University of Washington
VISUAL TECHNIQUES LABORATORY
OPERATIONS NOTE

ON – 148

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subject June 7 Union Bay Chirp Test

page 1 of 32

date 7/8/91 | rev. date

To: Dumand File
From B. Egaas
Subj: June 7 Union Bay Chirp Test
Date: 8 July 1991

Larry McCourry re-programmed the Gespac to simultaneously output a digitized waveform and log received data. The sample rate for both input and output was reduced to 133.34 KHz. This gave us the freedom to send an arbitrary waveform. Larry programmed in a ~5ms, 10-30 KHz linear FM pulse with cosine shaped rise and fall, complete with leading zeros. The program SIMUL carries out the chirping/logging.

I added an inverting op amp (gain =50) to the hydrophone input to boost the signal out of the quantization noise and thus alleviate some of our source level problems. (Note this also added a polarity shift to the received signal.)

We chose a test site down by the Waterfront Activities Center on Union Bay (see map, Fig. 1). The long straight dock allowed us to measure the distances much more accurately than in Frosh Pond. The projecting transducer and receiving hydrophone were submerged a few feet into the water.

We took several datafiles at 3.3, 7.9, 8.2, 15.2, 30.5, and 69.0 meter separations. Datafiles are listed in the lab notebook. Figures 2 and 3 are examples of the poor source level at 3.3 and 30.5 m, even with the added gain of the op amp. Note also the 60 Hz spikes due to the power inverter we used to supply the computers and amplifier. In the 30.5 m case, leading edge detection would be impossible.

The results of the correlation analysis were mixed. On the good side, the jitter of the new digital chirper was nonexistent. And the correlations at 3.3, 7.9, 8.2 and 30.5 meters gave consistently stable peaks, usually within 1 sample point. On the down side, the correlations at 15.2 and 69.0 meters failed miserably. In these cases, it is impossible to even see a received waveform - again, source level problems.

Table 1 again show a Quattro regression of the data. For the distances that worked at all, the correlations worked very well. In these cases, the residues (the differences between best fit predicted values and actual measurements) were less than 1 cm! The speed of sound came out 1471 m/s (book=1481 m/s).

The remaining plots show correlations for all received signals.

Conclusions

The new digitized chirper/logger works beautifully, eliminating time jitter in the waveform. The power amp works poorly. It needs a new set of output transistors (which Roger has since installed). And our current range resolution is approximately 1 cm, well within the 10 cm required for Dumand.

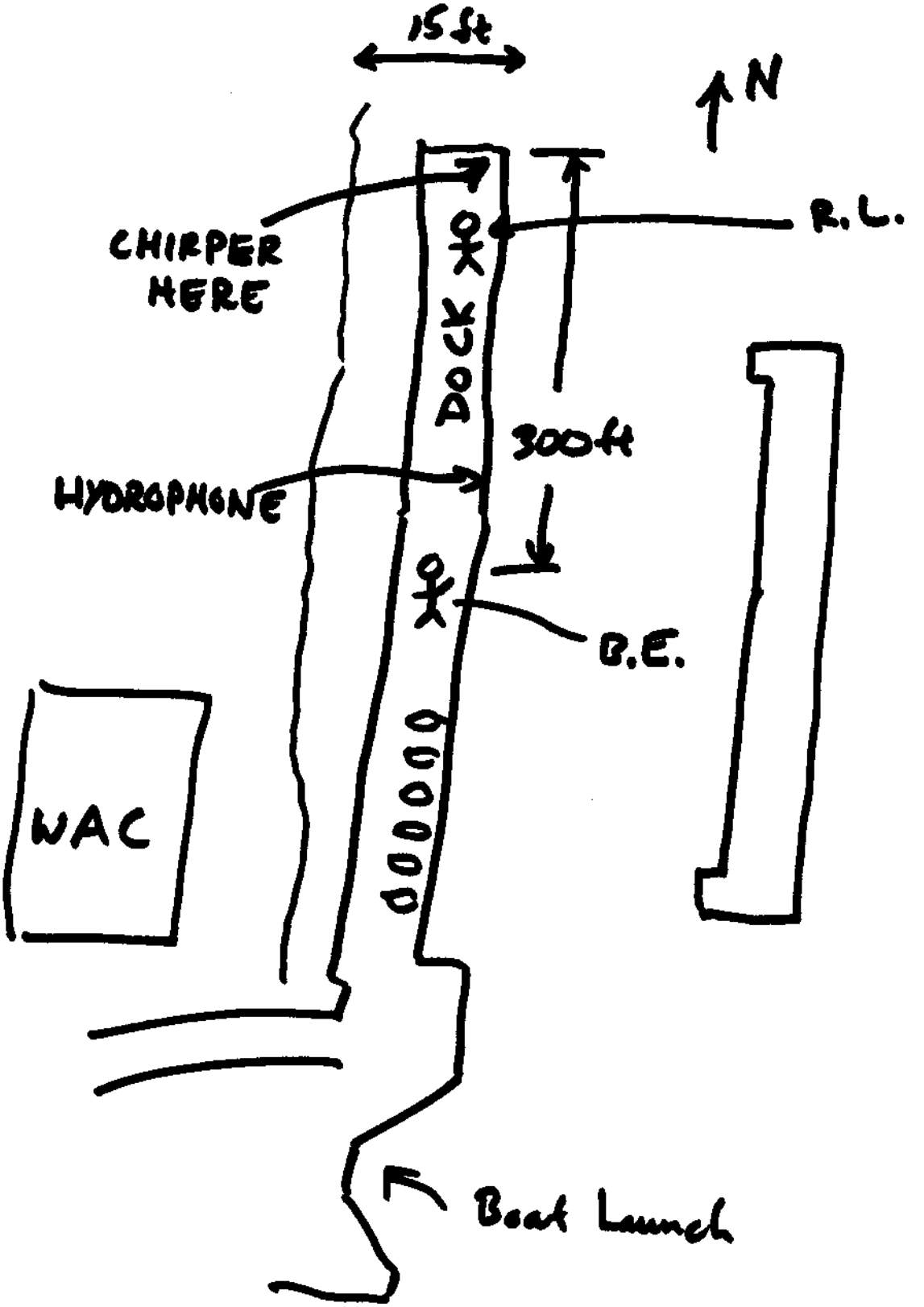
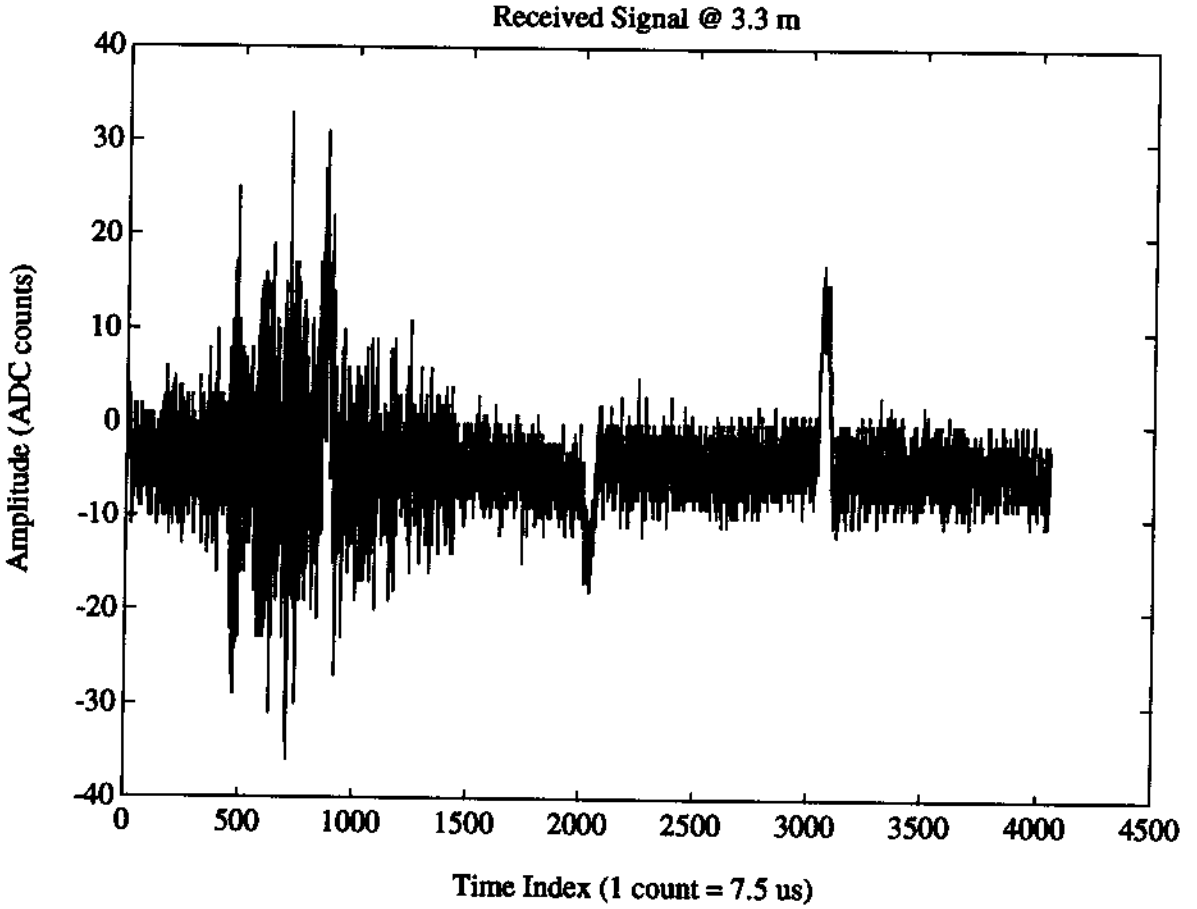


