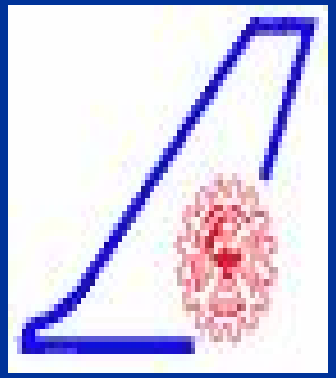
Detection and Analysis Of Burst Signal from Laser Doppler Velocimeter Using LAB VIEW

PROJECT WORK CARRIED AT



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EXTERNAL GUIDE

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- **What is LDV ?**

  Device used to measure Velocity

  Doppler shift is utilized

  Uses Laser for measuring Doppler frequency

It is used in Experimental Aero Dynamics

- **Principle**

  The frequency shift induced by Doppler effect is proportional to the velocity.

$$V = (\Delta f * 2 / (\lambda \sin \beta$$

Why LDV ?

No calibration required

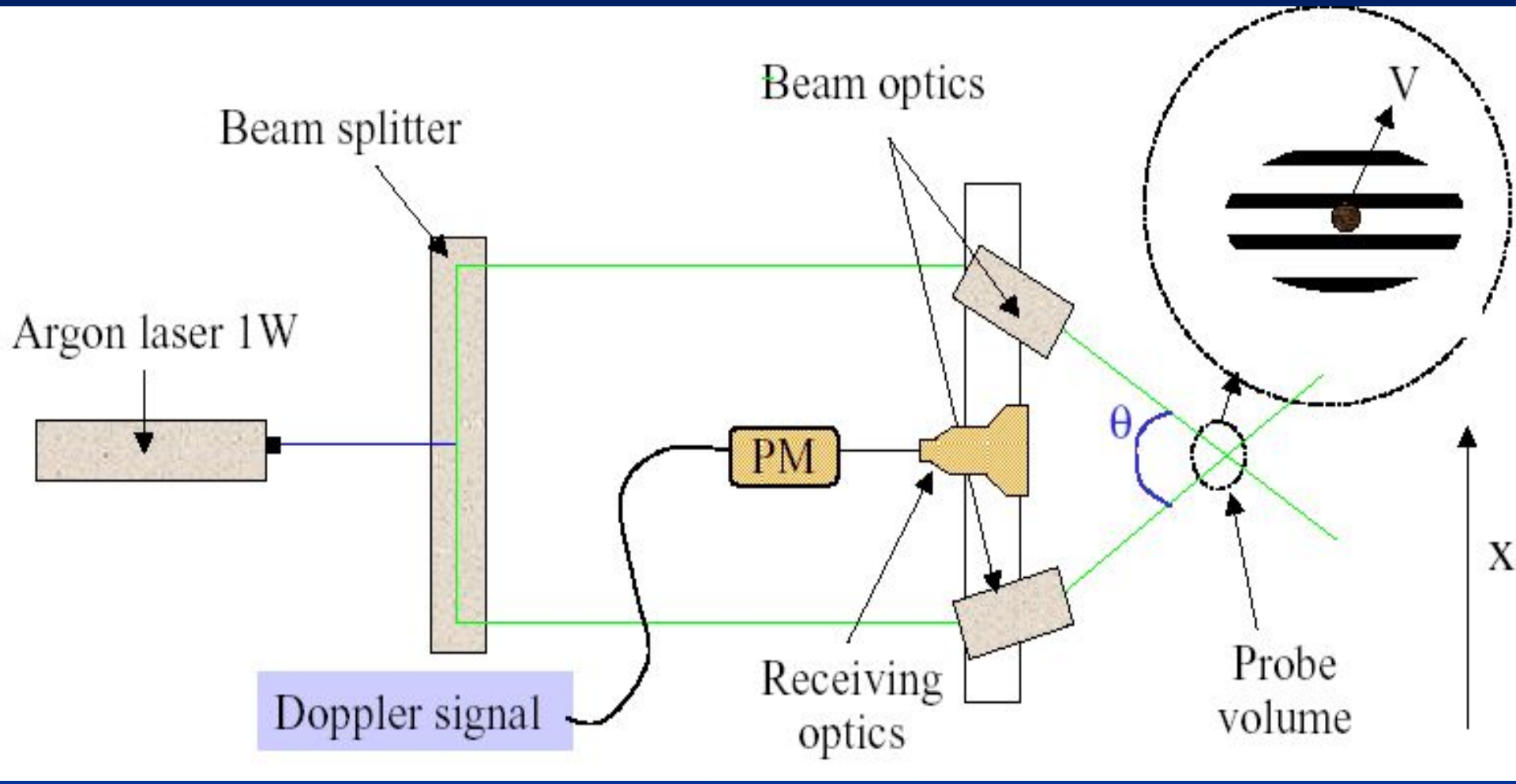
No probe in the flow

Senses velocity independent of temperature, density and composition.

