EE2016 – MidSem – Part-c

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EE19B054
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Report

1. Theory of FIR, Convolutions, DTFT, etc.

* FIR (Finite Impulse Response) Filter is a filter whose impulse Response is of finite duration, because it settles to zero in finite time.
* They can be discrete-time or continuous-time & digital or analog.
* For a Causal Discrete-time FIR filter of order N, each value of the output sequence is a weighted sum of the most recent input values.

$$y[n] = \sum_{i=0}^{N} b_i \cdot x[n-i]$$

* The above computation is also known as discrete Convolution.

$$(f * g)[n] = \sum_{m=-\infty}^{\infty} f[m]\,g[n-m] \quad \text{(for infinite)} \qquad \text{(or)} = \sum_{m=-M}^{M} f(n-m)\,g(m) \quad \text{(for finite)}$$

* DTFT: Discrete-Time Fourier Transform: The term discrete-time refers to the fact that the transform operates on discrete data, often samples whose interval has units of time.

$$X_{2\pi}(\omega) = \sum_{n=-\infty}^{\infty} x[n]\, e^{-i\omega n}$$

* The Fast Fourier Transform (FFT) is an algorithm for computing one cycle of the DFT, & its inverse produces one cycle of the inverse DFT.

2. Fixed Point Arithmetic:

To compute the FIR filter in Atmega8 microprocesor, we need to convert the floating point decimals to Fixed point. The Coefficients, inputs must be converted to Fixed point format. From the Hardware multiplier reading material, this can be understood. In our case of 8-bits for each coefficient & input, the first(MSB)bit acts as the sign bit & the rest 7 bits acts as the Fixed point approximation of the decimal number. Hence only values between (-1, 1) can be fed into the system. So our data must necessarily be Normalized.

3. DTFT:

* While the signals in Time Domain may be approximate, the DTFT computed by FFT (Fast Fourier Transform) gives correct output w.r.t the signals in Frequency Domain.
* DTFT of a DC signal is ideally an unit impulse function at 0 Hz. We can see that it is the case in our signal also.
* DTFT of a sine signal is a jump in the signal at the operating frequency (≈ 1800 Hz). We get 2 such jumps for ~~for~~ both positive & negative value of frequency.
* DTFT of a Whitenoise is ideally Flat, but is not the case in Real life signals. The signal is within the limit of Power spectrum.

4. Implementation Details

(a) **Input**: The input is provided as Fixed Point Integers in .db format at the end of the Code. As the size of input is large, it is not stored in SRAM, but stays in the Program Flash Memory.

(b) **Output**: The output is of 2 Bytes each. It is written into the SRAM from the address 0X0060. The output must be copied separately and converted to Floating point numbers by dividing with 2^7.

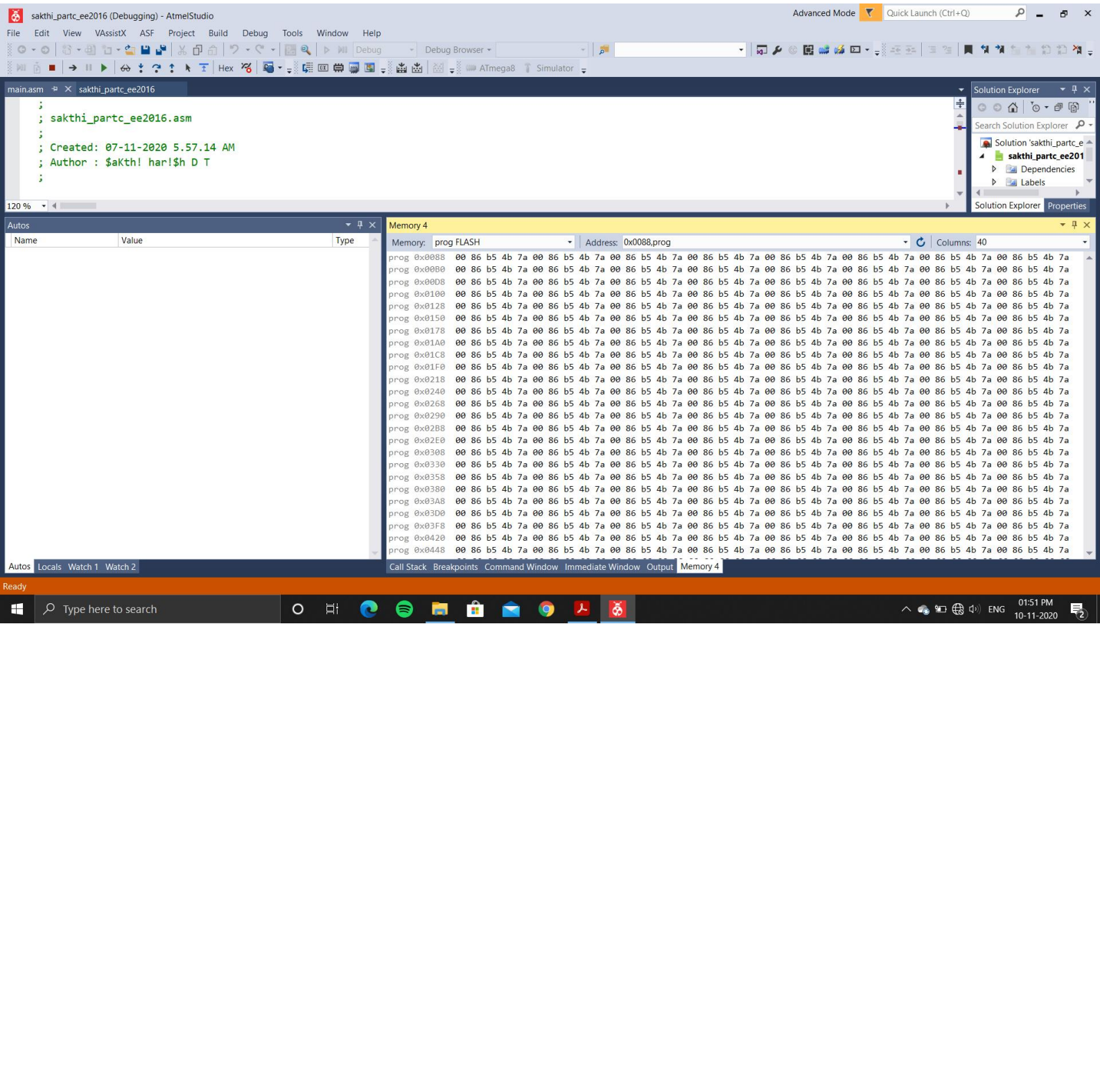
(c) **Coefficients**: The Coefficients are taken as input in .db format & stored in SRAM address starting from 0X043E

(d) **Multiplication Details**: For multiplication, the FMULS command is used to do Signed Multiplication on Fractions. R19 is the register which has the inputs & R18 has coefficients. Result is accumulated into R6 : R5 : R4 as 3 Bytes, but only R6 : R5 is written into SRAM (2 Bytes).