Fig. 1

Union Bay Test Site


Received Signal @ 3.3 m
Amplitude (ADC counts)
40
30
20
10
0
-10
-20
-30
-40
0
500
1000
1500
2000
2500
3000
3500
4000
4500
Time Index (1 count = 7.5 us)

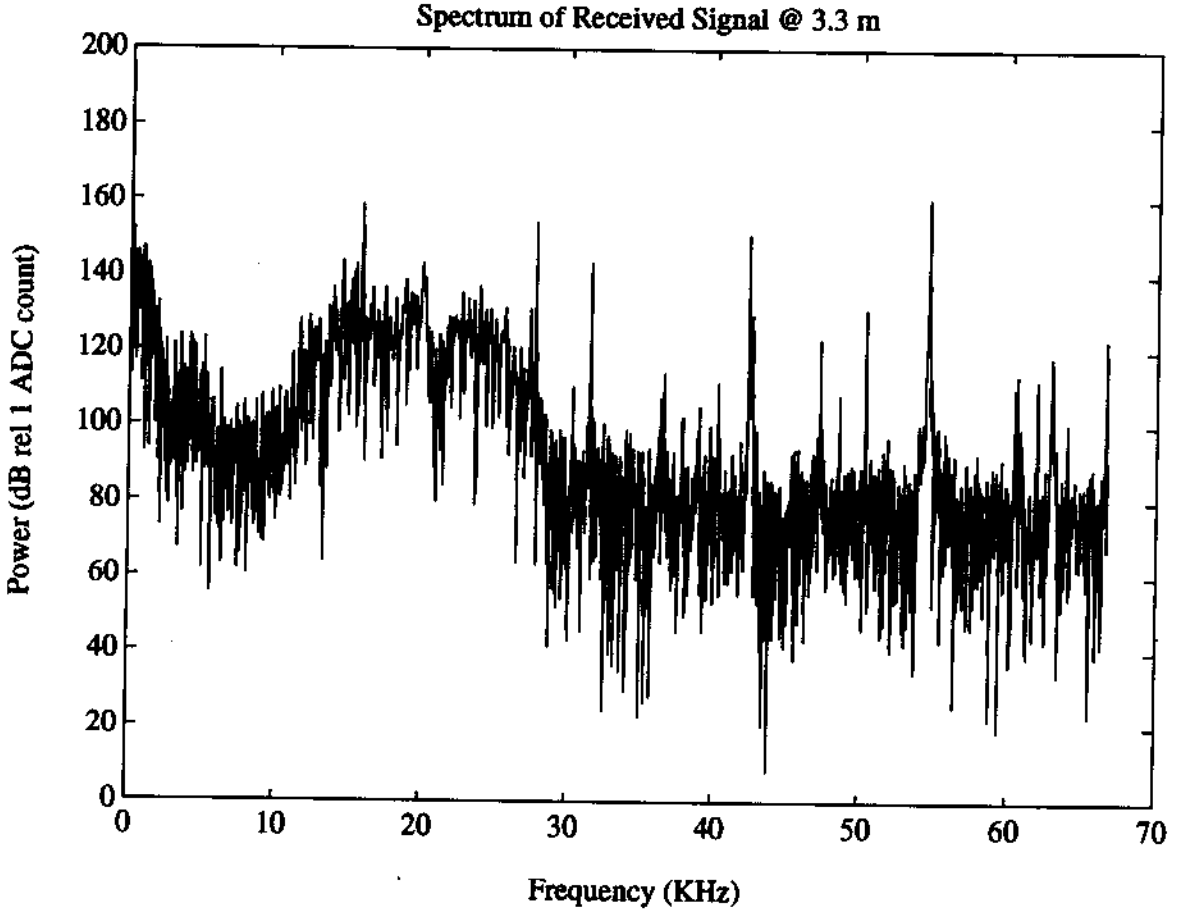
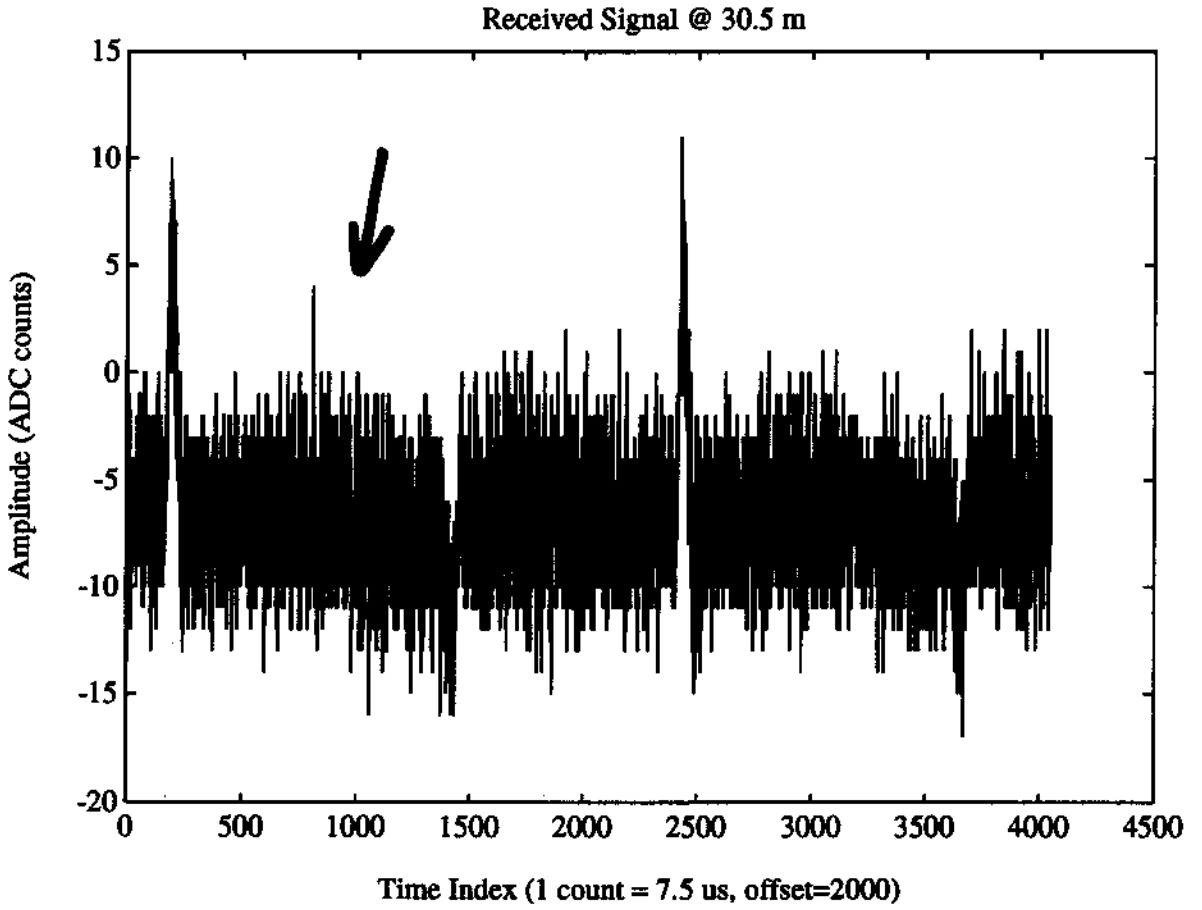