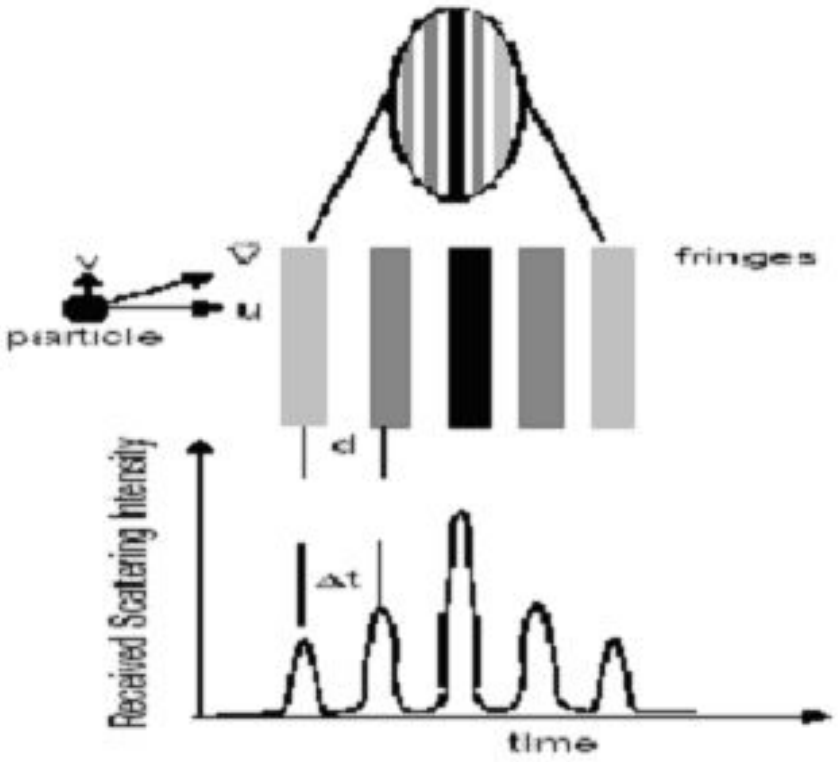
Not affected by turbulence

It is a Non-invasive technique

BLOCK DIAGRAM

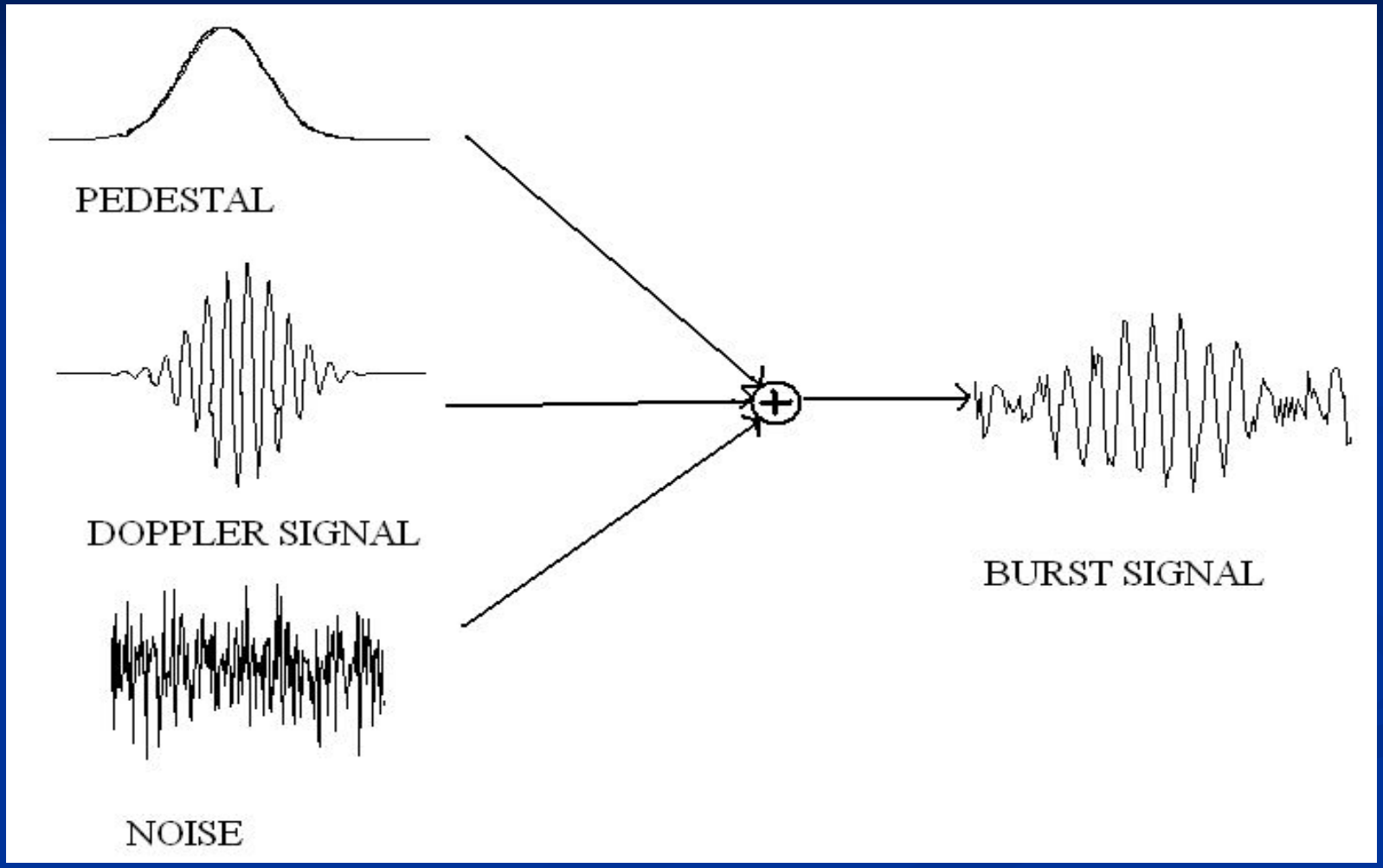


FRINGE PATTERN



Doppler Signal

NATURE OF SIGNAL FROM LDV



PROPERTIES

- **Random in Arrival**
- **Constant frequency**
- **Influenced by particle density and size**
- **Fewer number of cycles (< 30)**
- **Consists of electrical and external noises.**

TASK AHEAD

- Develop a way to detect and process the burst signal.
- Find the velocity through frequency.

Methods of Signal Processing

Demerits

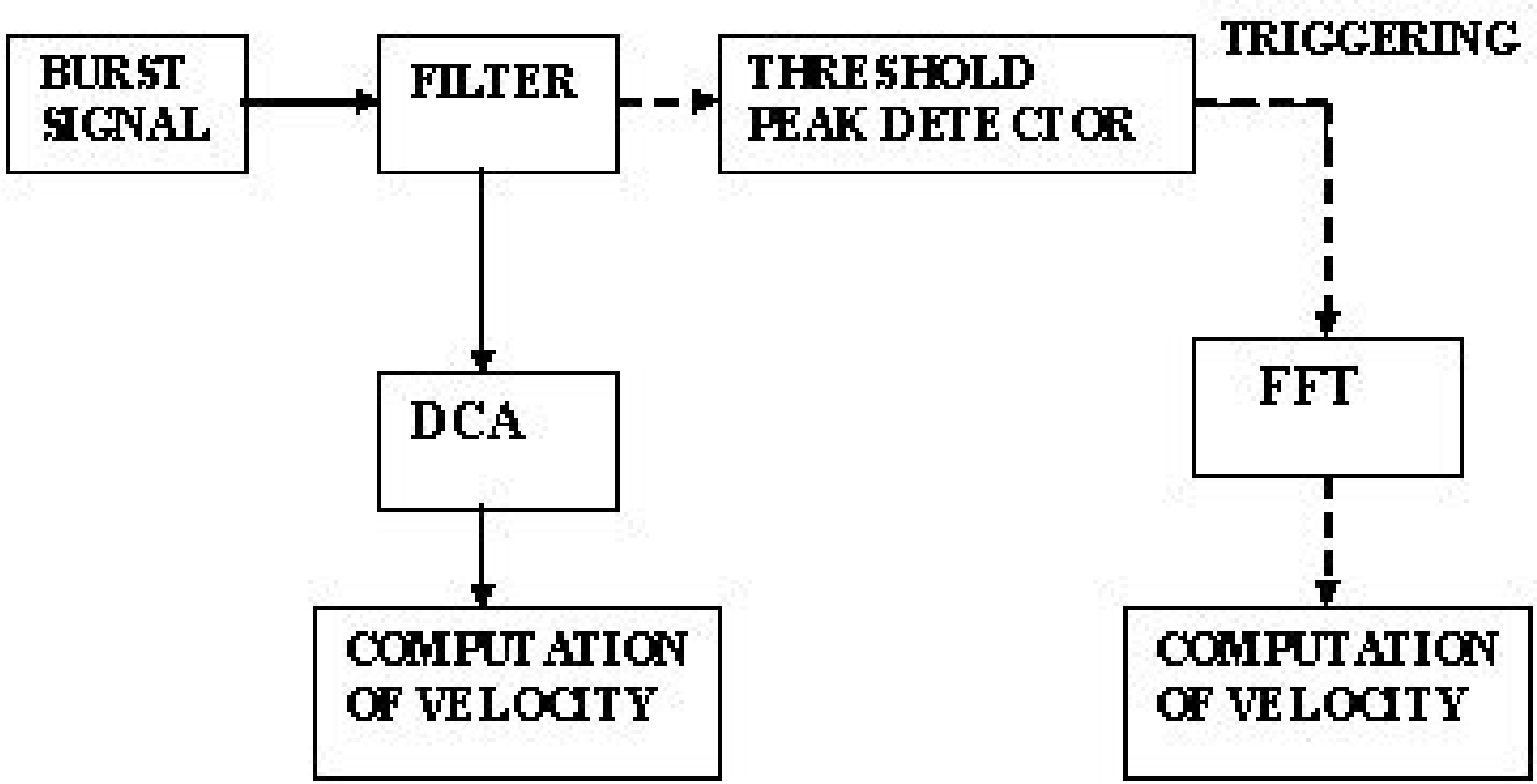
- Spectrum analyzer -- Poor Real time analysis
- Frequency Tracker -- Needs high rate of seeding.
- Periodic Counter -- Needs sophisticated logic to reject noise.
- Transient Recorders -- Low Data Rate.

BEST SUITED METHOD

- **Frequency Domain Real Time Processing.**

  FFT and DCA

SIGNAL PROCESSING BLOCK DIAGRAM



OBJECTIVES

- Noise Elimination.
- Burst Detection (using Peak Ratios).
- Computation of Frequency & Velocity.

PARAMETERS TO BE CONSIDERED

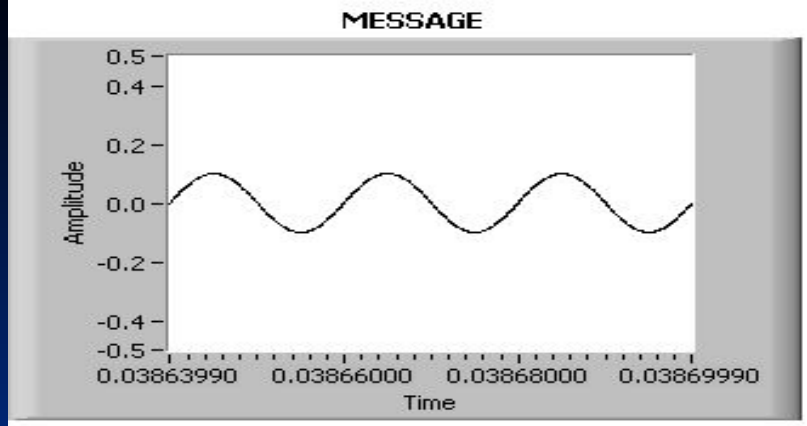
- SNR , Sampling Information.
- Filter parameters.
- Threshold Voltage level.