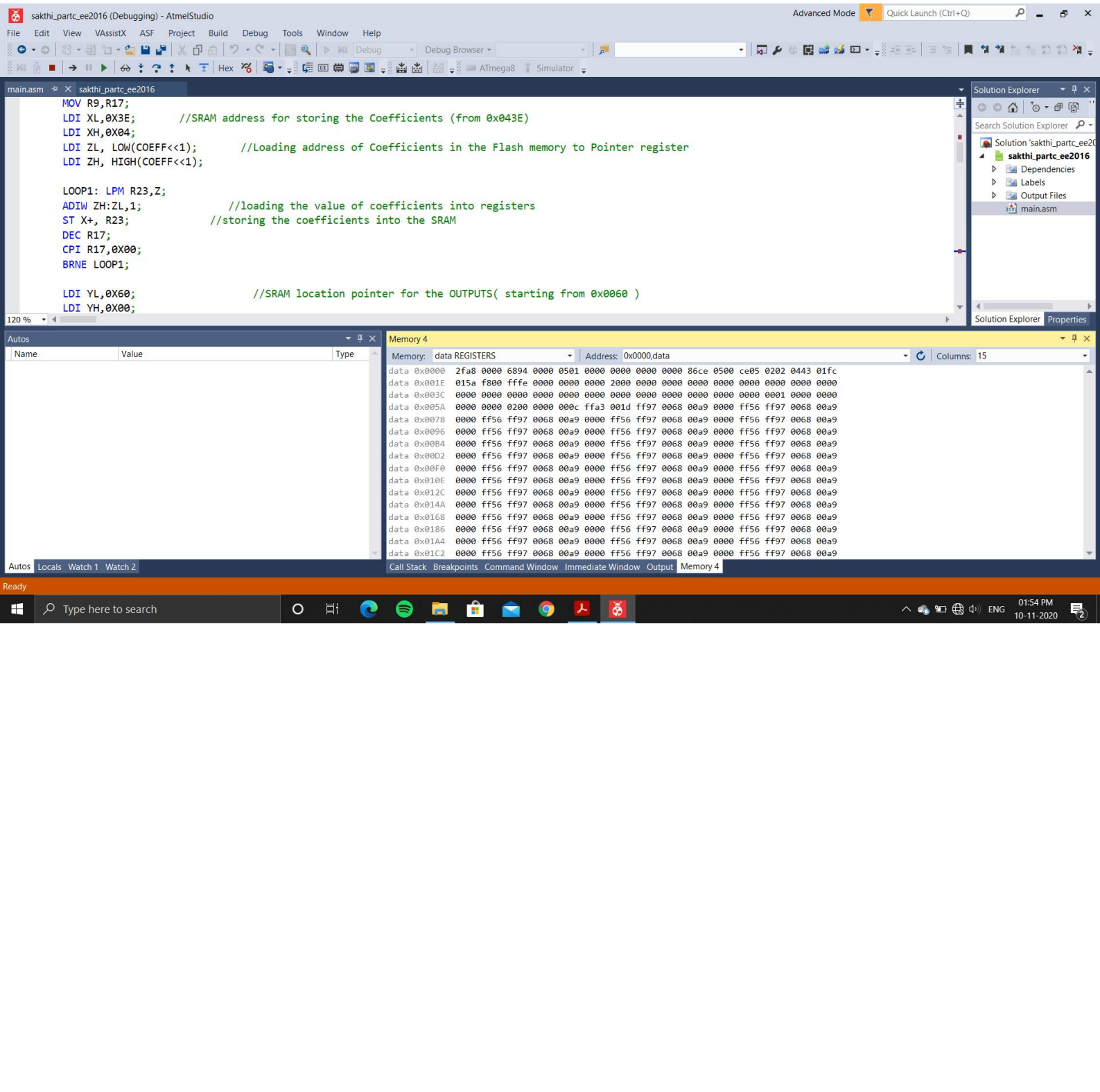
NOTE: As the input signals are Causal, the First 'N' outputs do not have 'N' product terms, hence output for periodic signals will be non-periodic in the beginning.

4) (e) Screenshots of Various Memory locations:

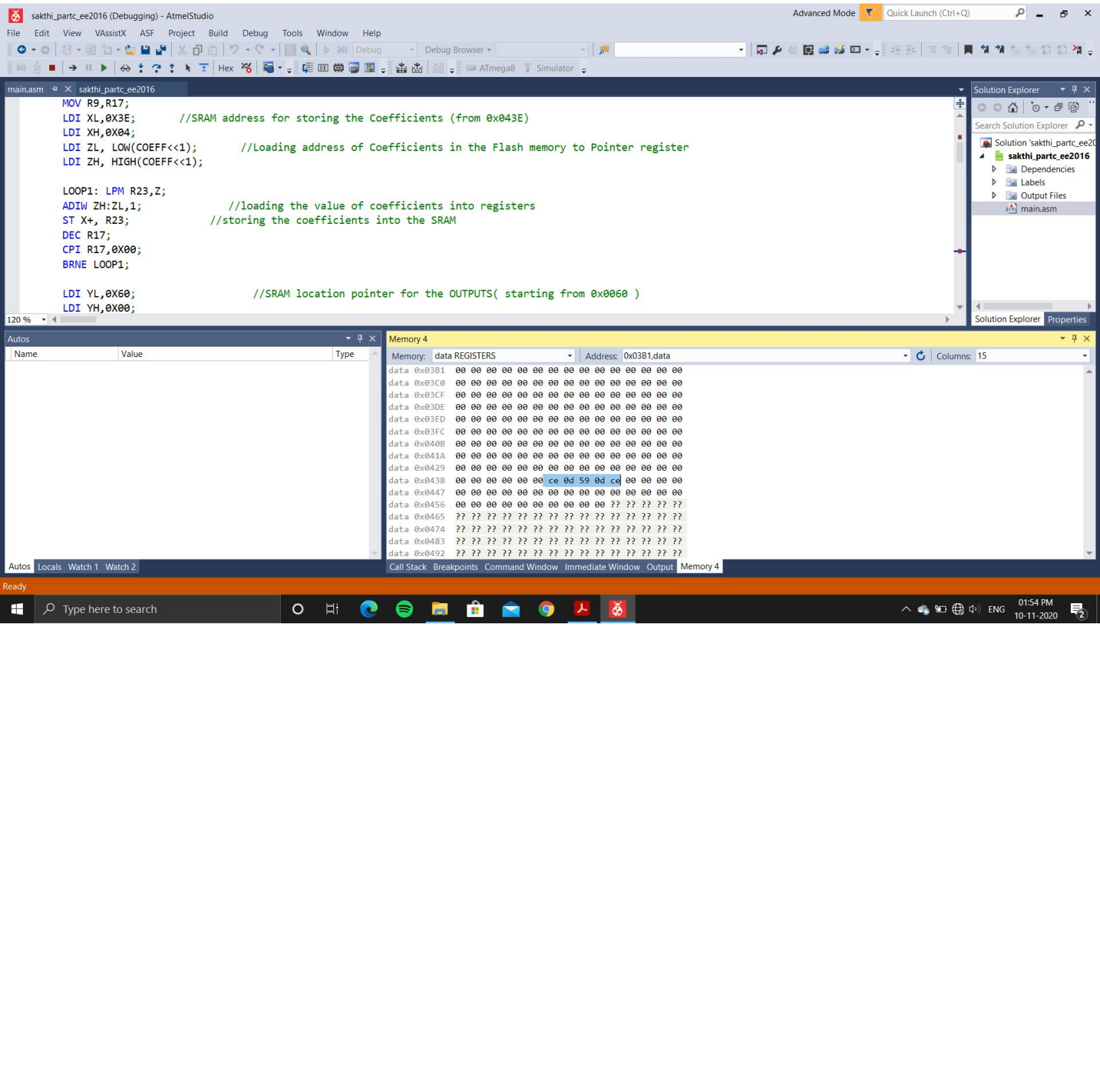
INPUTS Stored in Flash Memory



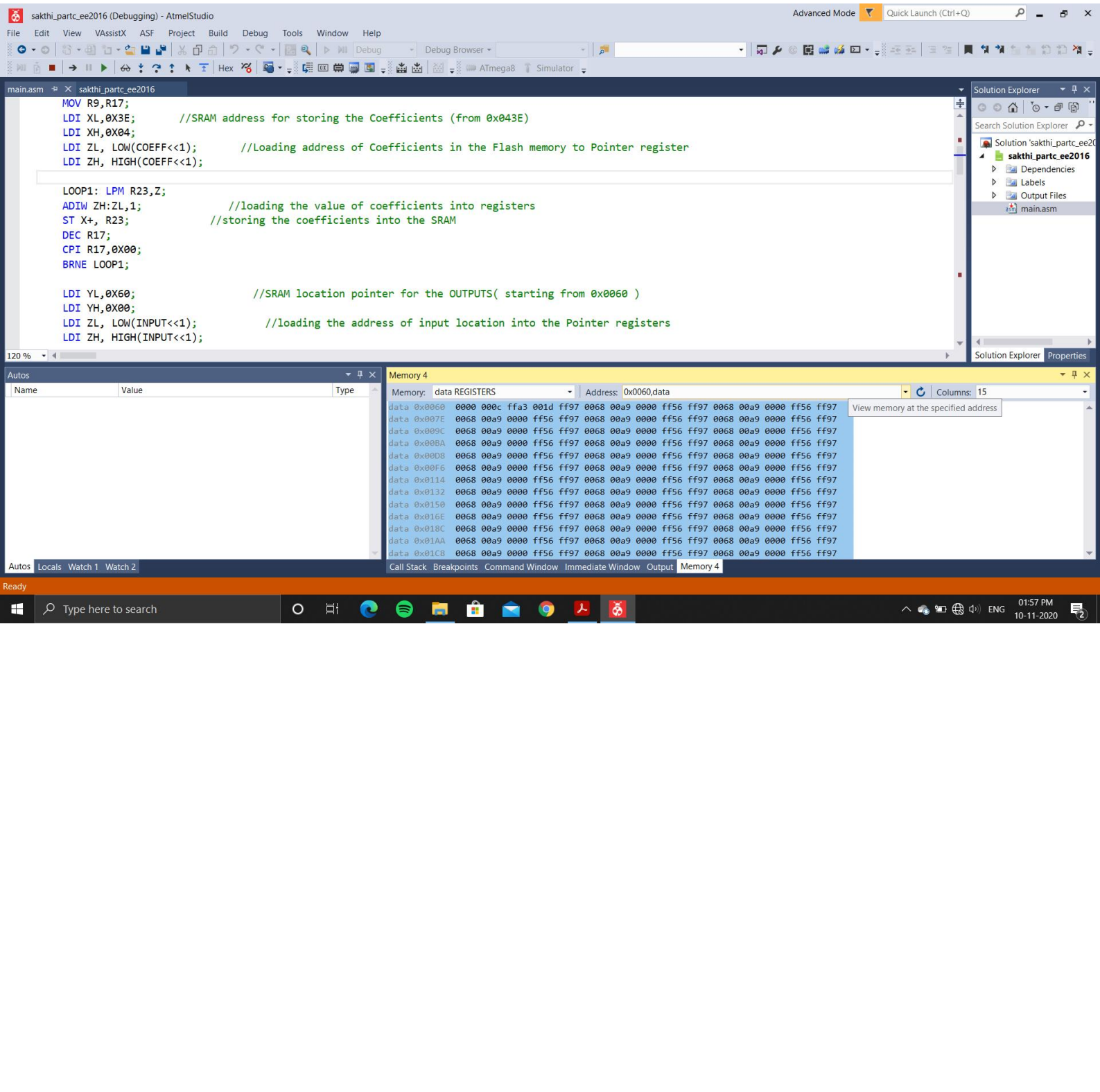
Data Registers



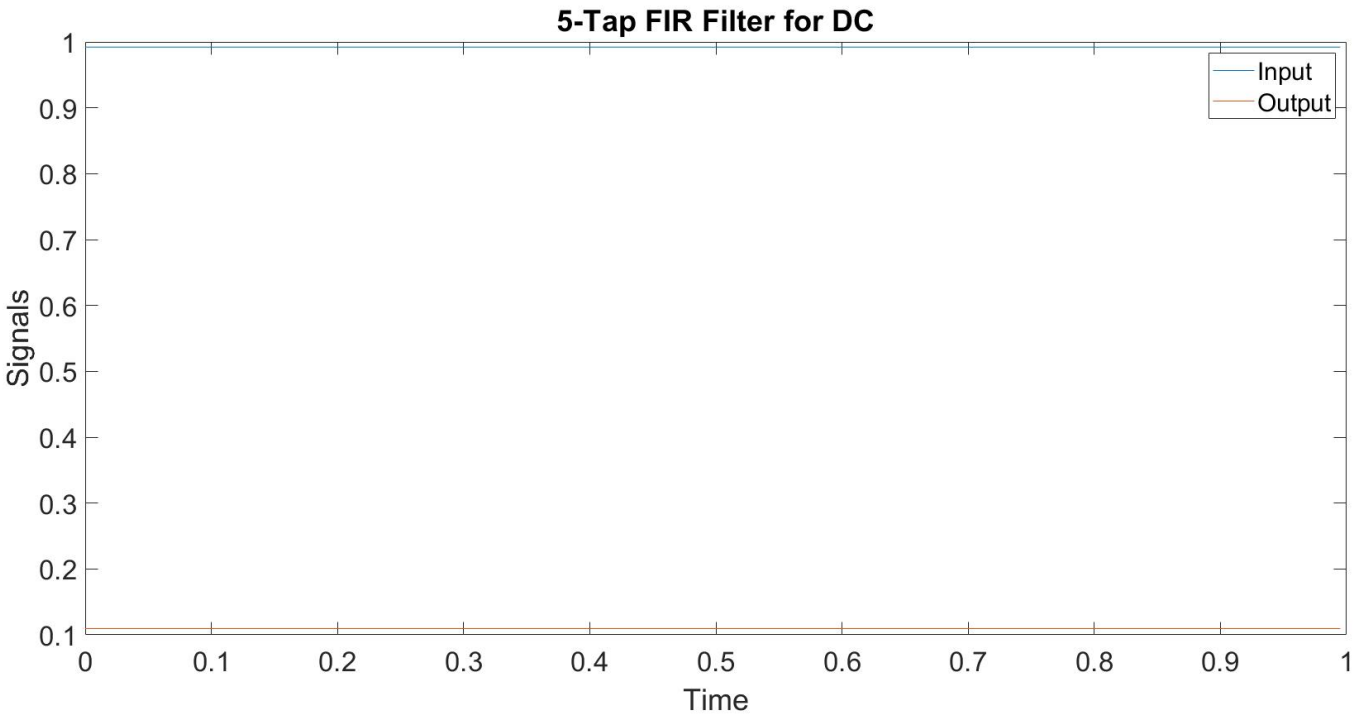
Coefficients Stored in SRAM(5-tap for example)