Spectrum of Received Signal @ 3.3 m
Power (dB rel 1 ADC count)
200
180
160
140
120
100
80
60
40
20
0
0
10
20
30
40
50
60
70
Frequency (KHz)

Fig. 2


Received Signal @ 30.5 m
Amplitude (ADC counts)
15
10
5
0
-5
-10
-15
-20
0
500
1000
1500
2000
2500
3000
3500
4000
4500
Time Index (1 count = 7.5 us, offset=2000)

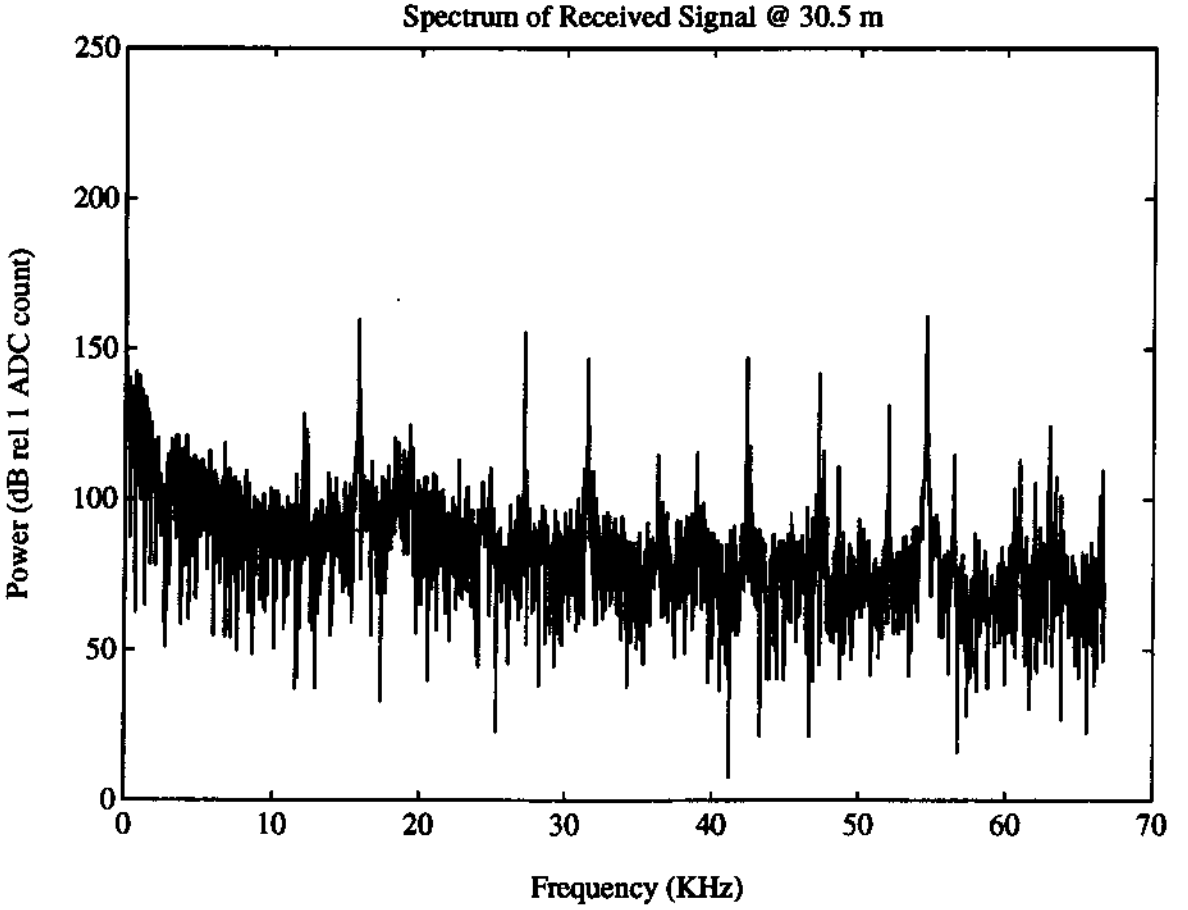

Spectrum of Received Signal @ 30.5 m
Power (dB rel 1 ADC count)
250
200
150
100
50
0
0
10
20
30
40
50
60
70
Frequency (KHz)

Fig. 3

10 June/91

Fit to Yacht club chirper data by BE

302.5	3.28	0.002269	RegressioRegression Output:		
715.5	7.85	0.005366	Constant	-0.05235	-0.05235
744	8.15	0.00558	Std Err of Y Est	0.008303	0.008303
2768	30.48	0.020759	R Squared	1	1
			No. of ObNo. of Observation	4	4
			Degrees oDegrees of Freedom	2	2
			X CoefficX Coefficient(s)	1470.849	
			Std Err oStd Err of Coef.	0.576488	

Rcalc	residue
3.284456	-0.00446
7.840167	0.009833
8.154544	-0.00454
30.48083	-0.00083