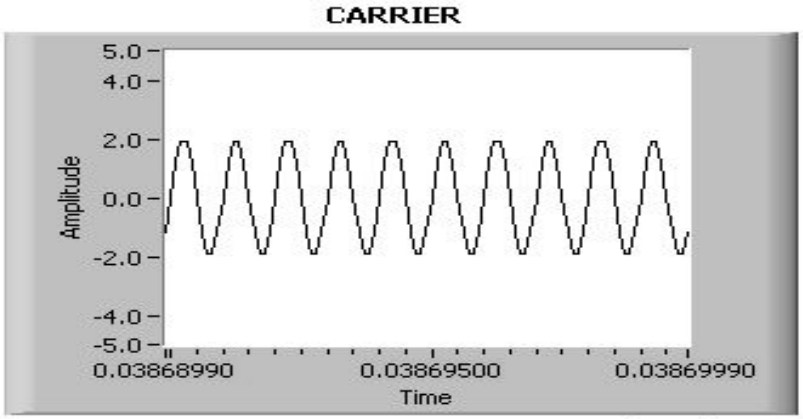
IMPLEMENTATION

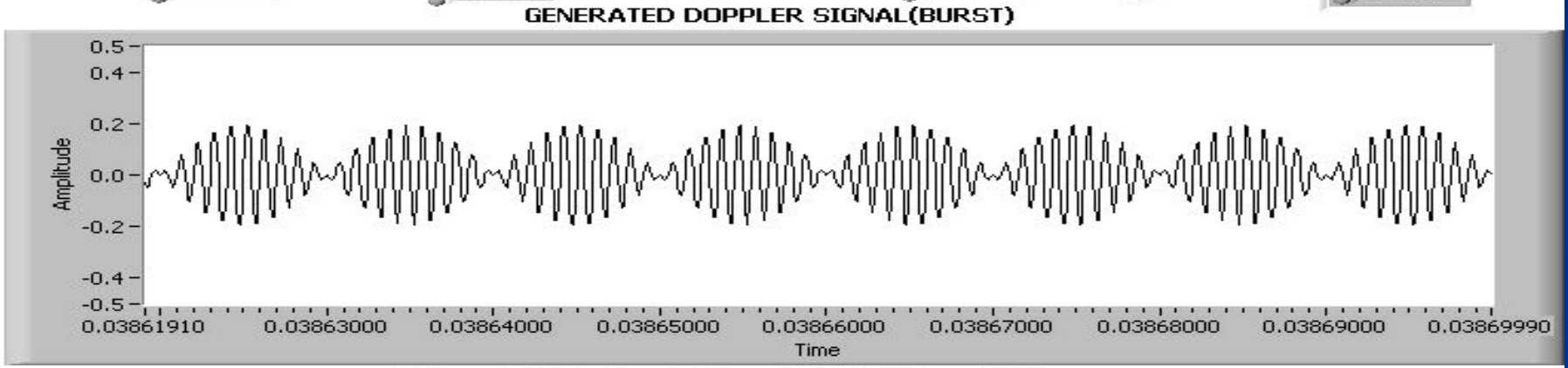
- GENERATION OF BURST SIGNAL FROM LDV
- BURST DETECTION AND VALIDATION
- COMPUTATION OF FREQUENCY THROUGH FFT
- COMPUTATION OF FREQUENCY THROUGH DCA
- COMPUTATION OF VELOCITY THROUGH FREQUENCY

METHODS OF GENERATION

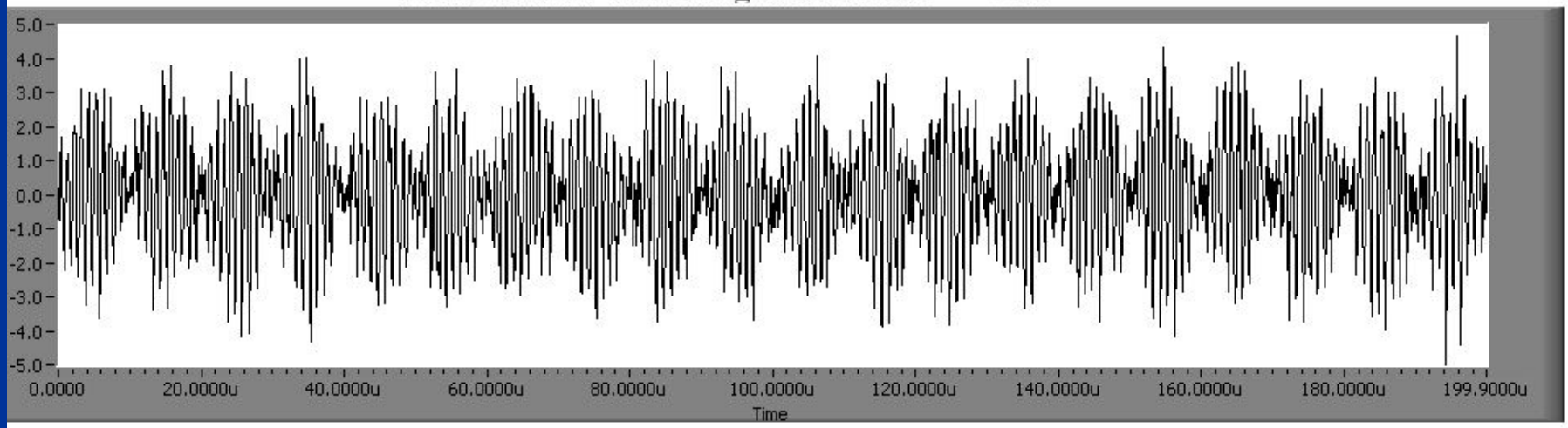
- Simulation of Burst Signals
- Generation of Burst Signal by Reading Samples from a file
- Direct Real Time Acquisition







Noise Added Burst Signal for SNR = - 5 dB



PEAK DETECTION

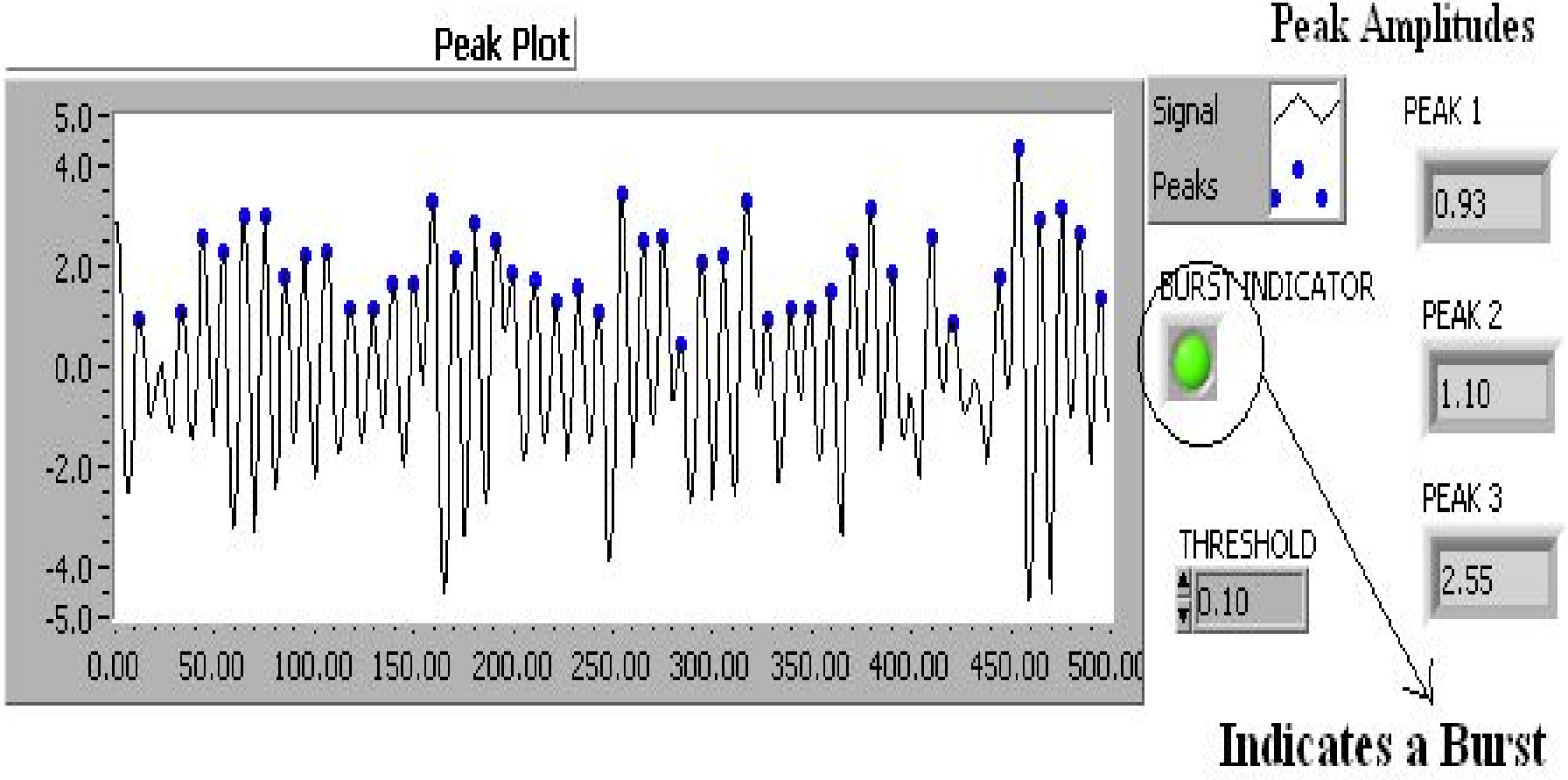
- **Objectives**

1. **To identify the valid burst that can be processed**
2. **Faster, Rugged validation (within first few cycles)**