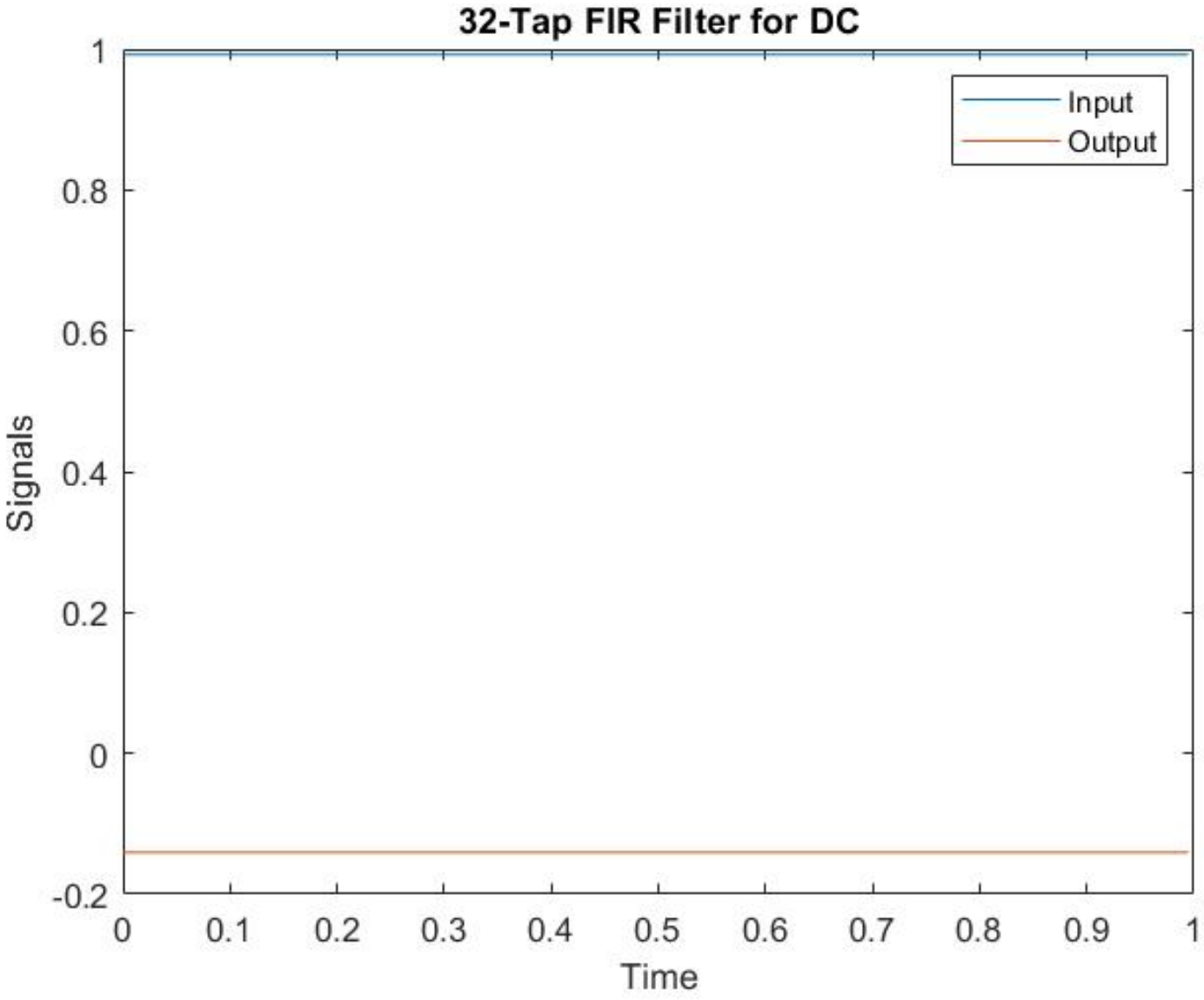


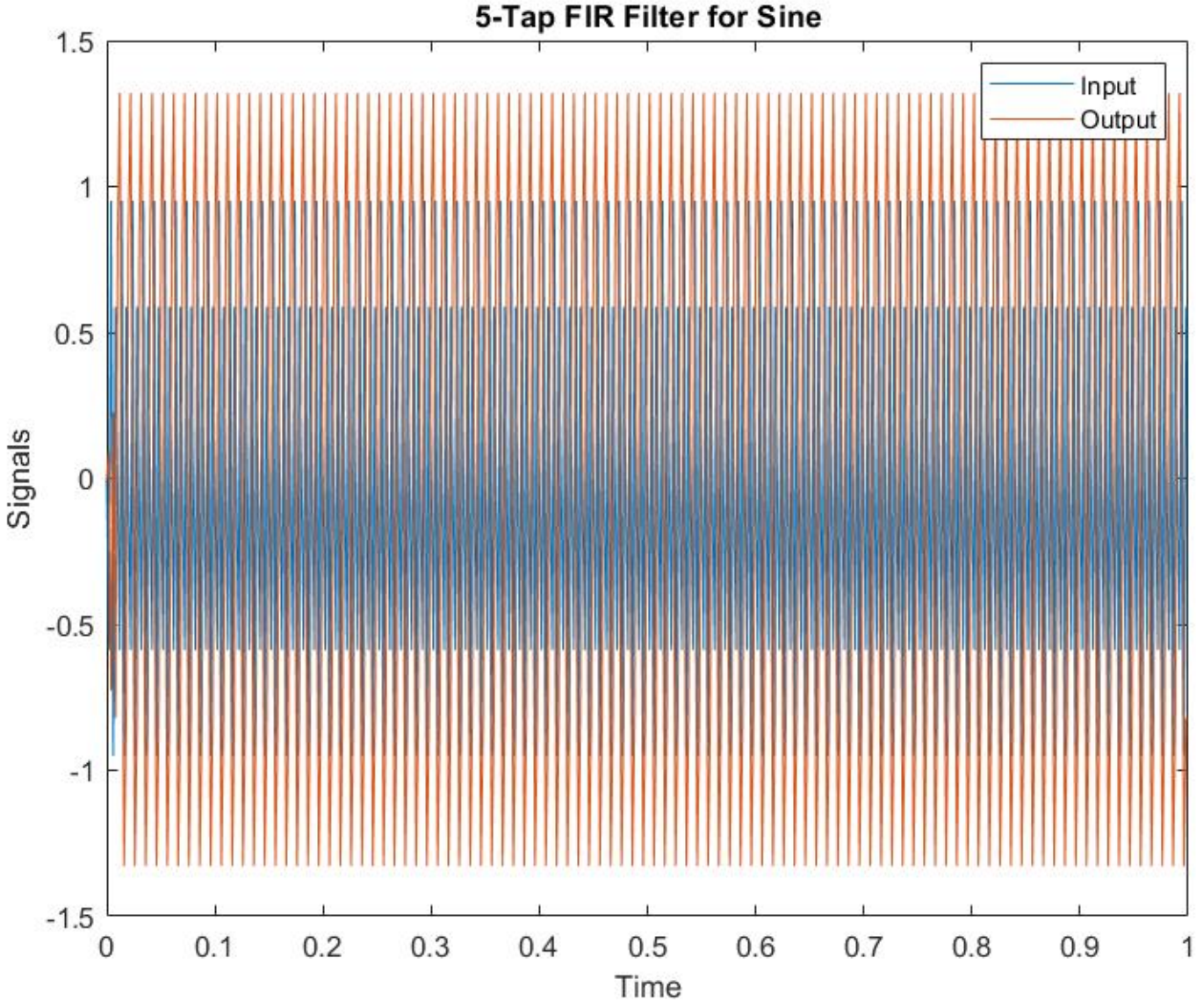
Outputs stored in SRAM

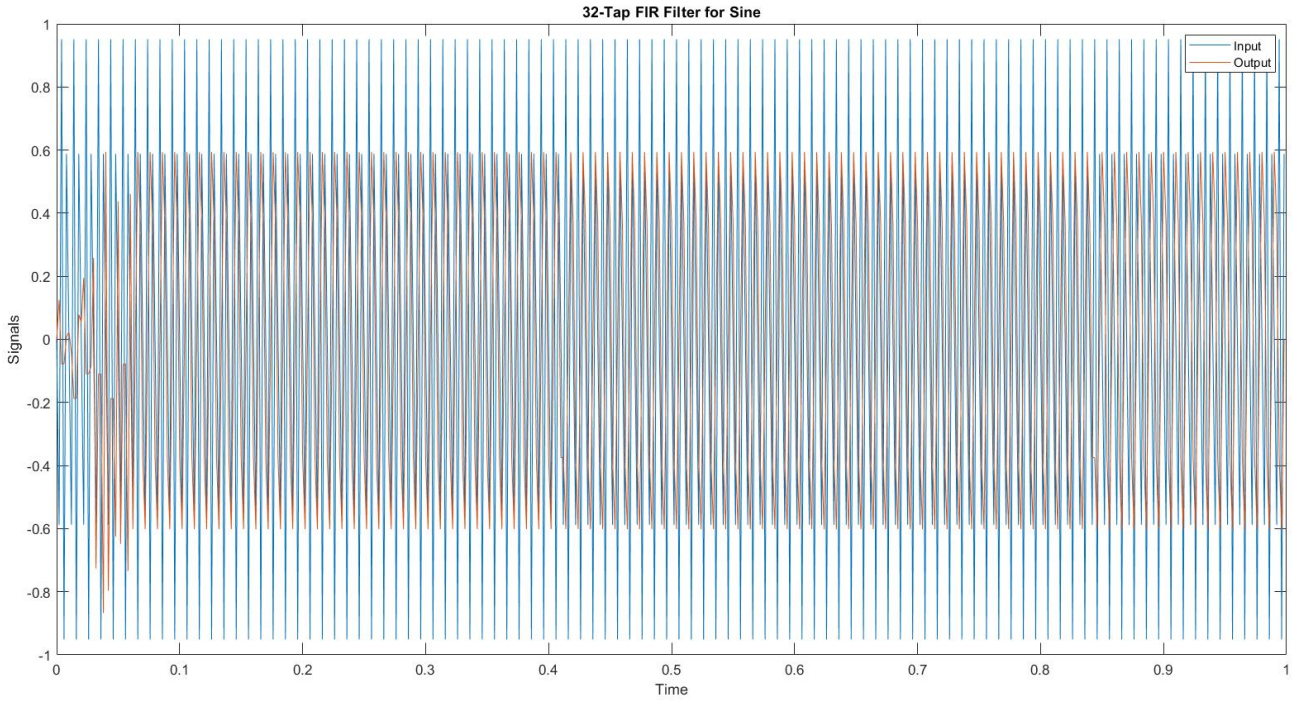


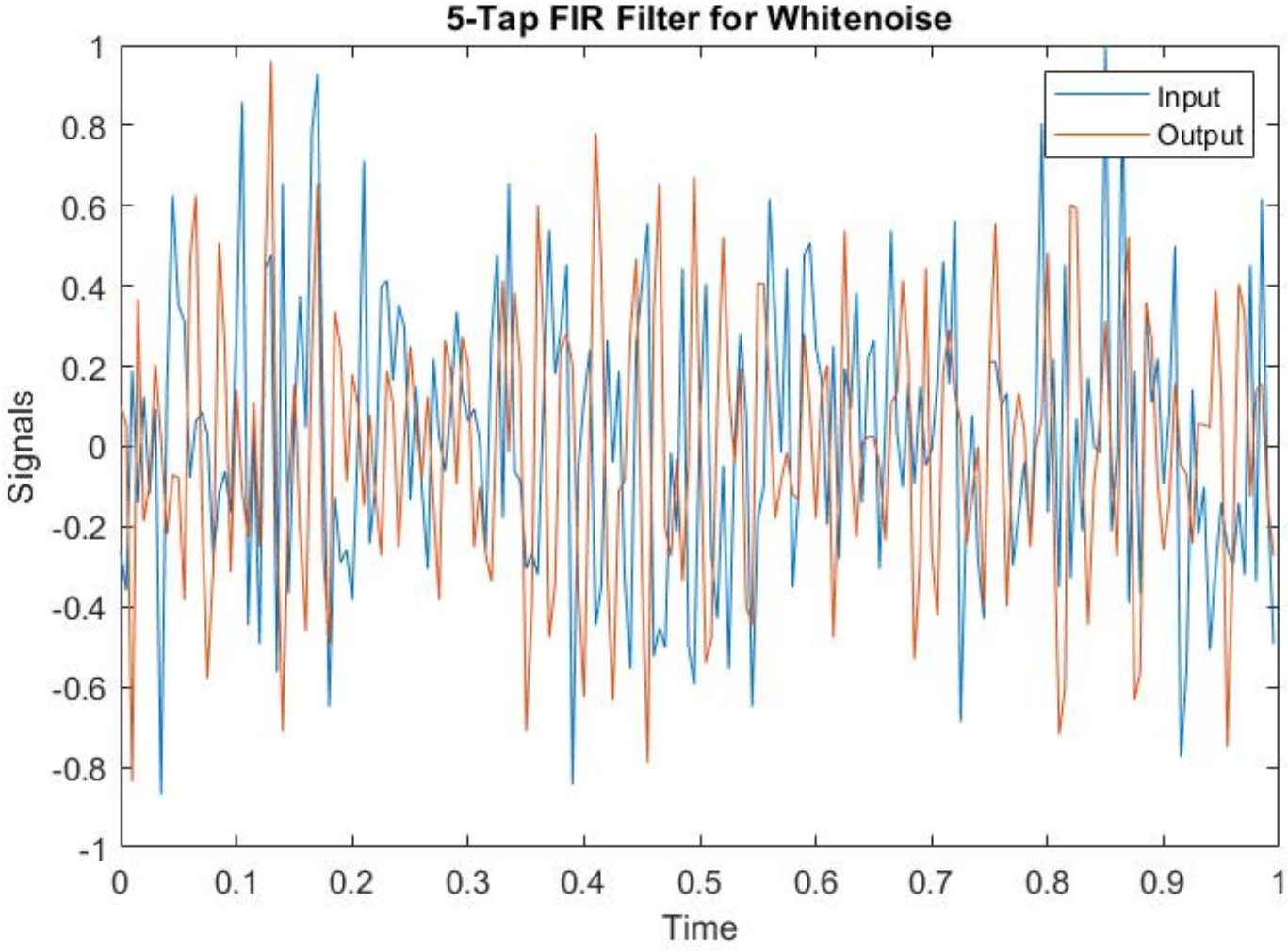