- no jitter due to digital chirper/logger

- residues ~ 1 cm

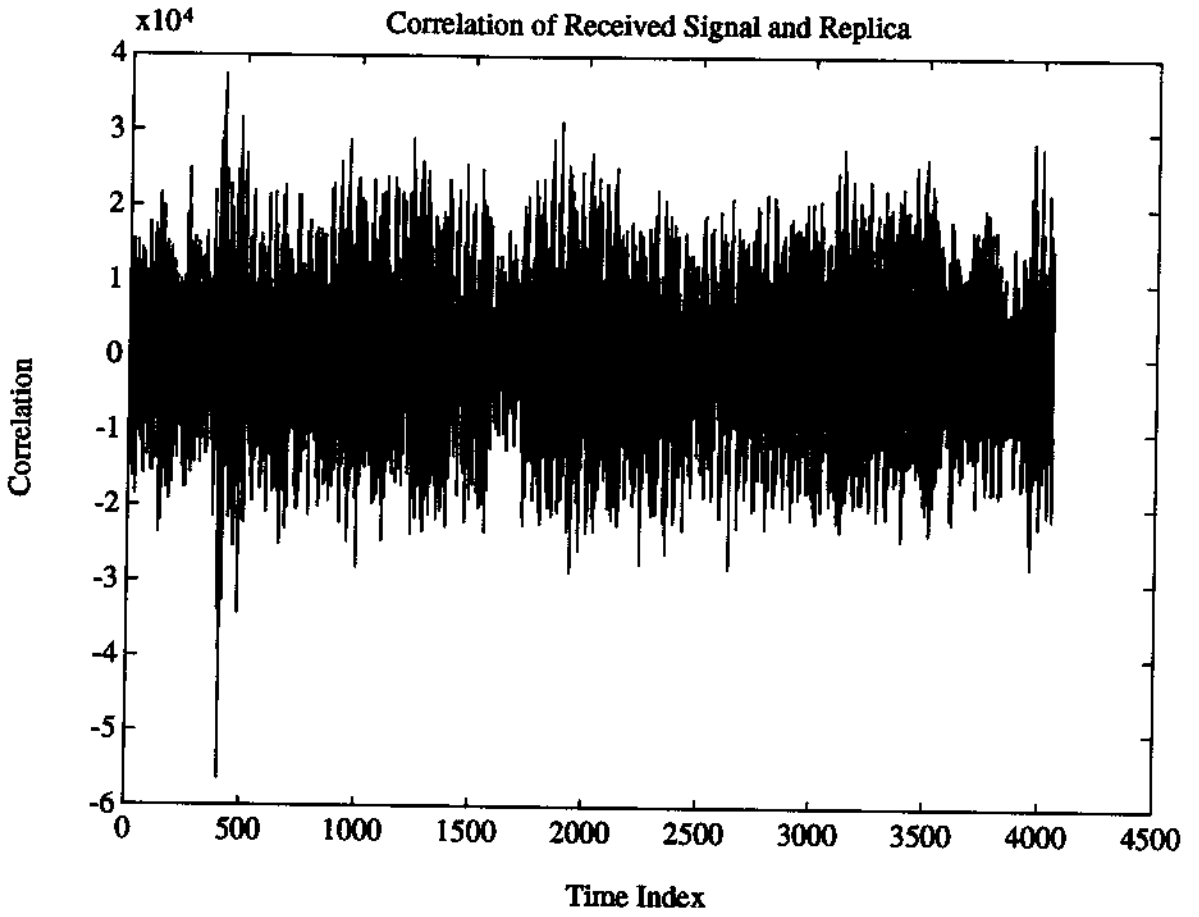
- poor source level → mixed results

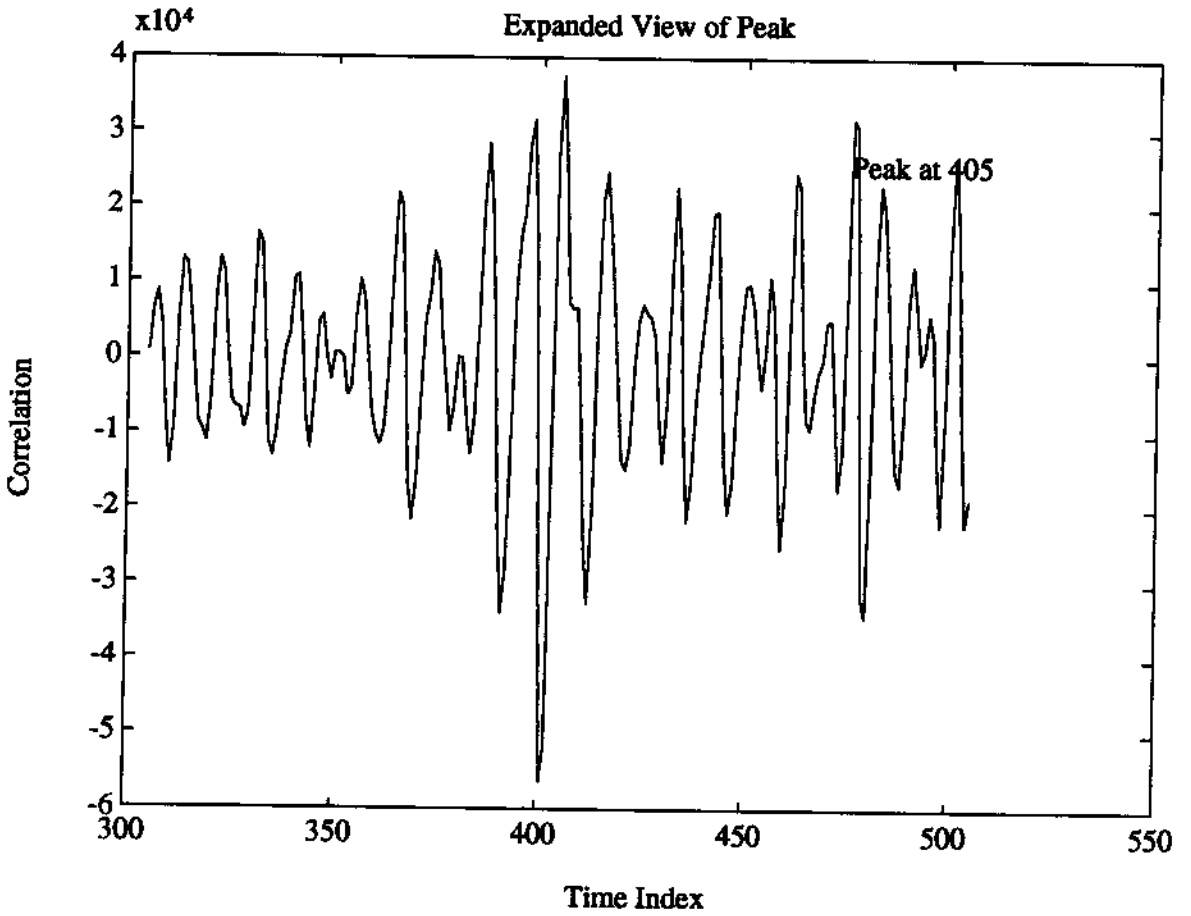
- c ≈ 1471 m/s (Book 1481 m/s)