- **Algorithm**

1. **Digitize and compare with the threshold.**
2. **Compare the successive peak amplitudes**
3. **Trigger the FFT block.**

PEAK DETECTOR OUTPUT



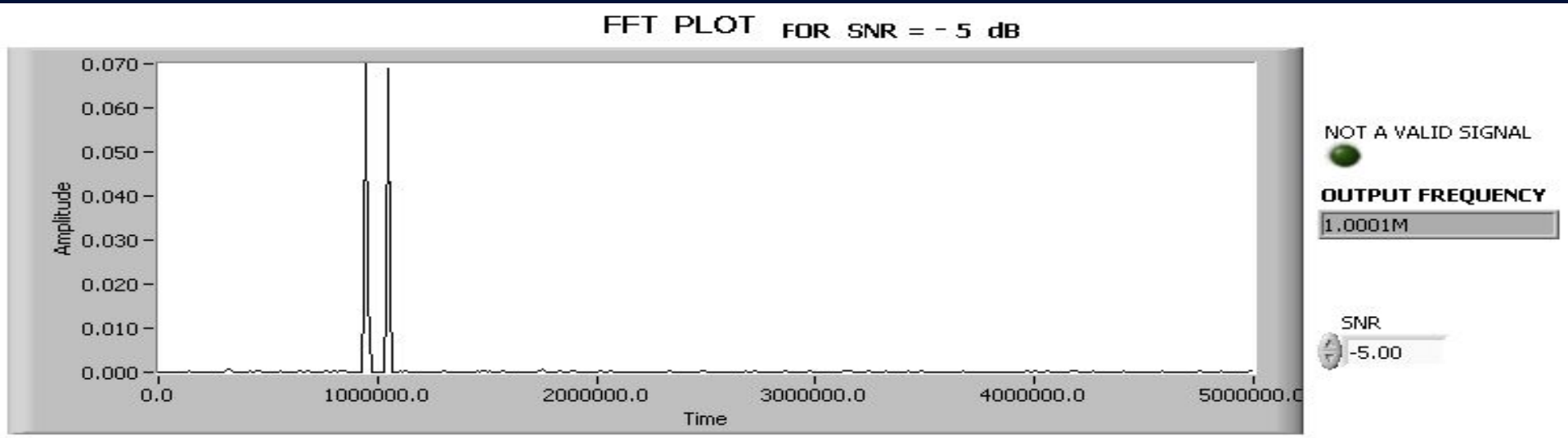
FFT

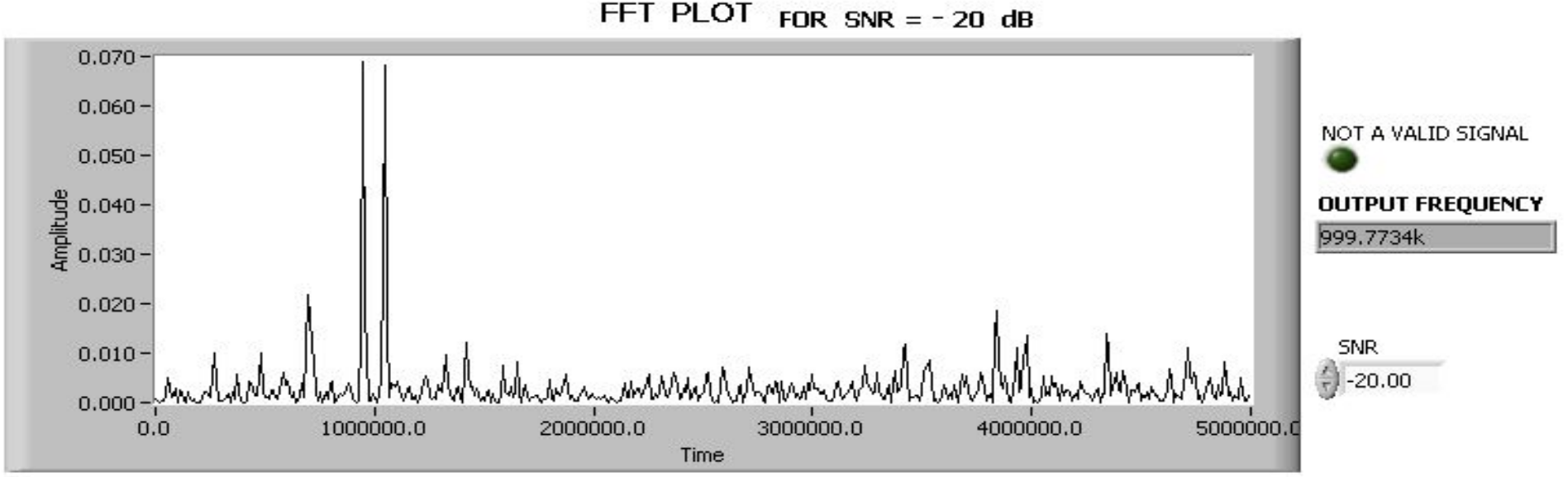
$$X(k) = \sum_{n=0}^{N-1} X(n) * \exp(-2j\ pi\ n\ k\ /\ N)\ ;\quad k = 0 \ldots N-1$$

OBJECTIVES

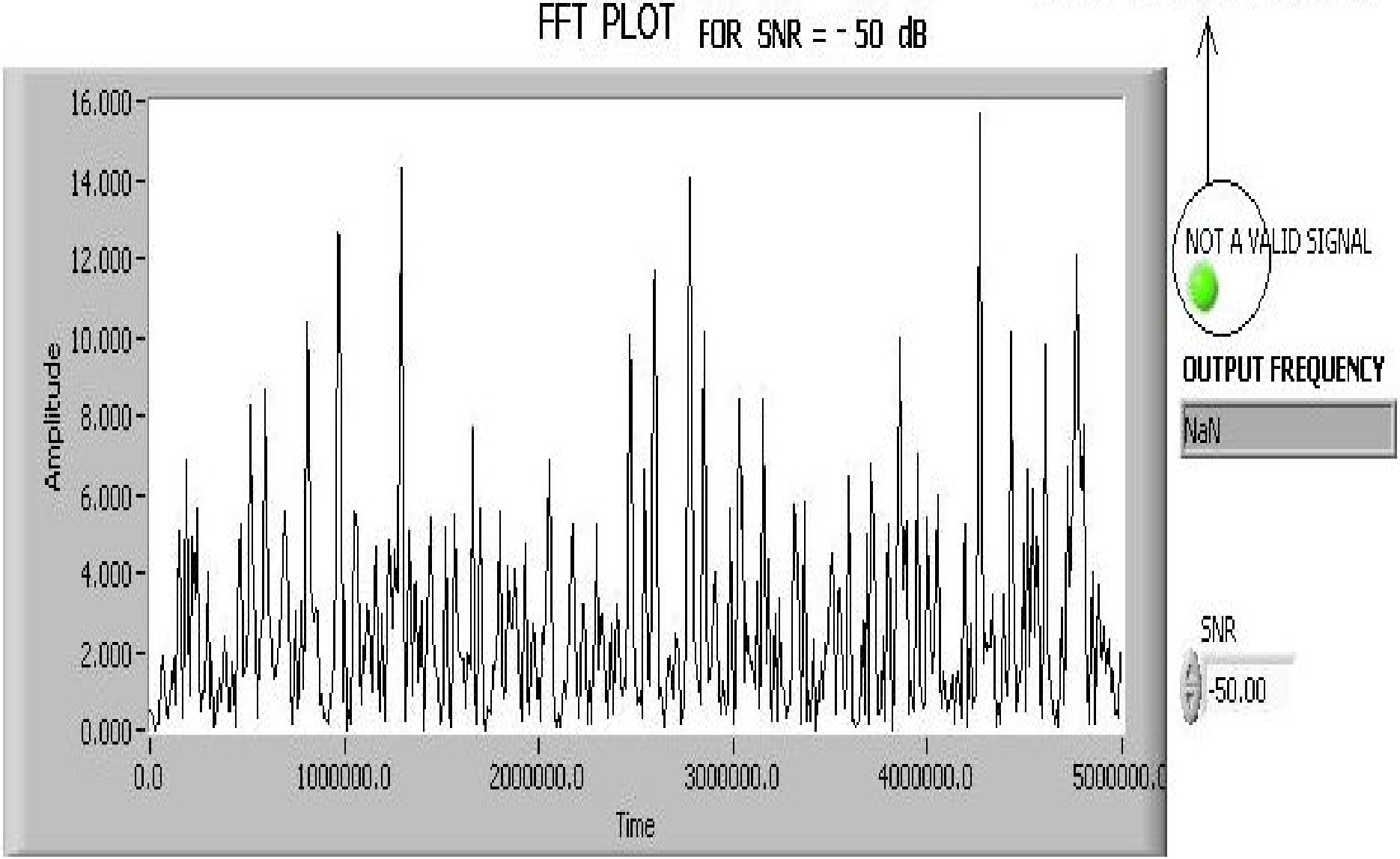
- To display the results as spectrum plots.
- To get amplitude and phase information from the plots.
- To check the validity of the burst detection.
- Computing the Frequency.