5) RESULTS:

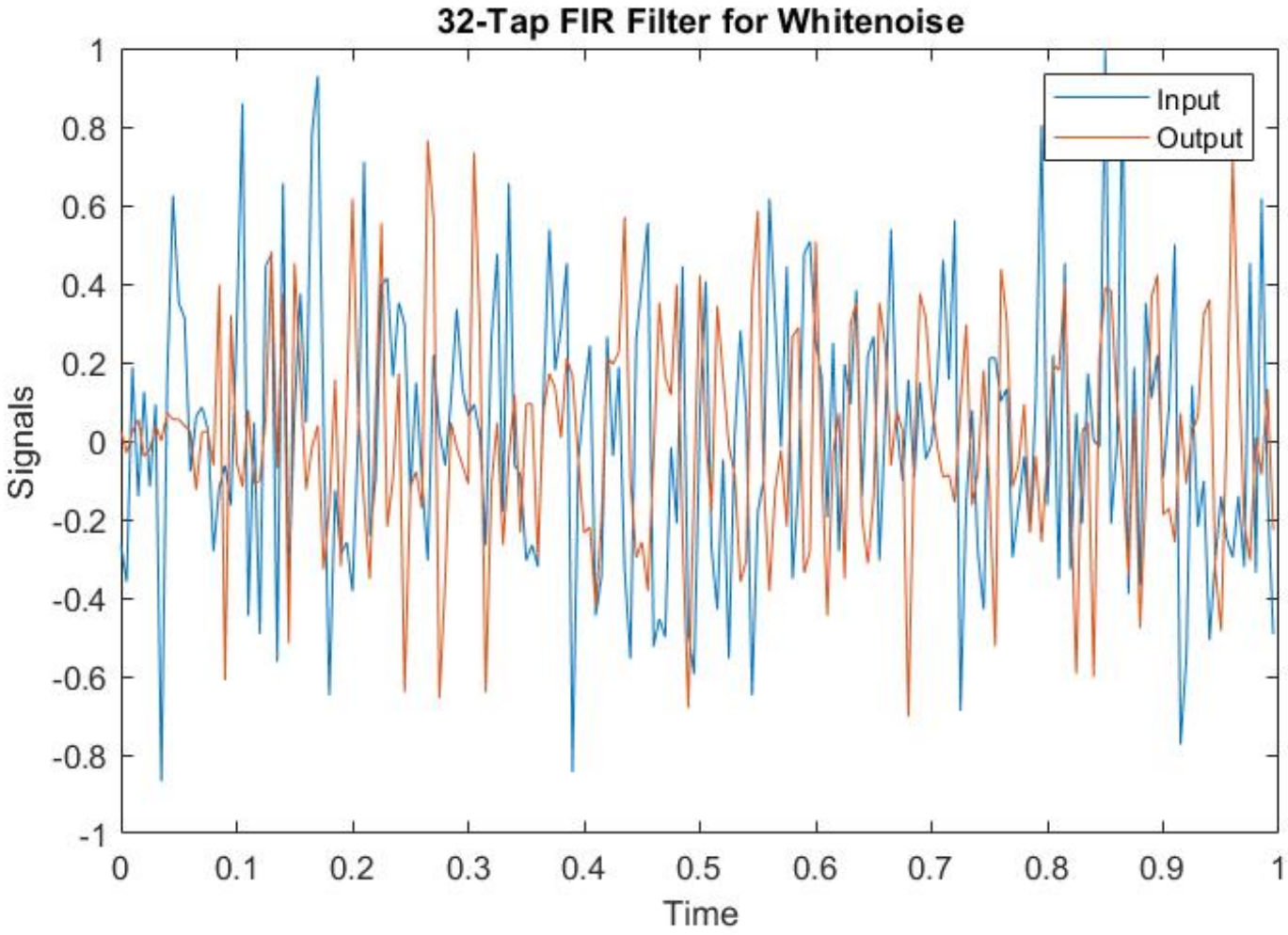

5-Tap FIR Filter for DC
Input
Output
Signals
Time
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