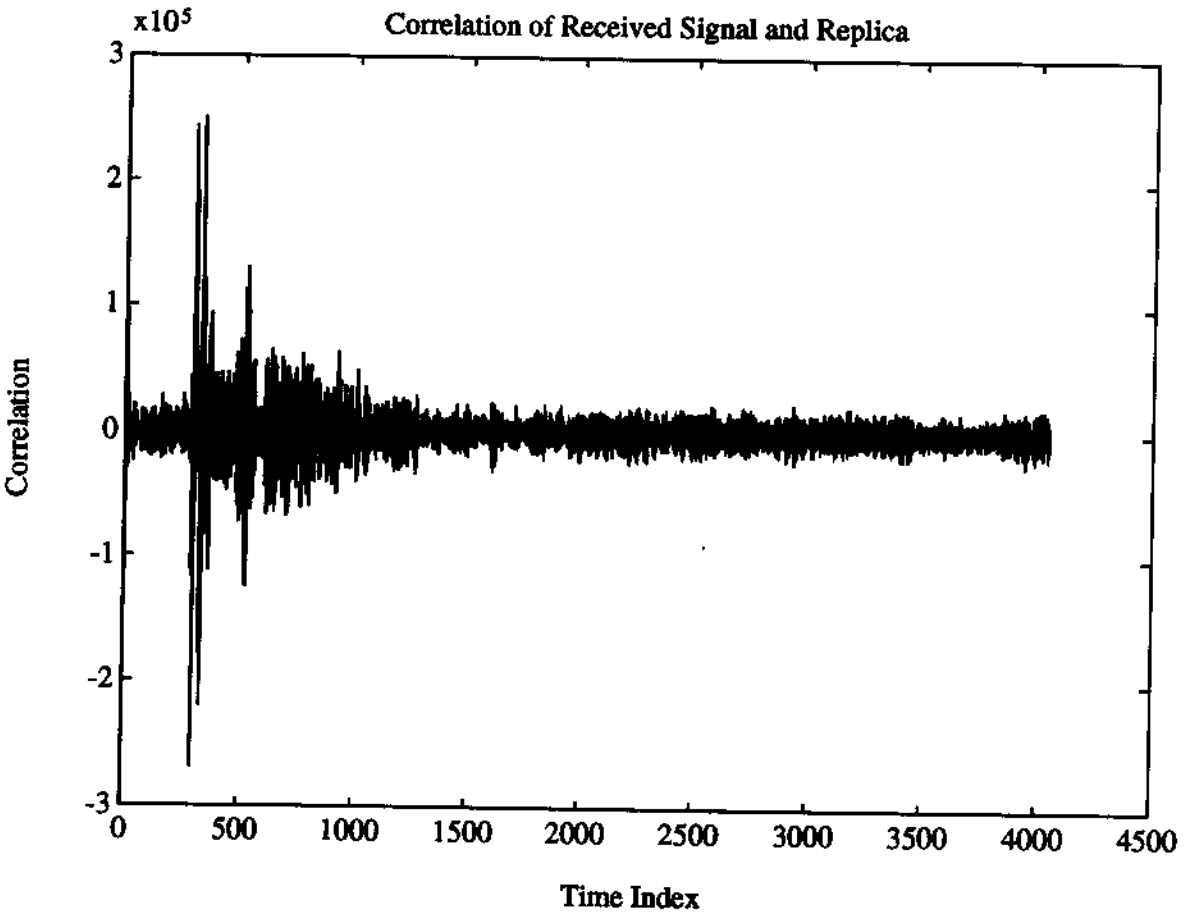
Table 1

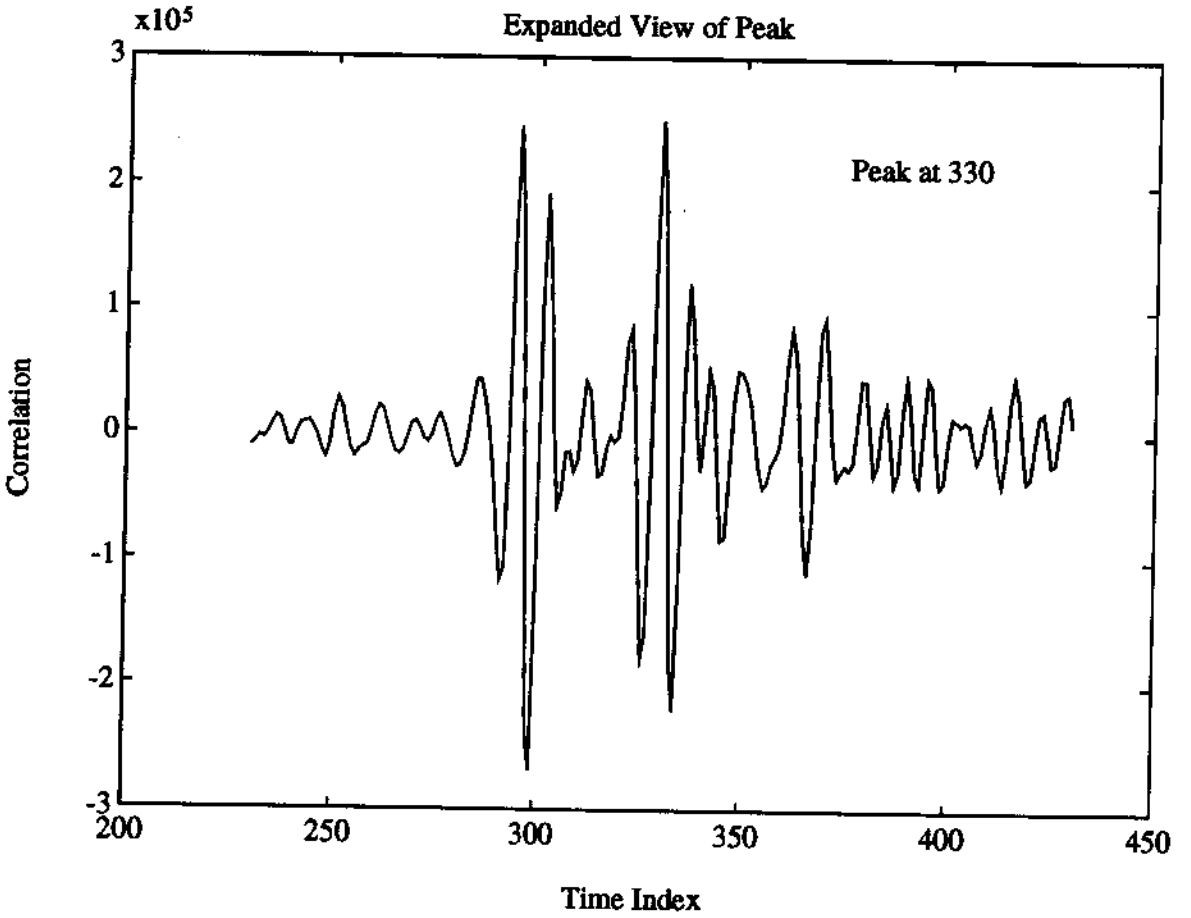
Union Bay Test Results

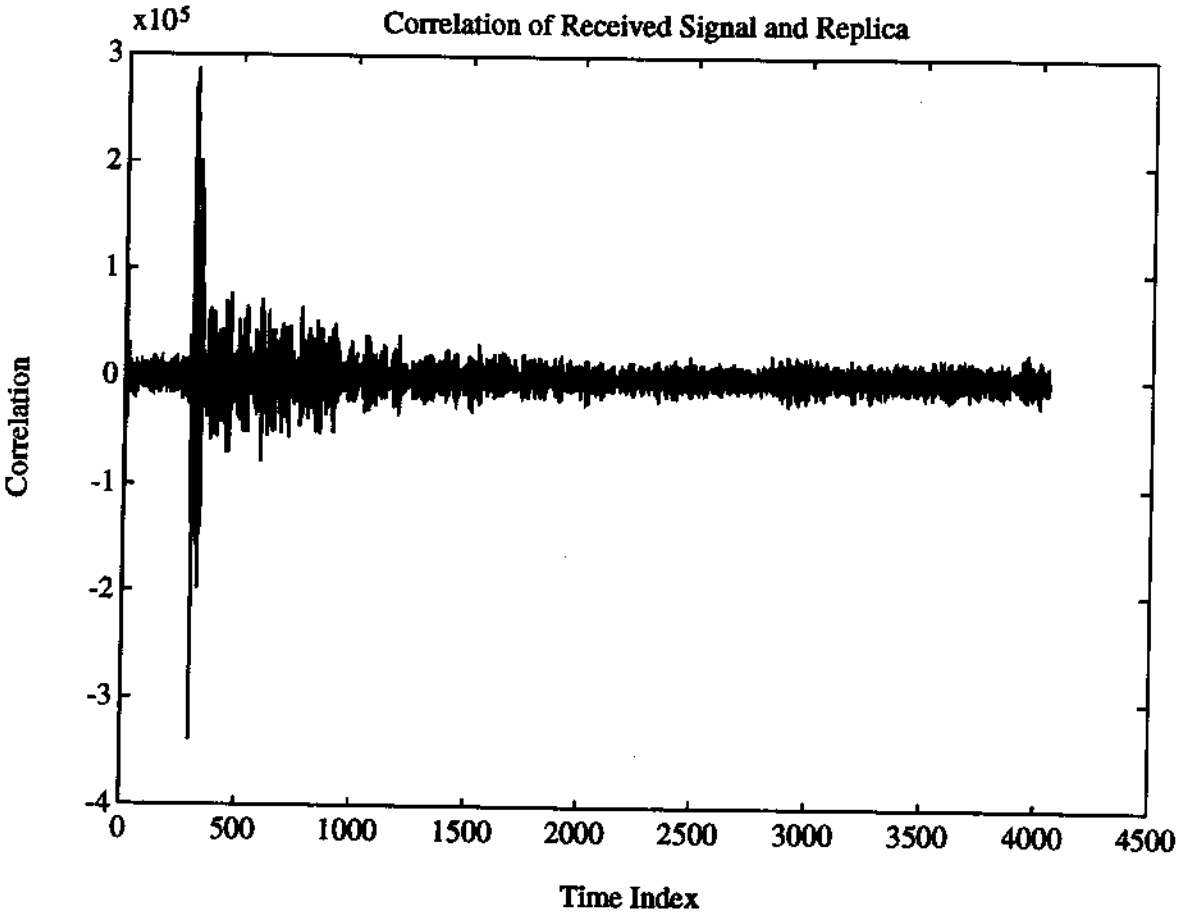
June 7, 1991

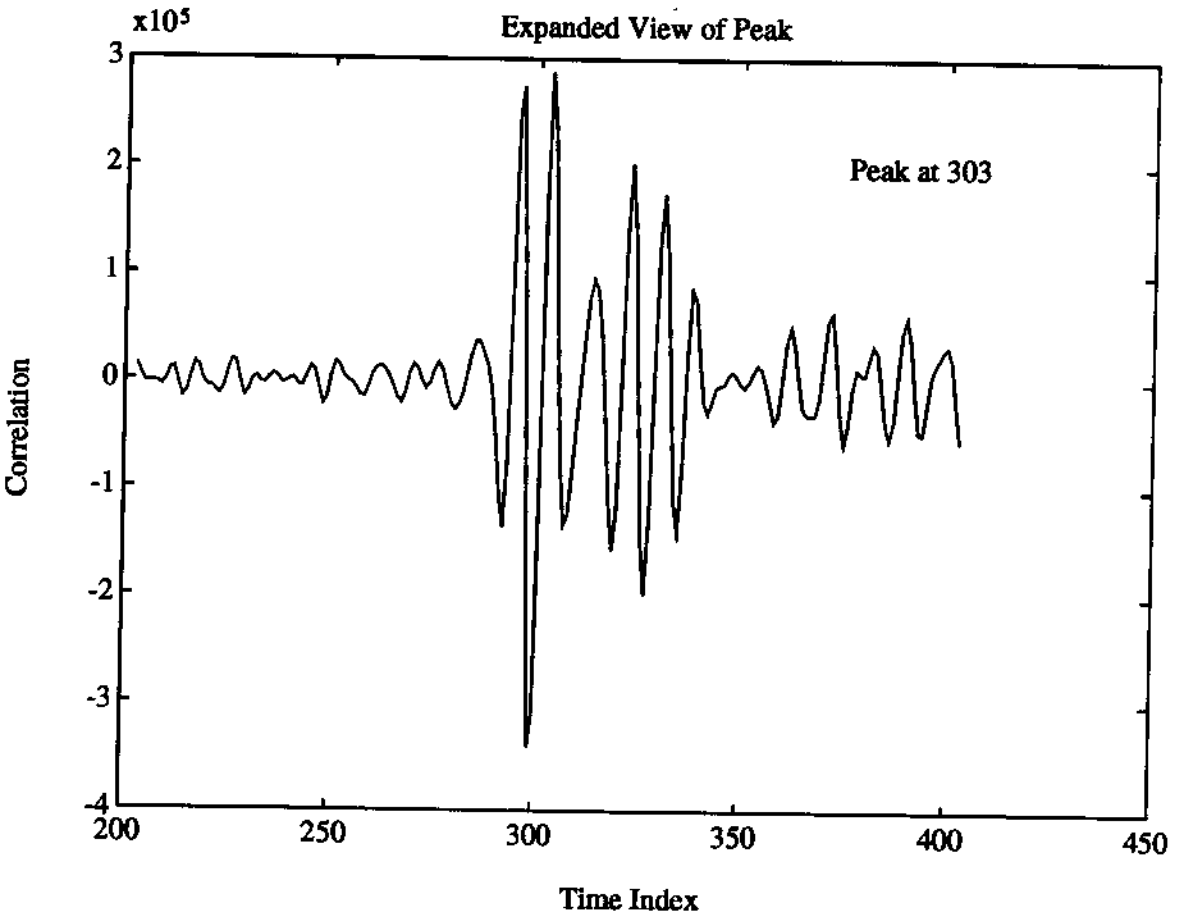

x10^4
Correlation of Received Signal and Replica