FFT OUTPUT


FFT PLOT FOR SNR = - 5 dB
Amplitude
0.070
0.060
0.050
0.040
0.030
0.020
0.010
0.000
0.0
1000000.0
2000000.0
3000000.0
4000000.0
5000000.0
Time
NOT A VALID SIGNAL
OUTPUT FREQUENCY
1.0001M
SNR
-5.00


FFT PLOT FOR SNR = - 20 dB
Amplitude
0.070
0.060
0.050
0.040
0.030
0.020
0.010
0.000
0.0
1000000.0
2000000.0
3000000.0
4000000.0
5000000.0
Time
NOT A VALID SIGNAL
OUTPUT FREQUENCY
999.7734k
SNR
-20.00

Highlights an Invalid Signal



DOUBLE CLIPPED AUTO-CORRELATION

It refers to degree of correspondence between a code and a phase shifted replica of it self .

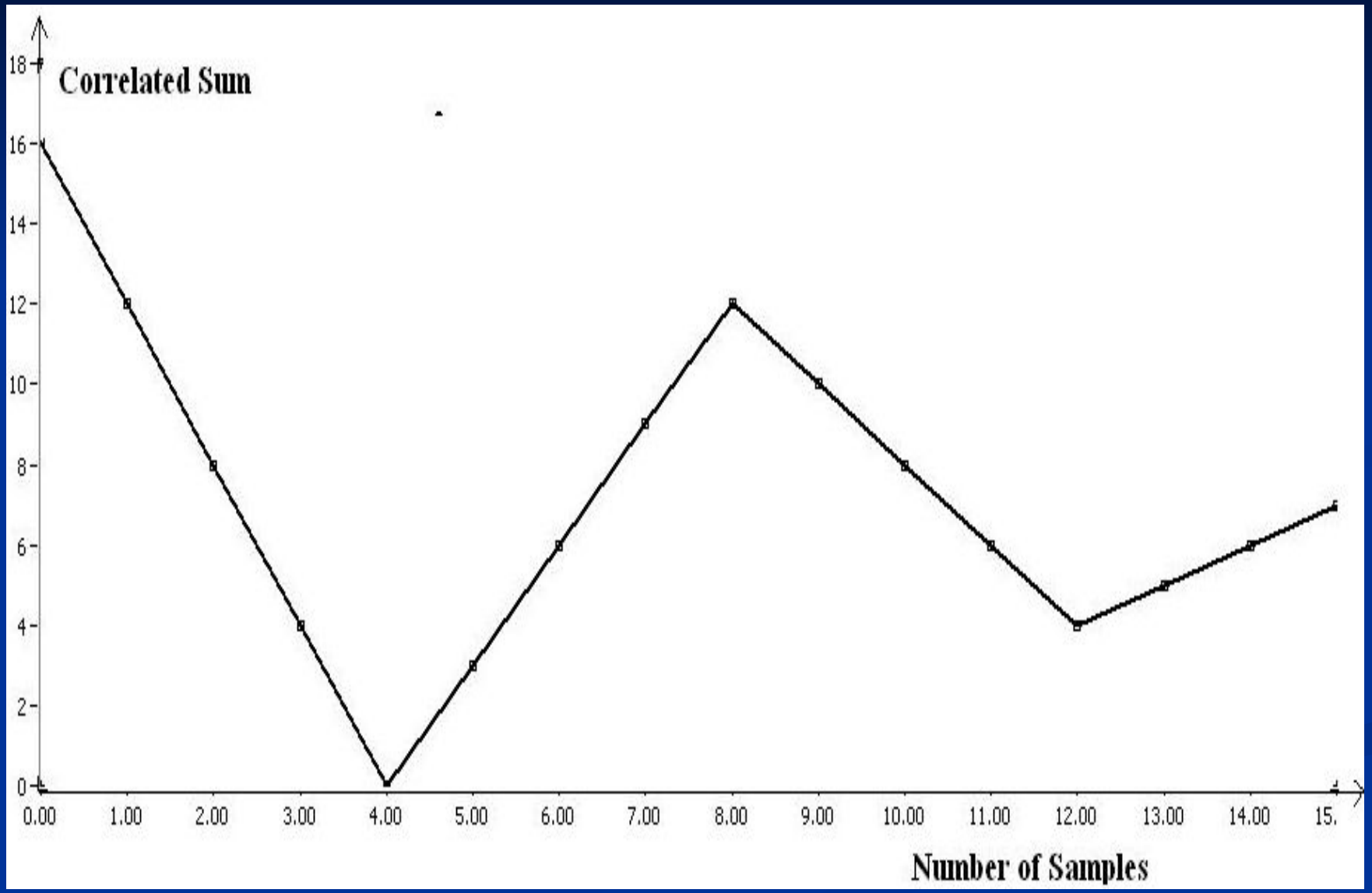
$$S(k) = \sum_{n=0}^{N-1} A(n) \text{ xnor } B(n+k) \; ; \; k = 0 \ldots N-1$$

Highlighting property

-- Correaltion Peaks only at Zero shift.

Number of Shifts	Correlated Sequence	Corr. Sum
Original Sequence	1 1 1 1 0 0 0 0 1 1 1 1 0 0 0 0	
0	1 1 1 1 0 0 0 0 1 1 1 1 0 0 0 0	16
1	0 1 1 1 1 0 0 0 0 1 1 1 1 0 0 0	12
2	0 0 1 1 1 1 0 0 0 0 1 1 1 1 0 0	8
3	0 0 0 1 1 1 1 0 0 0 0 1 1 1 1 0	4
4	0 0 0 0 1 1 1 1 0 0 0 0 1 1 1 1	0
5	0 0 0 0 0 1 1 1 1 0 0 0 0 1 1 1	3
6	0 0 0 0 0 0 1 1 1 1 0 0 0 0 1 1	6
7	0 0 0 0 0 0 0 1 1 1 1 0 0 0 0 1	9
8	0 0 0 0 0 0 0 0 1 1 1 1 0 0 0 0	12
9	0 0 0 0 0 0 0 0 0 1 1 1 1 0 0 0	10
10	0 0 0 0 0 0 0 0 0 0 1 1 1 1 0 0	8
11	0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 0	6
12	0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1	4
13	0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1	5
14	0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1	6
15	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1	7
16	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	8

AUTO-CORRELOGRAM



Objectives

-- To convert the sample values in to 1's and 0's.