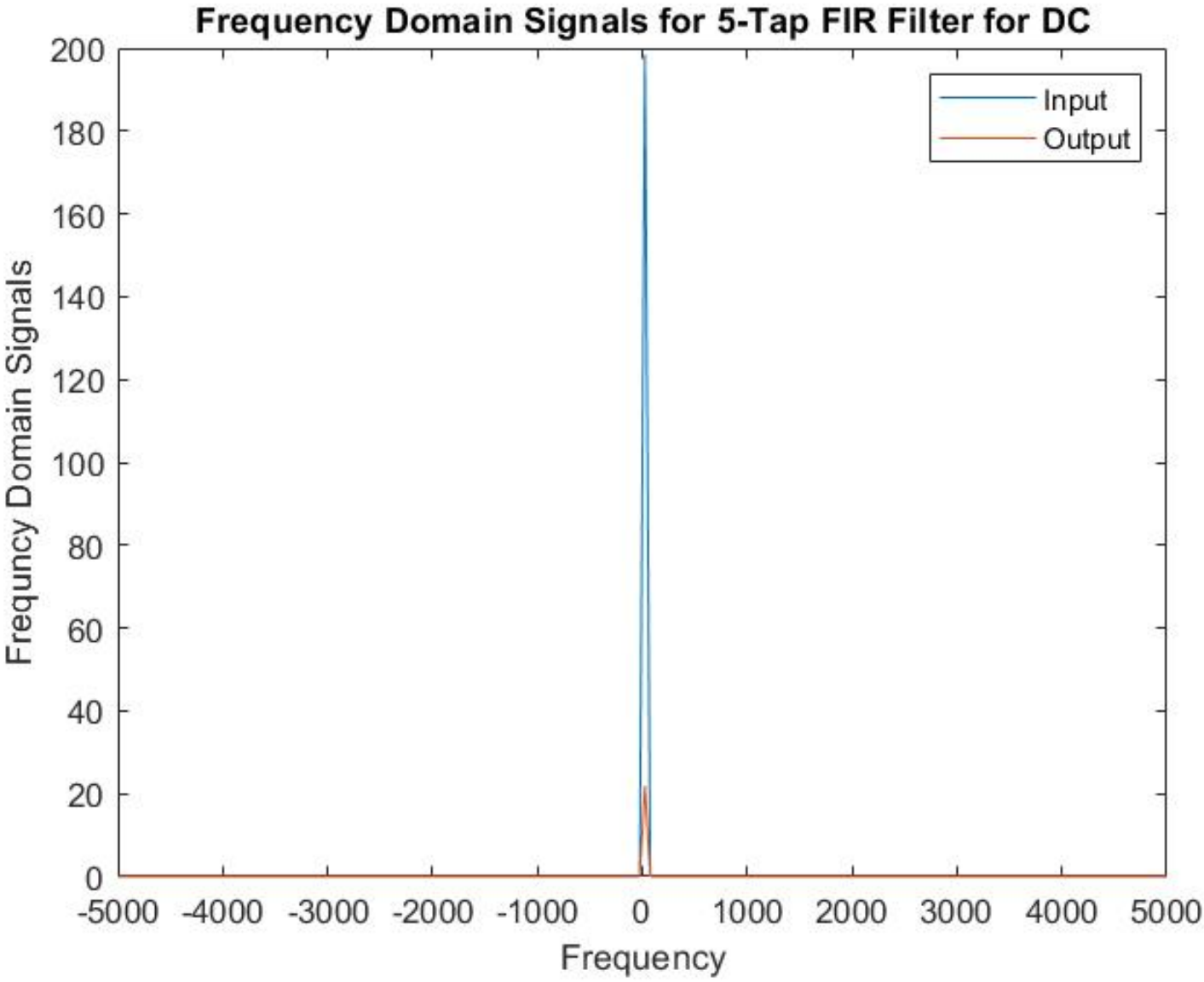

32-Tap FIR Filter for DC
Input
Output
Signals
Time
1
0.8
0.6
0.4
0.2
0
-0.2
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

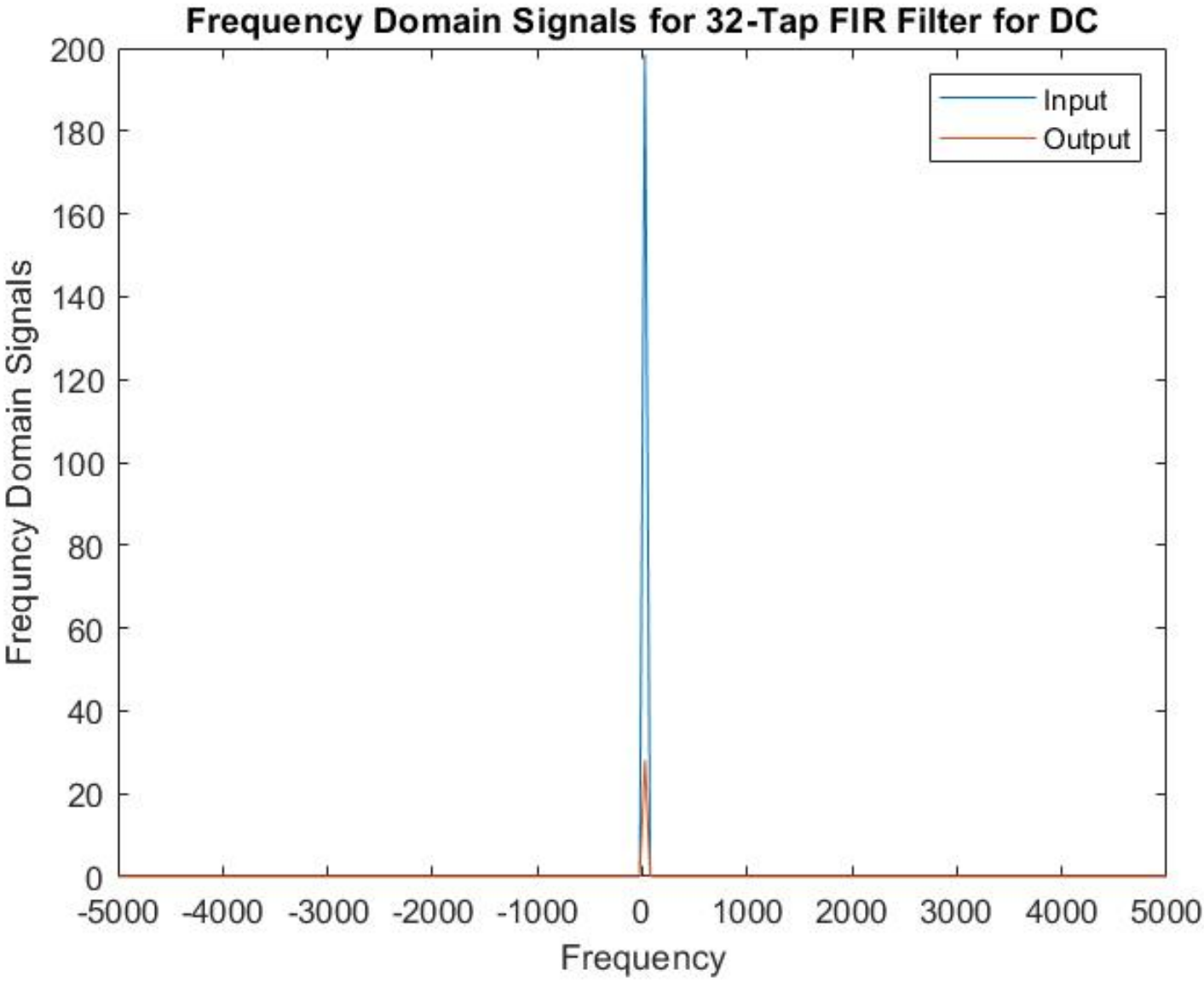

5-Tap FIR Filter for Sine
Input
Output
Signals
Time
1.5
1
0.5
0
-0.5
-1
-1.5
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

