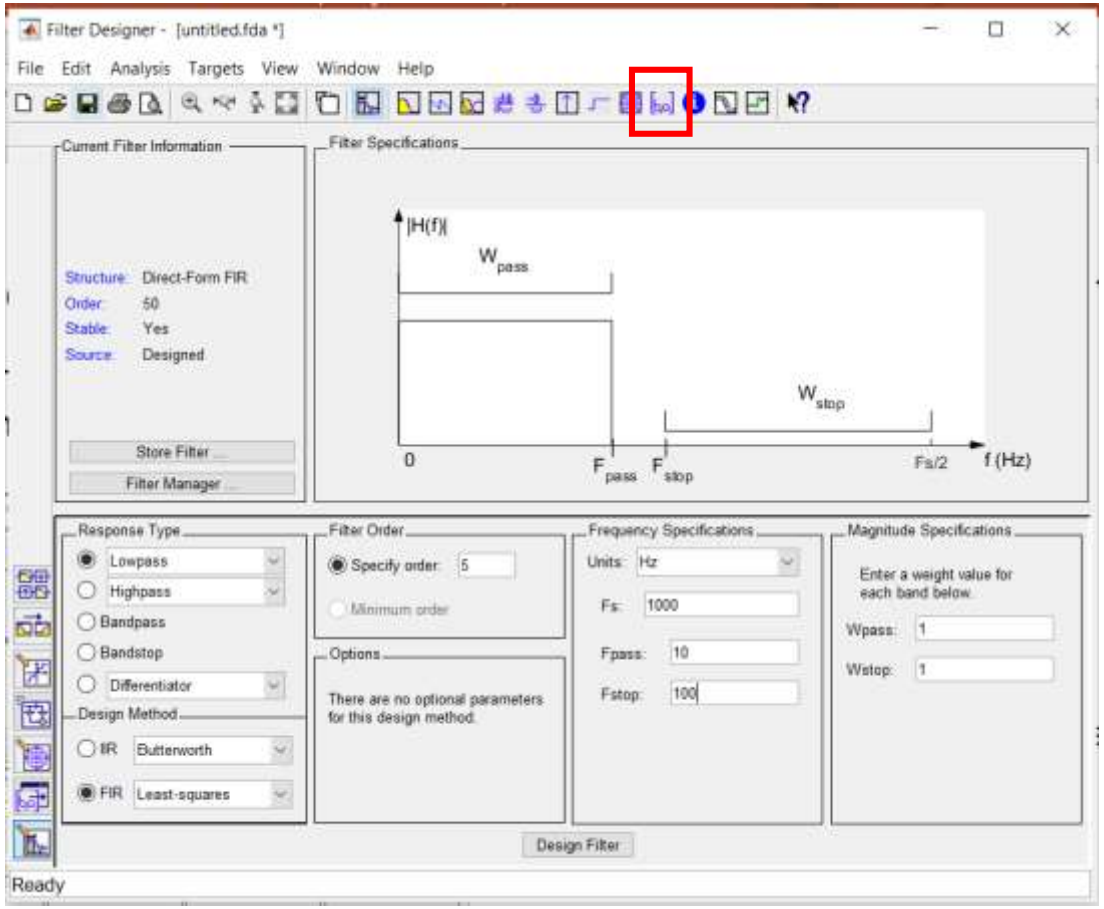
- 8-bit coefficients??

FIR Filter Specifications

- Low pass filter
- Order = 5
- Pass band frequency = 10Hz, Stop band frequency = 100Hz

Filter design using MATLAB Filter Designer tool

In MATLAB, go to APPS then Filter Designer under Signal Processing and Communications