Correlation
Time Index
4
3
2
1
0
-1
-2
-3
-4
-5
-6
0
500
1000
1500
2000
2500
3000
3500
4000
4500

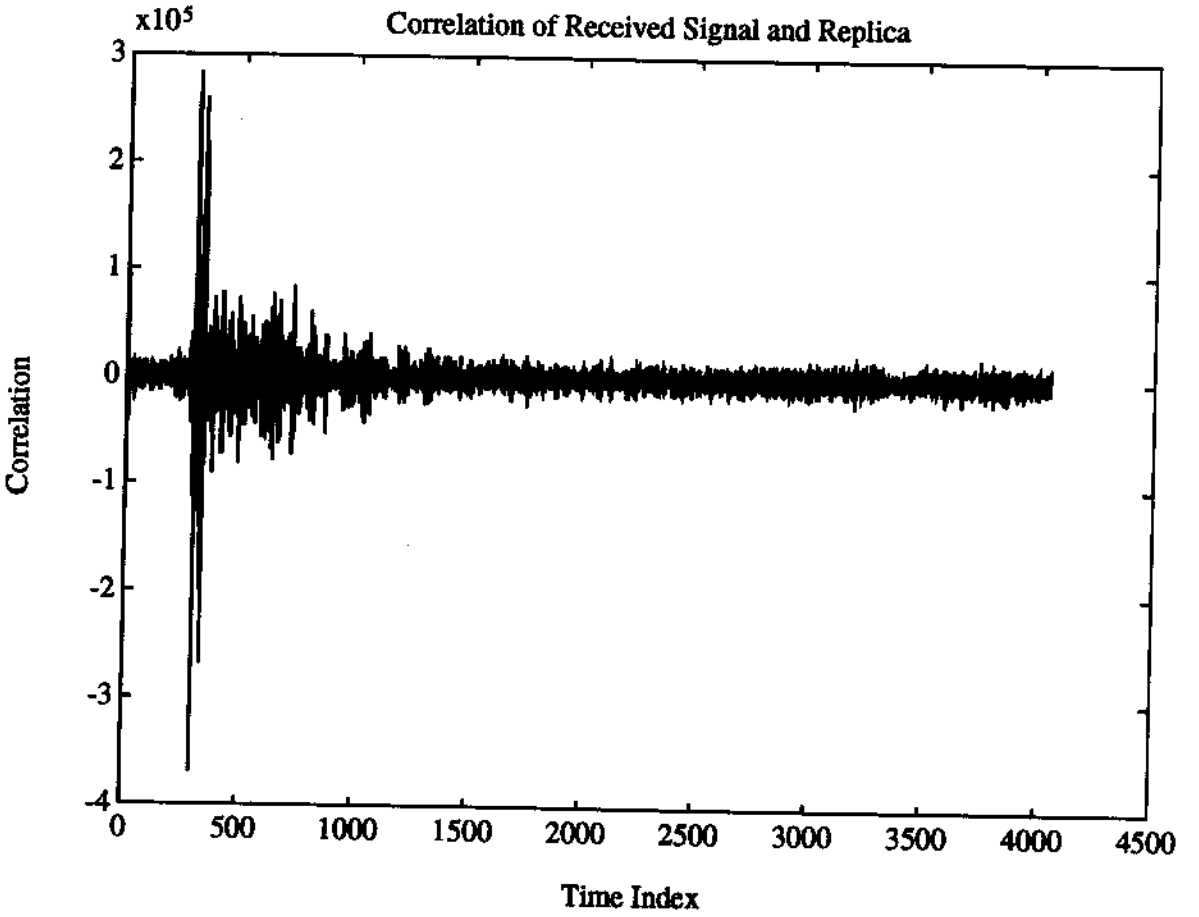

x10^4
Expanded View of Peak
Peak at 405
Correlation
Time Index
4
3
2
1
0
-1
-2
-3
-4
-5
-6
300
350
400
450
500
550