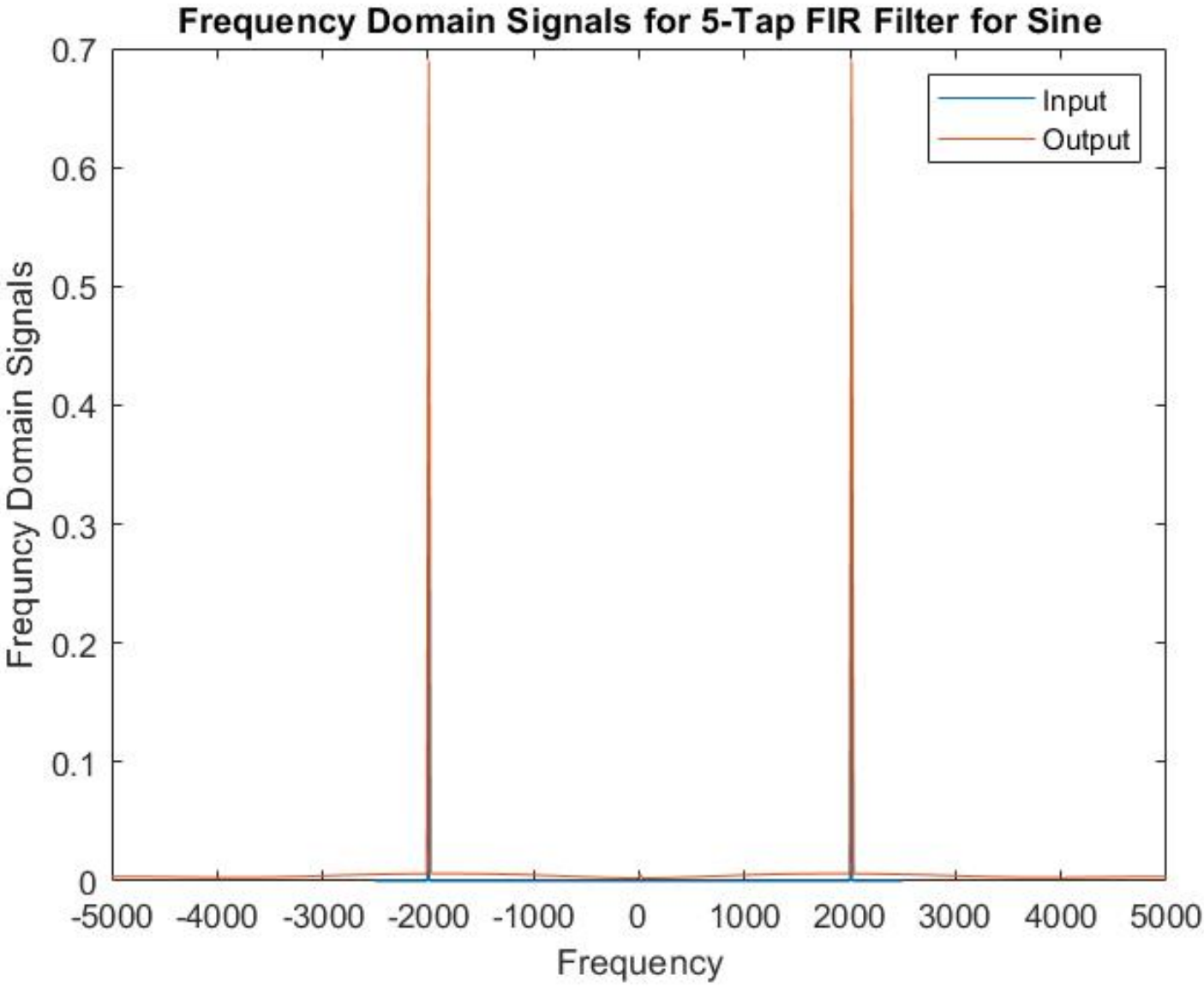

32-Tap FIR Filter for Sine
Input
Output
Signals
Time
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

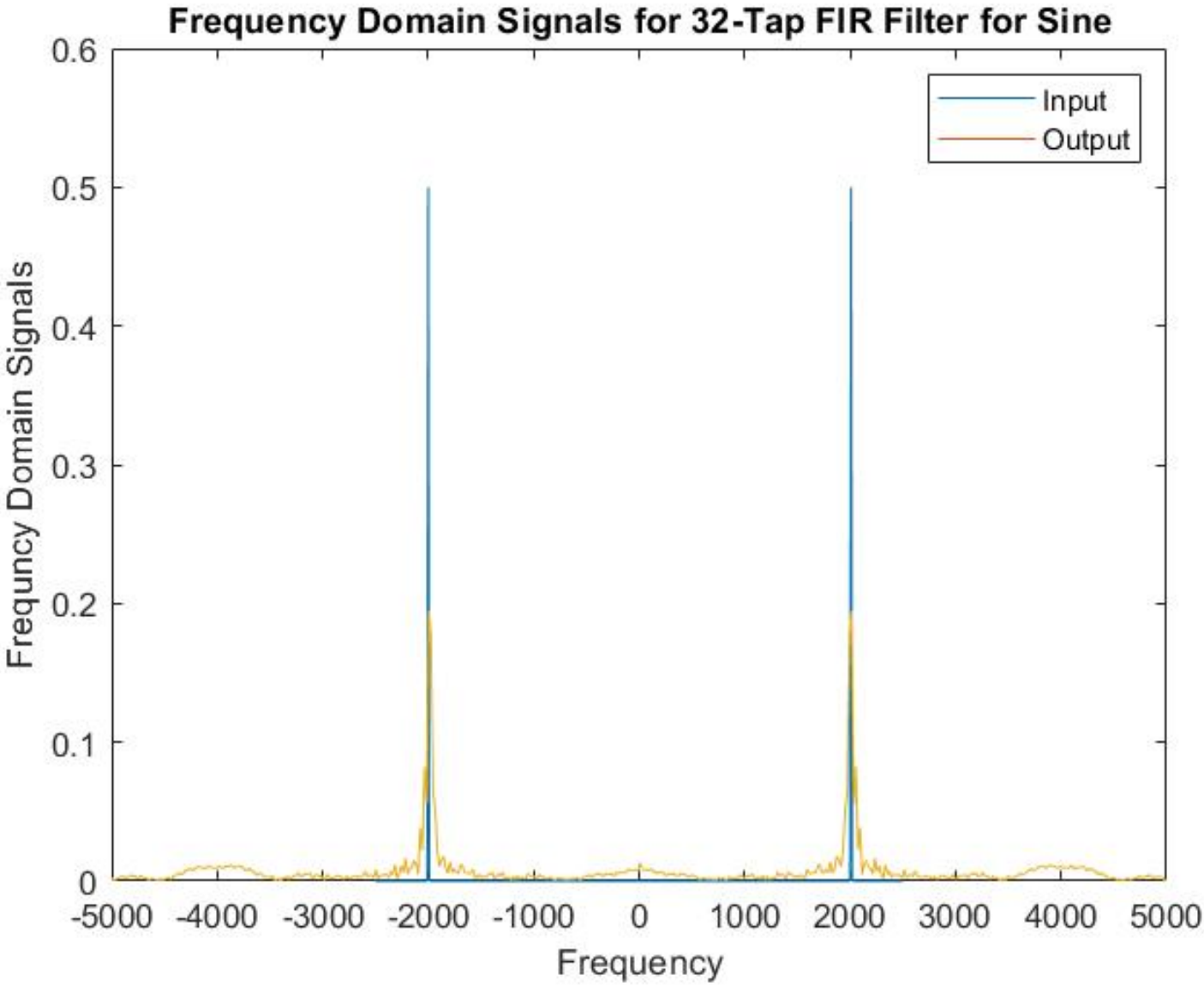

5-Tap FIR Filter for Whitenoise
Input
Output
Signals
Time
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