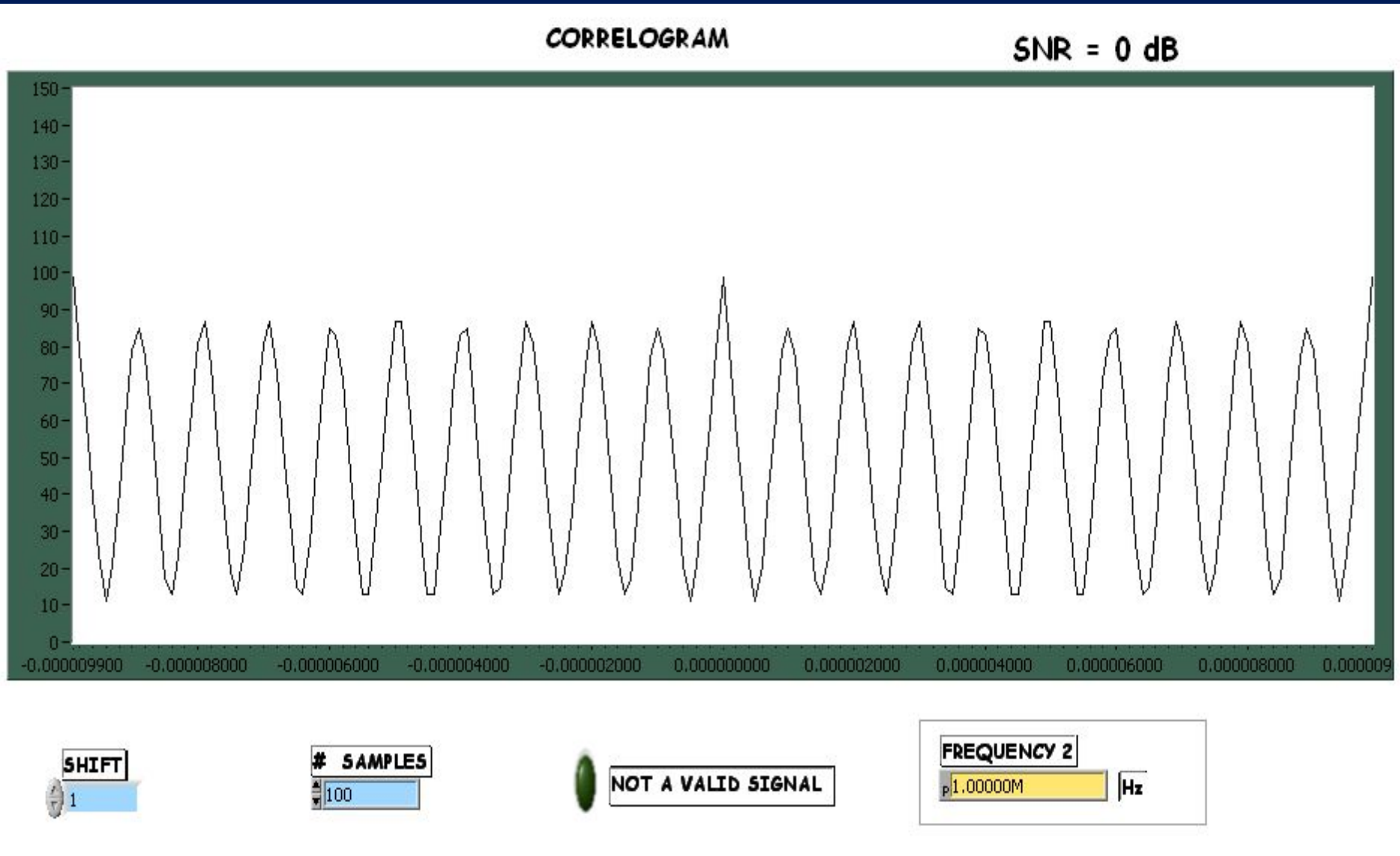
-- To XNOR the original and shifted data & find the Sum.

-- To plot the Auto-Correlation waveform.

-- To identify the valid burst.

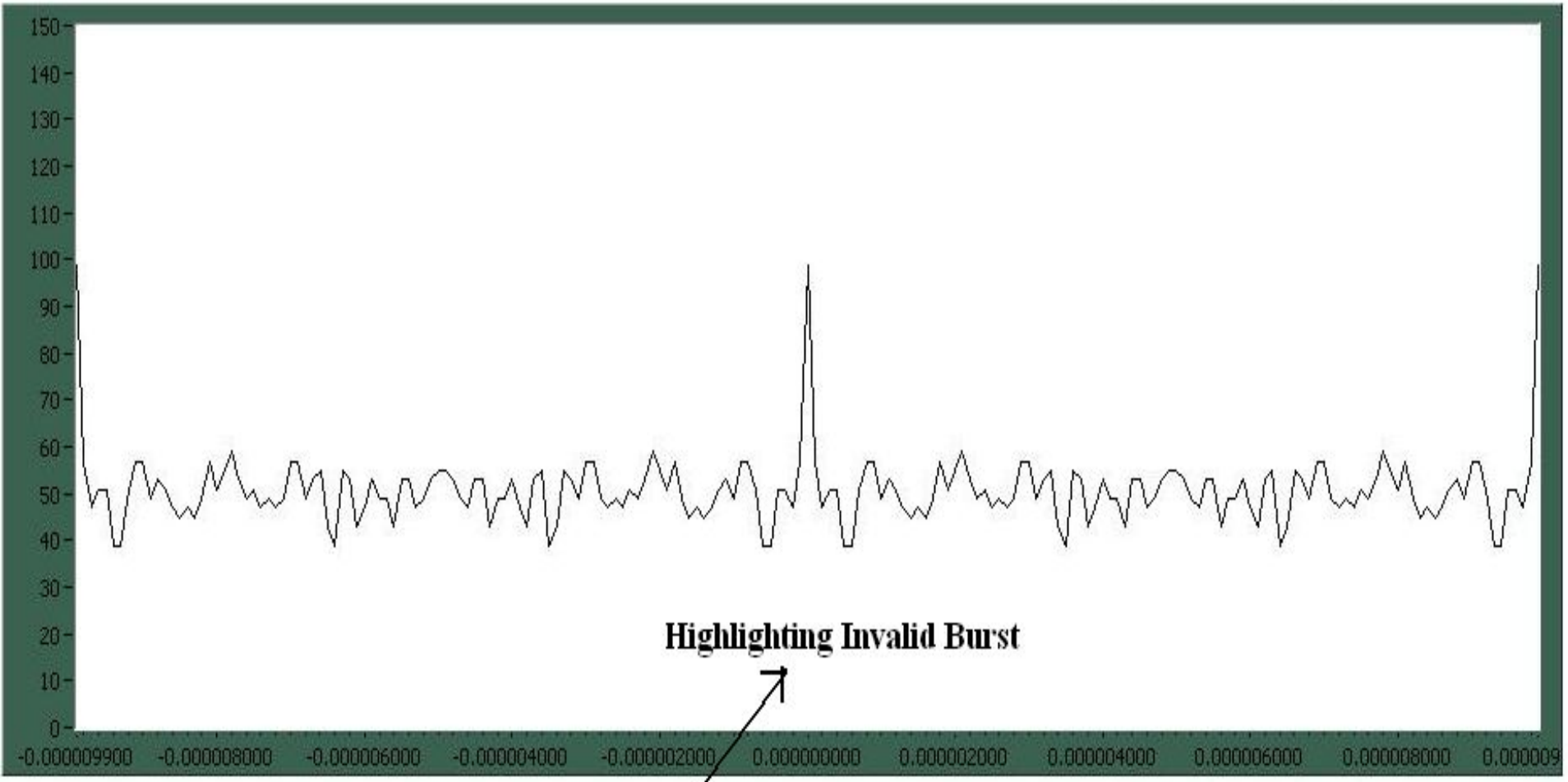
-- To compute the frequency and Velocity.

DCA OUTPUT


CORRELOGRAM
SNR = 0 dB
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-0.000009900
-0.000008000
-0.000006000
-0.000004000
-0.000002000
0.000000000
0.000002000
0.000004000
0.000006000
0.000008000
0.000009
SHIFT
1
SAMPLES
100
NOT A VALID SIGNAL
FREQUENCY 2
1.00000M
Hz