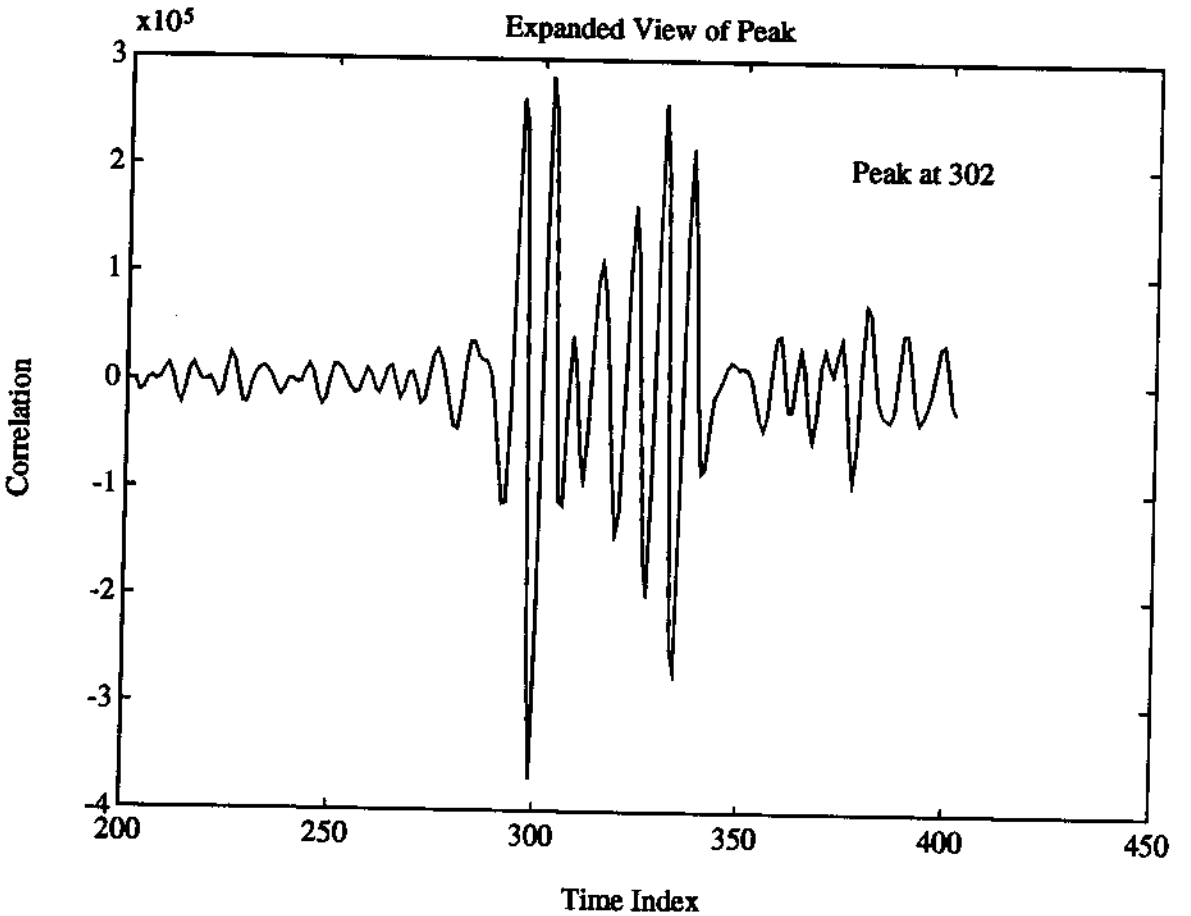

x10^5
Correlation of Received Signal and Replica
Correlation
Time Index
3
2
1
0
-1
-2
-3
0
500
1000
1500
2000
2500
3000
3500
4000
4500

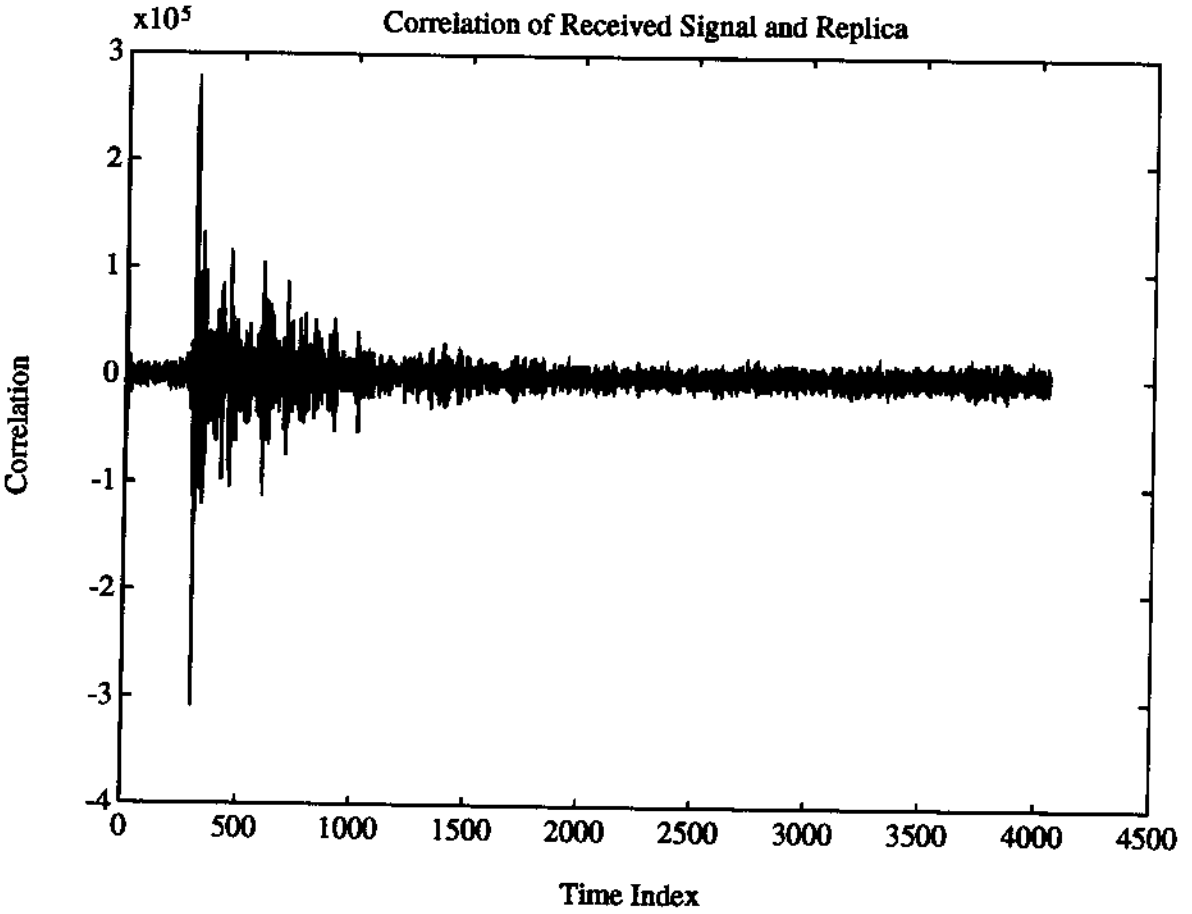

x10^5
Expanded View of Peak
Peak at 330
Correlation
Time Index
3
2
1
0
-1
-2
-3
200
250
300
350
400
450

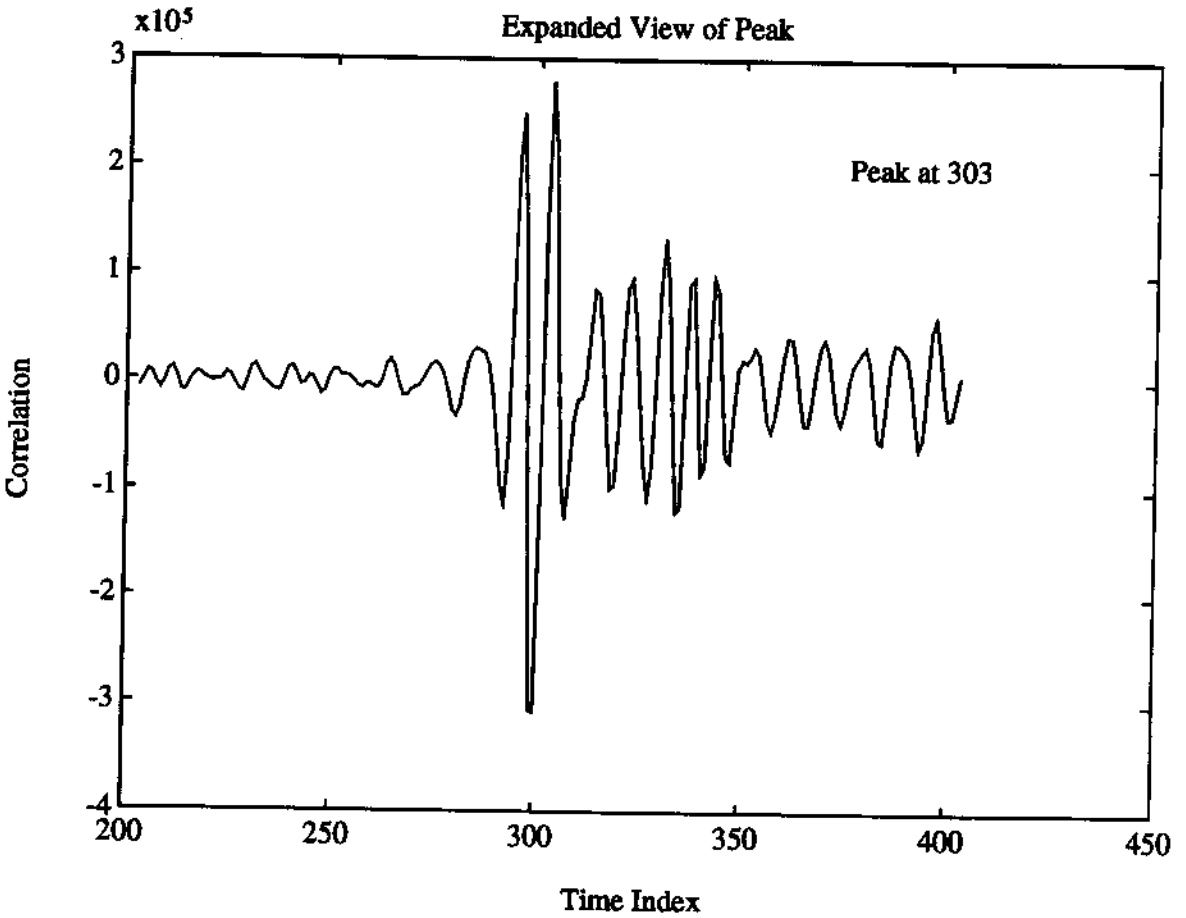

x10^5
Correlation of Received Signal and Replica
Correlation
Time Index
3
2
1
0
-1
-2
-3
-4
0
500
1000
1500
2000
2500
3000
3500
4000
4500