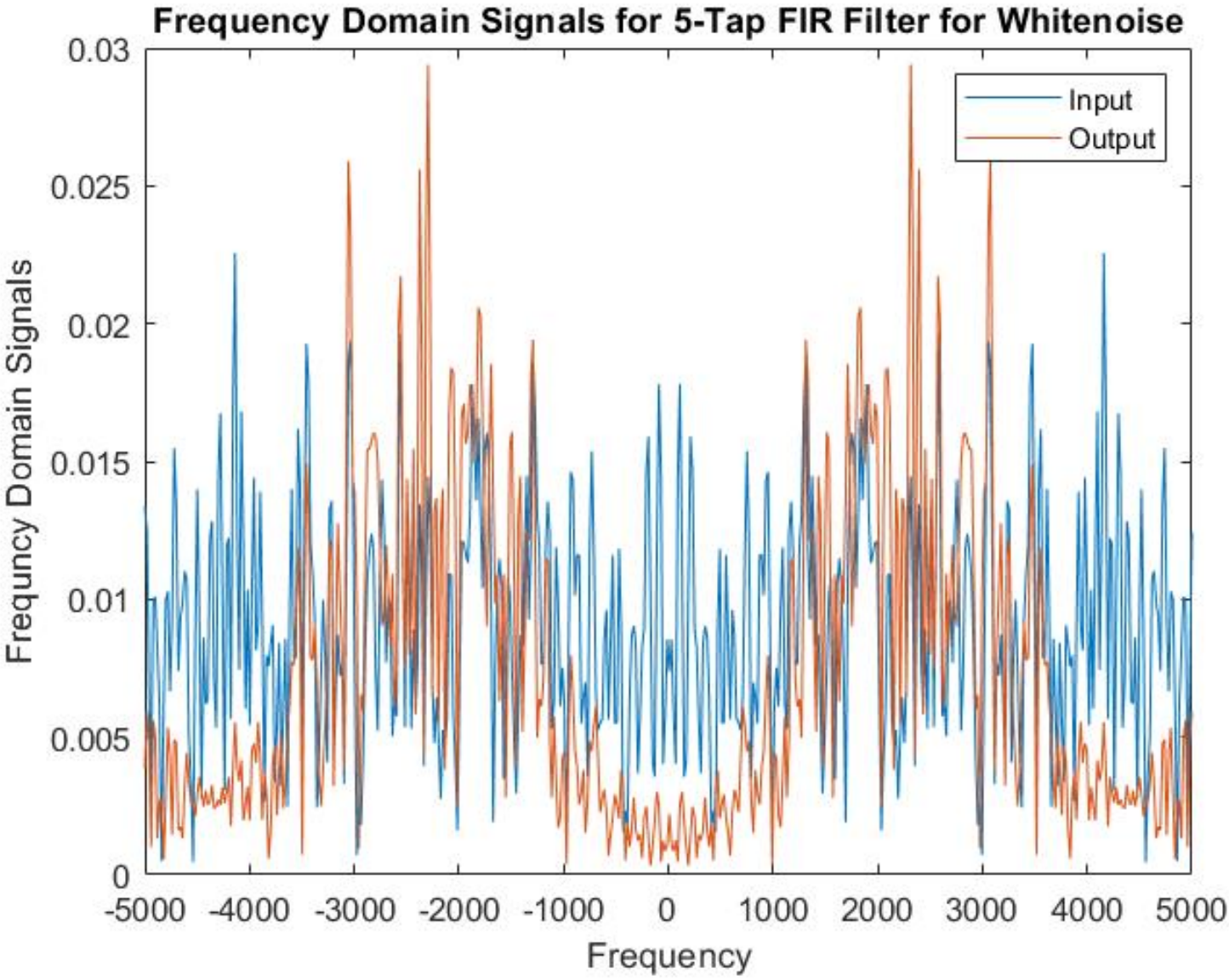

32-Tap FIR Filter for Whitenoise
Input
Output
Signals
Time
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

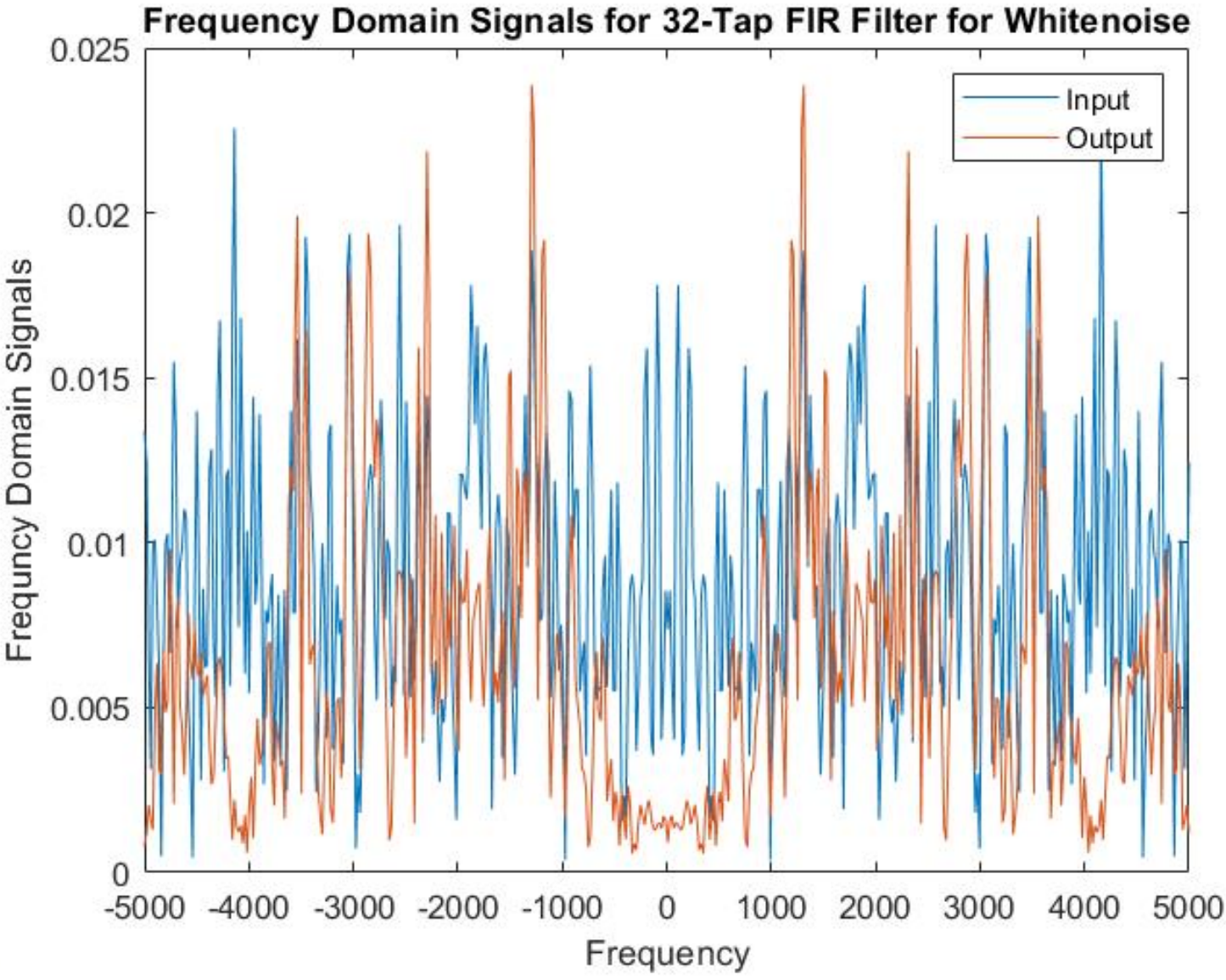

Frequency Domain Signals for 5-Tap FIR Filter for DC
Input
Output
Frequncy Domain Signals
Frequency
200
180
160
140
120
100
80
60
40
20
0
-5000
-4000
-3000
-2000
-1000
0
1000
2000
3000
4000
5000


Frequency Domain Signals for 32-Tap FIR Filter for DC
Input
Output
Frequncy Domain Signals
Frequency
200
180
160
140
120
100
80
60
40
20
0
-5000
-4000
-3000
-2000
-1000
0
1000
2000
3000
4000
5000


Frequency Domain Signals for 5-Tap FIR Filter for Sine
Input
Output
Frequncy Domain Signals
Frequency
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-5000
-4000
-3000
-2000
-1000
0
1000
2000
3000
4000
5000


Frequency Domain Signals for 32-Tap FIR Filter for Sine
Input
Output
Frequncy Domain Signals
Frequency
0.6
0.5
0.4
0.3
0.2
0.1
0
-5000
-4000
-3000
-2000
-1000
0
1000
2000
3000
4000
5000


Frequency Domain Signals for 5-Tap FIR Filter for Whitenoise
Input
Output
Frequncy Domain Signals
Frequency
0.03
0.025
0.02
0.015
0.01
0.005
0
-5000
-4000
-3000
-2000
-1000
0
1000
2000
3000
4000
5000


Frequency Domain Signals for 32-Tap FIR Filter for Whitenoise
Input
Output
Frequncy Domain Signals
0.025
0.02
0.015
0.01
0.005
0
-5000
-4000
-3000
-2000
-1000
0
1000
2000
3000
4000
5000
Frequency