CORRELOGRAM

SNR = - 20 dB



SHIFT 1

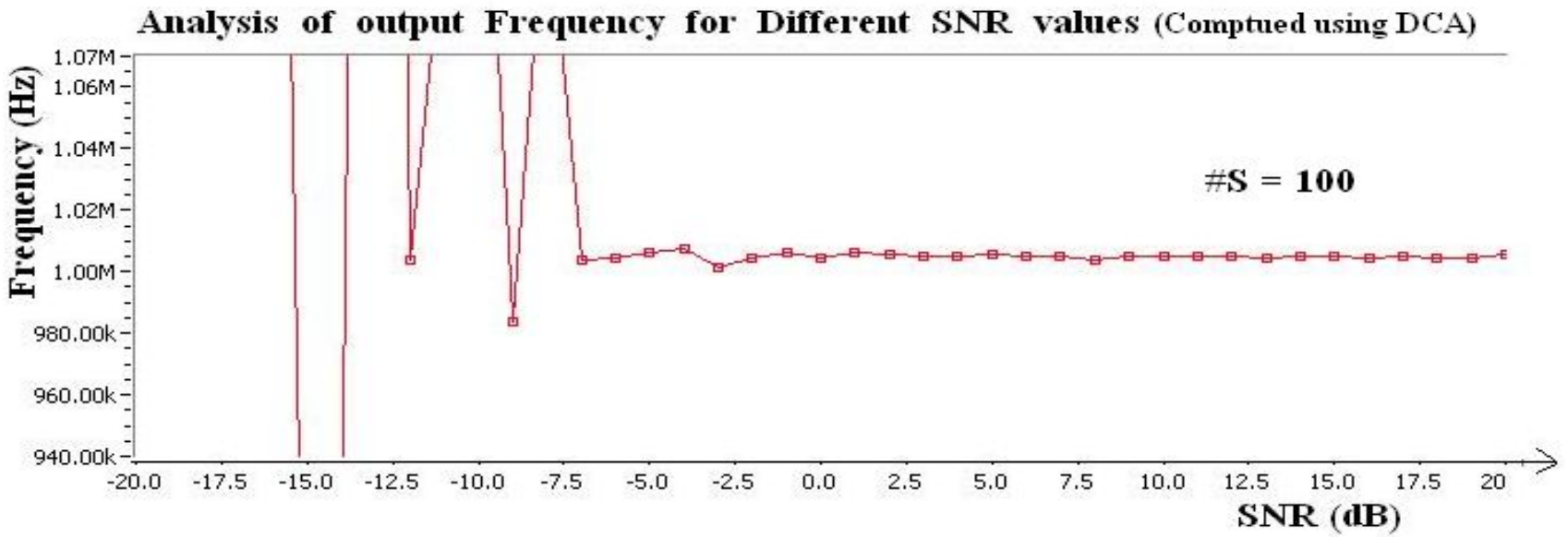
SAMPLES 100

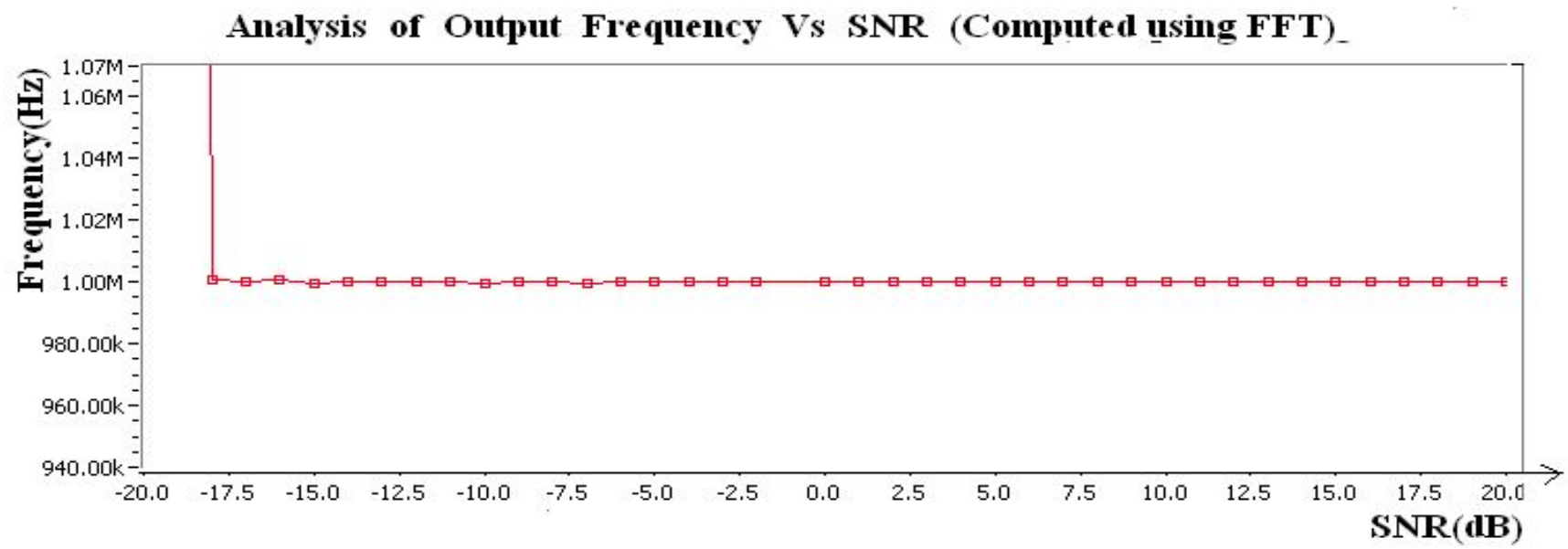
NOT A VALID SIGNAL

FREQUENCY 2

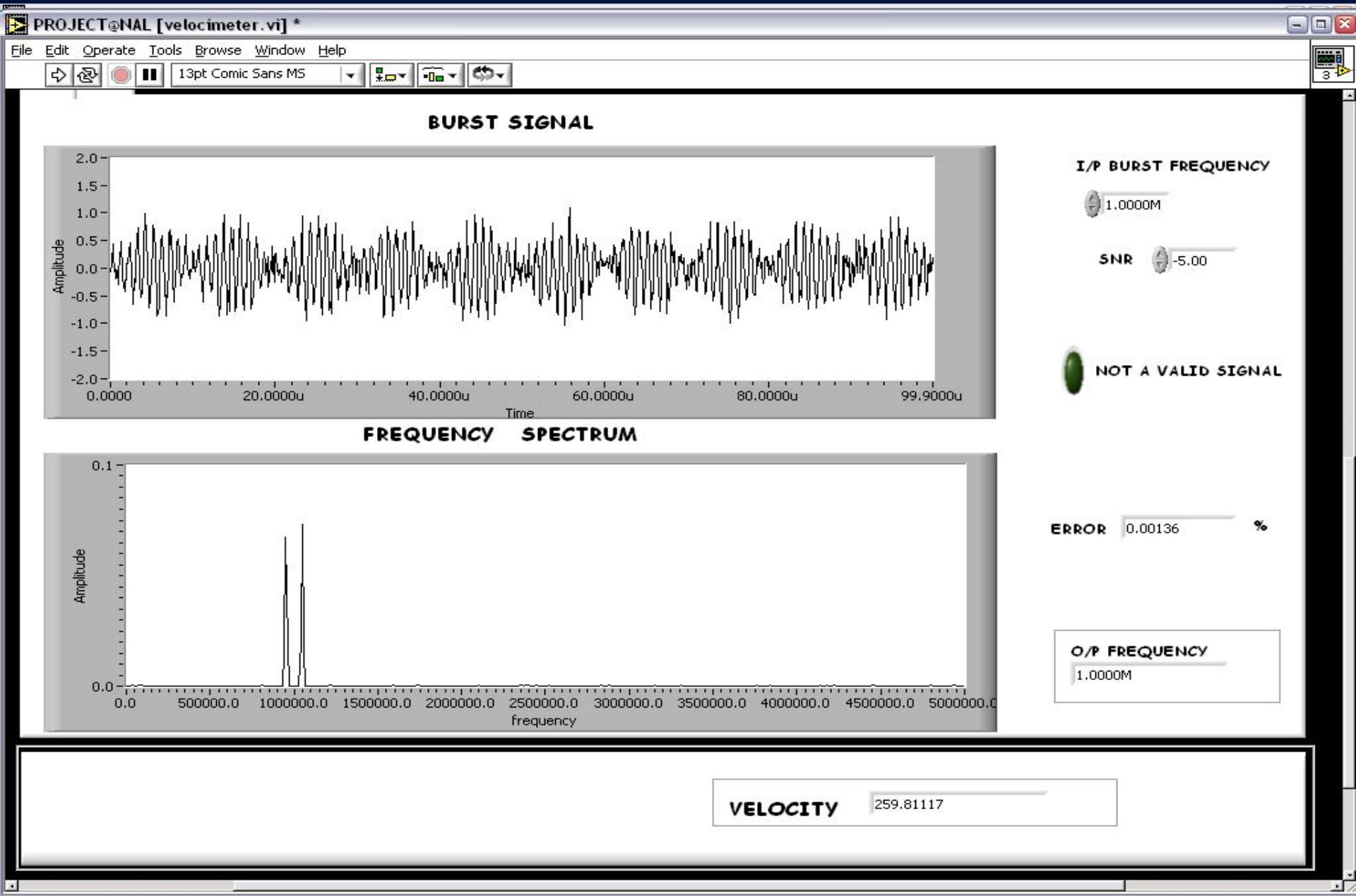
0.00000 Hz

VALIDATION


Analysis of output Frequency for Different SNR values (Comptued using DCA)
Frequency (Hz)
1.07M
1.06M
1.04M
1.02M
1.00M
980.00k
960.00k
940.00k
#S = 100
-20.0 -17.5 -15.0 -12.5 -10.0 -7.5 -5.0 -2.5 0.0 2.5 5.0 7.5 10.0 12.5 15.0 17.5 20
SNR (dB)


Analysis of Output Frequency Vs SNR (Computed using FFT)
Frequency(Hz)
1.07M
1.06M
1.04M
1.02M
1.00M
980.00k
960.00k
940.00k
-20.0 -17.5 -15.0 -12.5 -10.0 -7.5 -5.0 -2.5 0.0 2.5 5.0 7.5 10.0 12.5 15.0 17.5 20.0
SNR(dB)