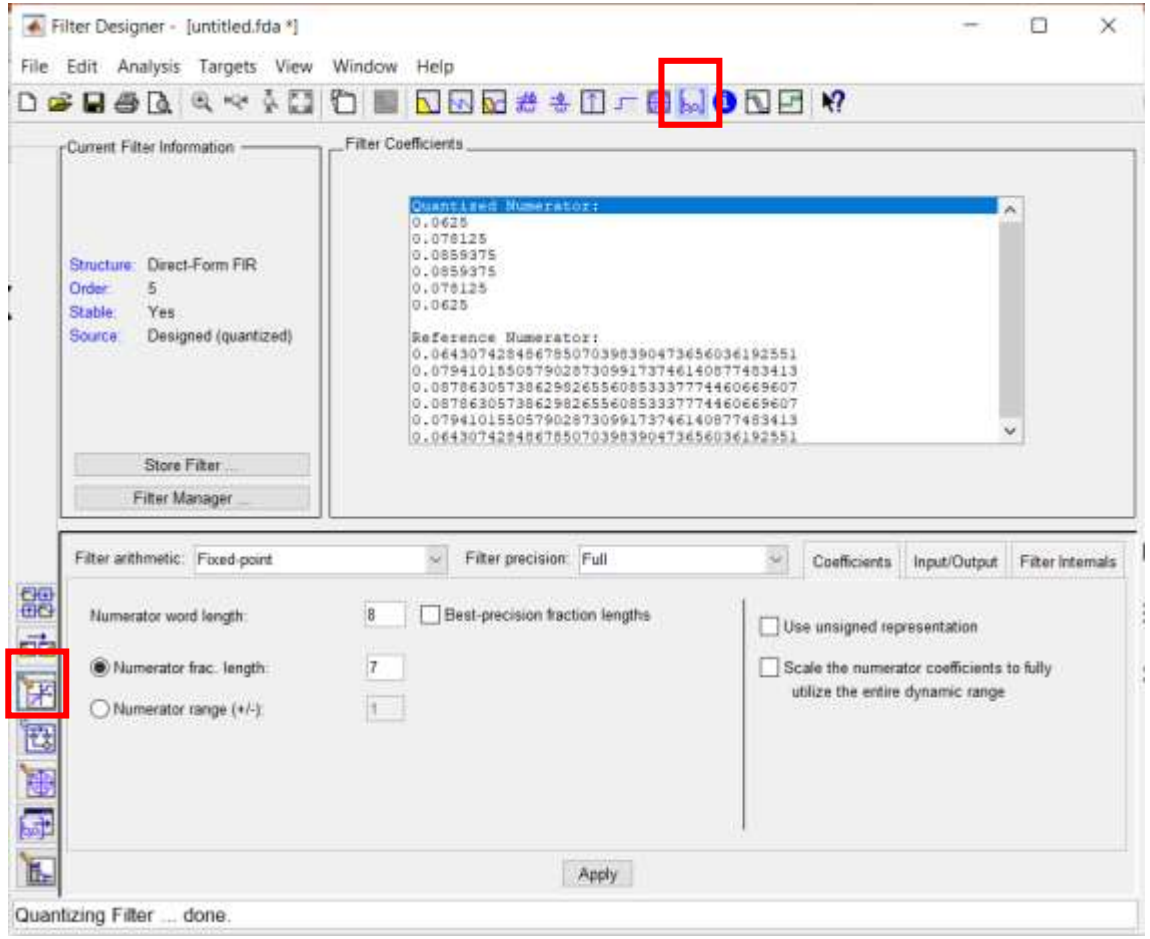


1. Select Filter Response type
2. Select Design Method
3. Specify Filter Order

(No. of coefficients = Order+1)

4. Give Frequency Specifications
5. Design Filter
6. Go to Filter Coefficients

Fixed Point Quantization of Filter Coefficients



1. Filter coefficients are 64bit precision
2. Convert to 8-bit fixed point
3. Go to Set quantization parameters
4. Select Filter Arithmetic as fixed point
5. Set Numerator word length as 8
6. Uncheck Best-precision fraction lengths
7. Set fraction length as 7
8. Apply
9. Go to File – Export – Export to Workspace
10. Multiply coefficients with 2^7
11. Convert to HEX using dec2hex command

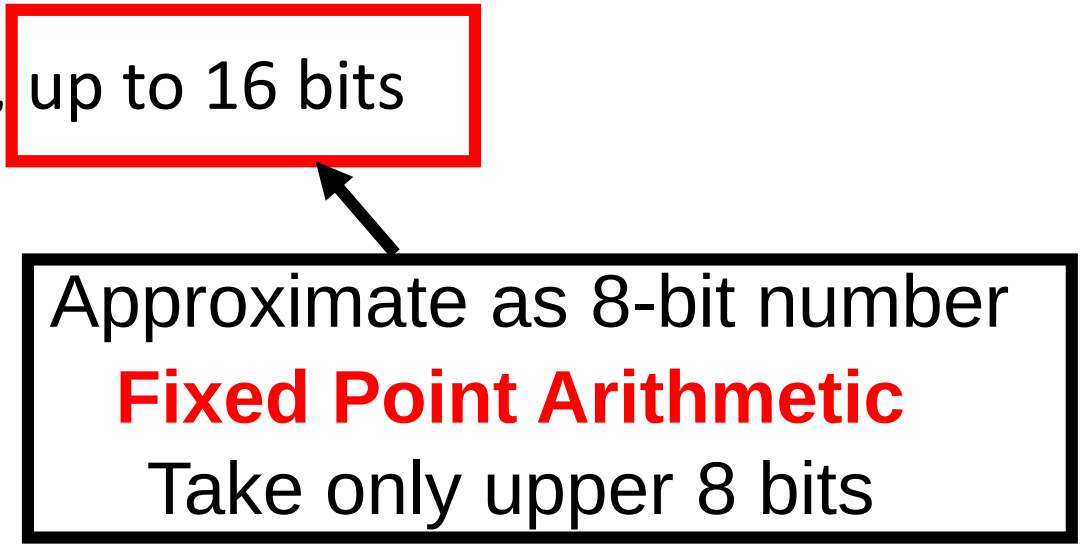
Multiplication of two 8-bit numbers

```
%% Take two hex numbers of 8 digits
a='5A';b='45';
%% Do multiplication of hex numbers, so result in hex format
c=mult_hex(a,b); % result = '1842’  ,  is 16 digits

function c=mult_hex(a,b)
a1=hex2dec(a);b1=hex2dec(b);
c=dec2hex(a1*b1);
end
```

Multiplication and Addition of 8-bit numbers

- Multiplication of two 8-bit numbers, up to 16 bits
- Addition of 8-bit numbers
- Overflow consideration



- Keep result up to 8 bits, by scaling input and output

Fixed Point Considerations

1. fir_fixed_point.pdf
2. fixed_point_read.pdf
3. fixed_point_intro.pdf

Steps

- FIR Filter design using MATLAB Filter Design tool → FIR filter coefficients
- Assembly coding in Microchip Studio with the coefficients
- Circuit Connections in SimulIDE
- Load assembly HEX file in SimulIDE and Simulate

Schematic in SimullDE