FRONT PANELS

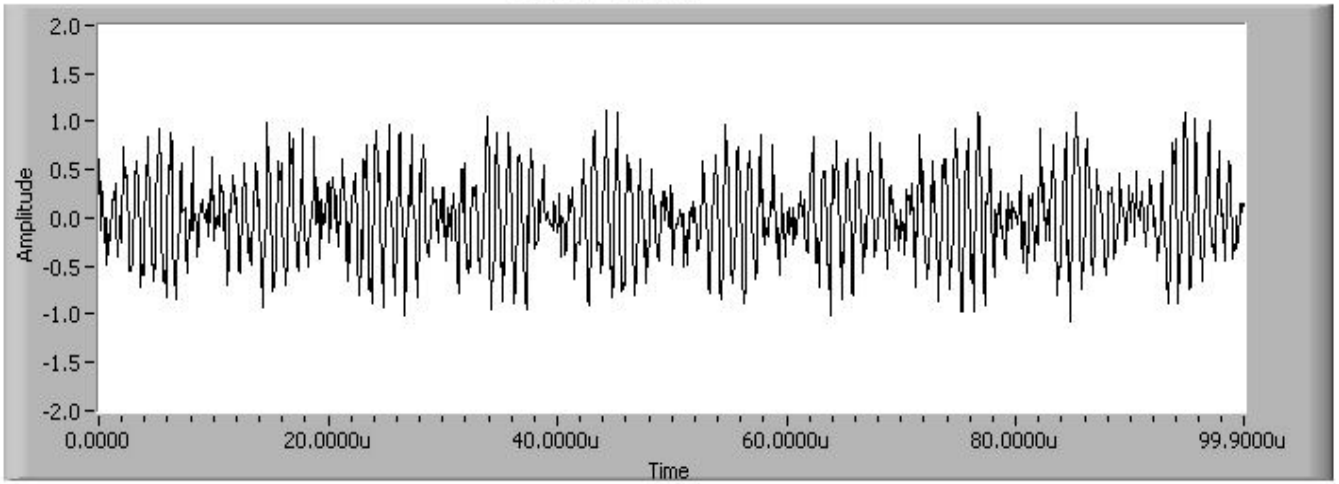


PROJECT@NAL [velocimeter.vi] *

File Edit Operate Tools Browse Window Help

13pt Comic Sans MS

Burst Signal



I/P BURST FREQUENCY

1.0000M

SNR -8.00

ERROR 2.04082

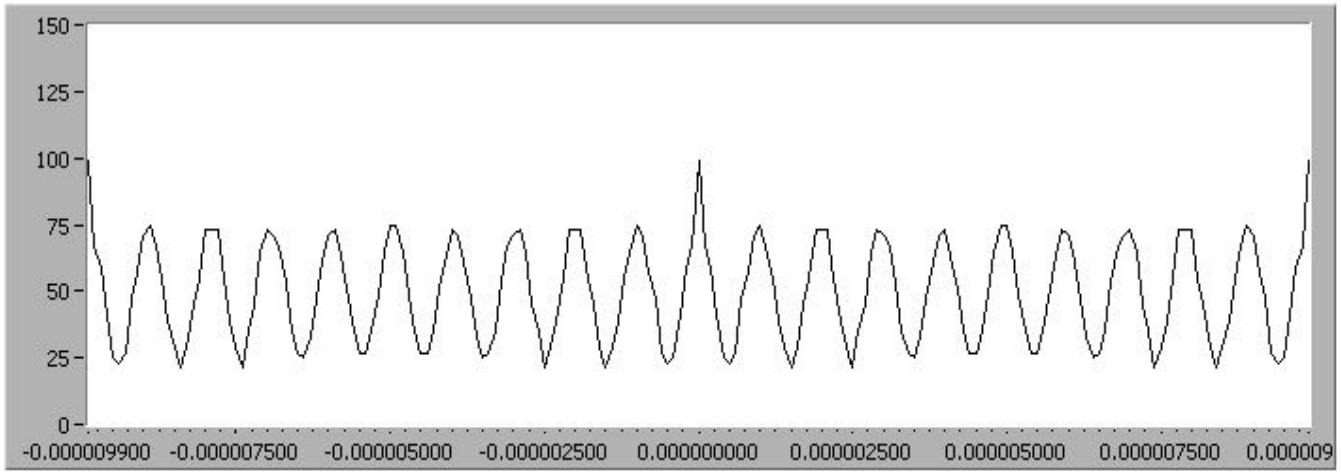
SHIFT

1

 # SAMPLES

100

CORRELOGRAM



NOT A VALID SIGNAL

FREQUENCY

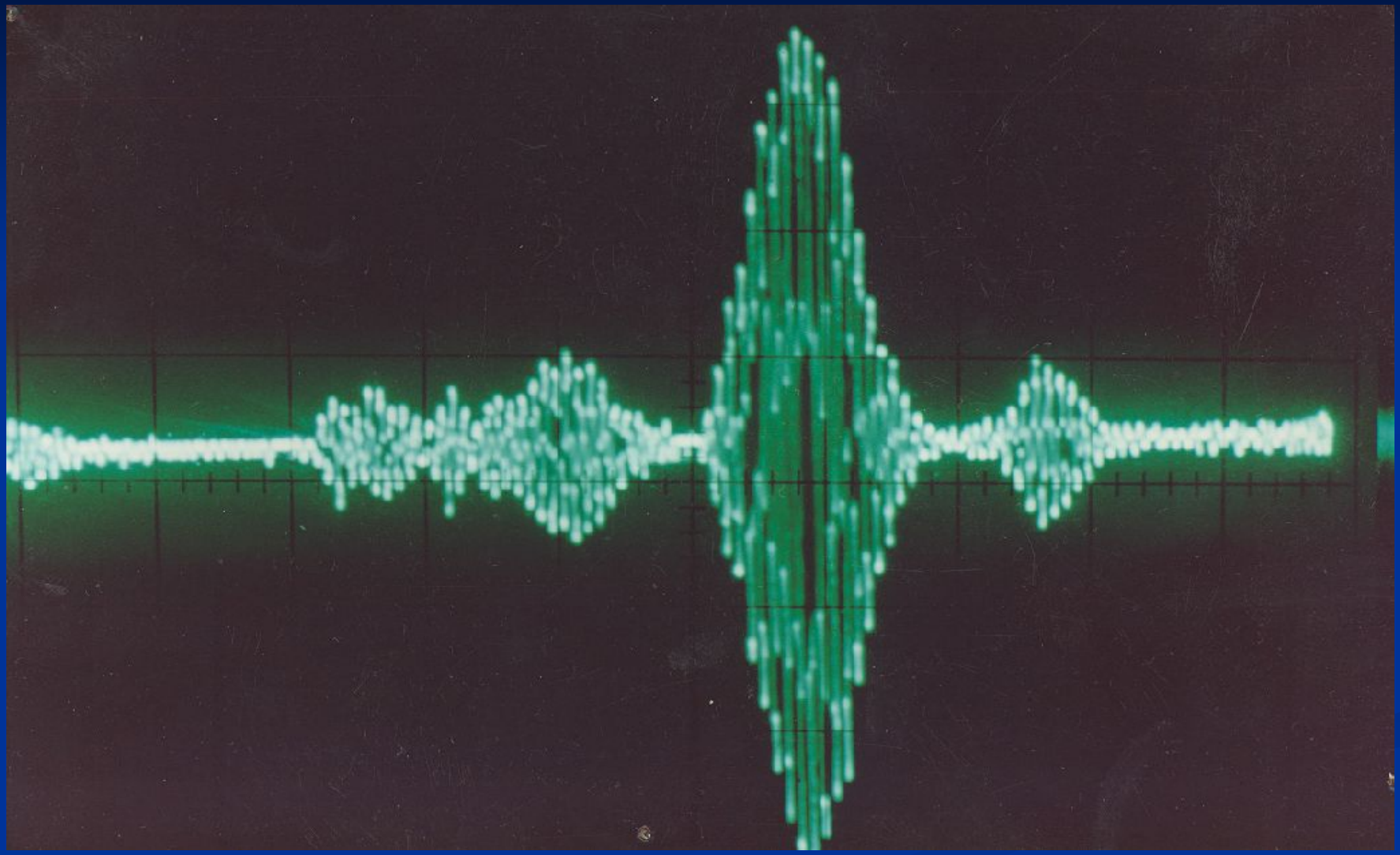
1.02041M

VELOCITY 265.10982

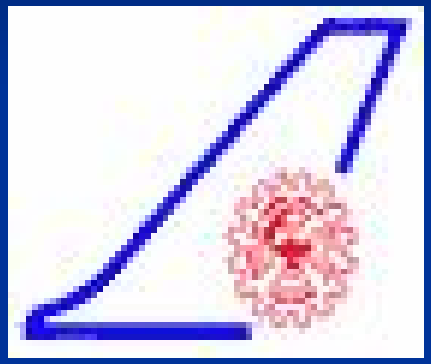
FUTURE DEVELOPMENTS

- **Implementation in Digital Signal Processors.**
- **Implementation in FPGA.**


0.55M
LOW SPEED TUNNEL
COHERENT
DANTEC



OUR SINCERE THANKS TO



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&

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