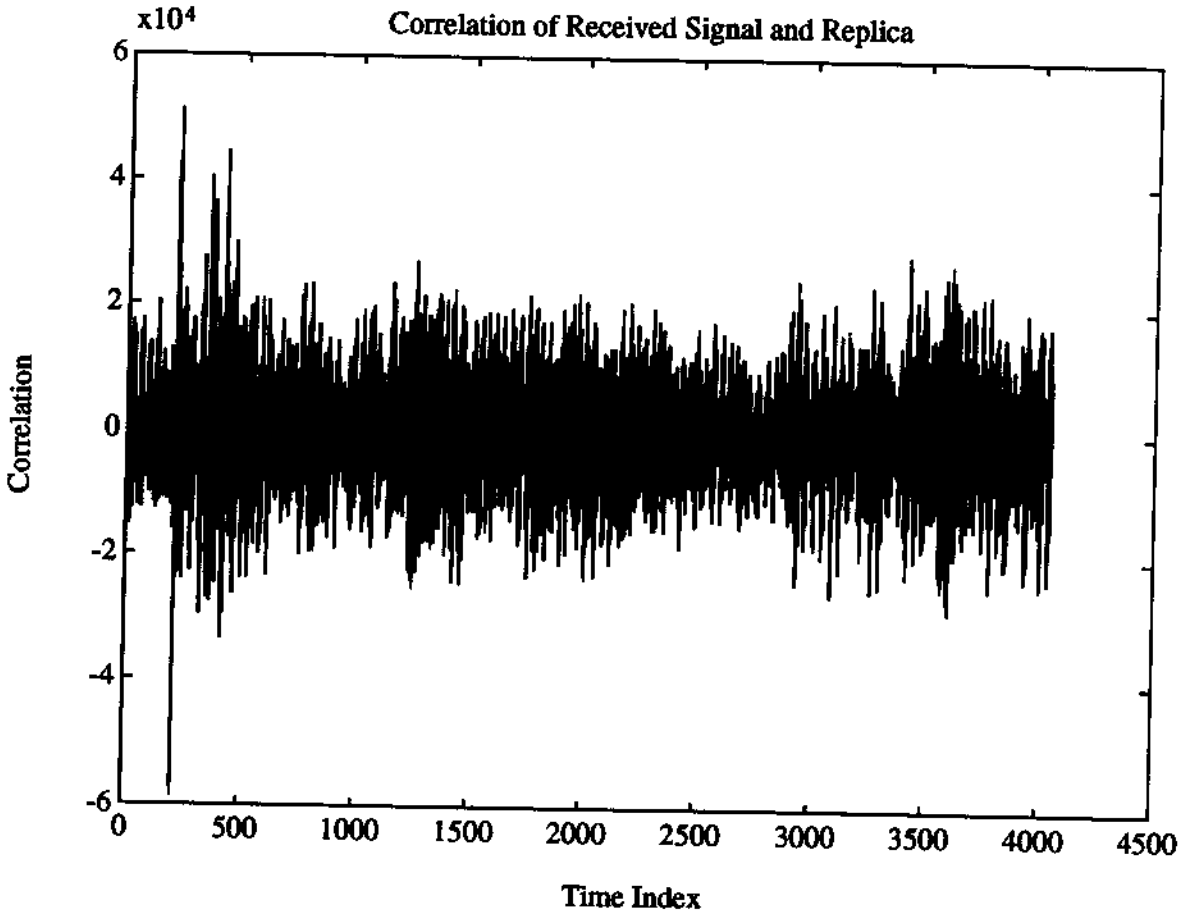

x10^5
Expanded View of Peak
Peak at 303
Correlation
Time Index
3
2
1
0
-1
-2
-3
-4
200
250
300
350
400
450

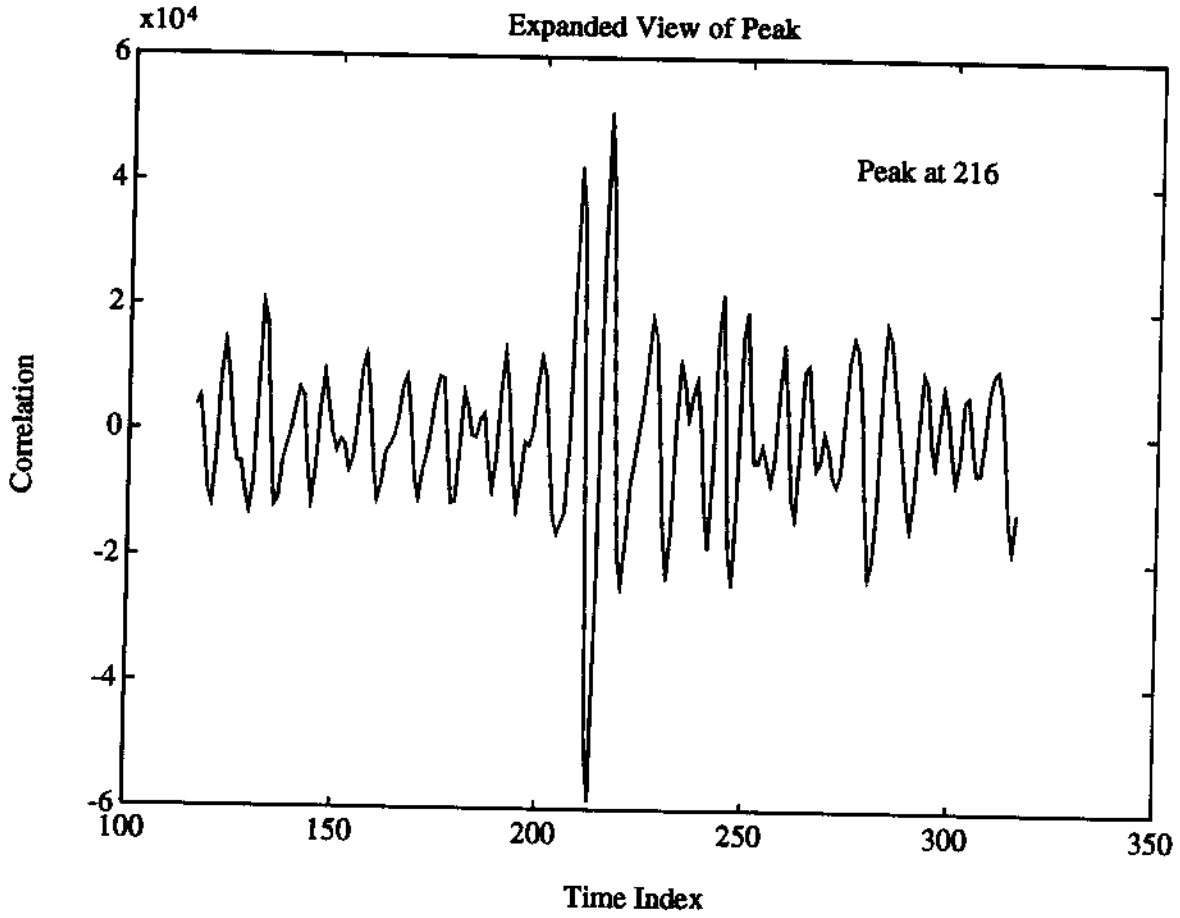

x10^5
Correlation of Received Signal and Replica
Correlation
Time Index
3
2
1
0
-1
-2
-3
-4
0
500
1000
1500
2000
2500
3000
3500
4000
4500

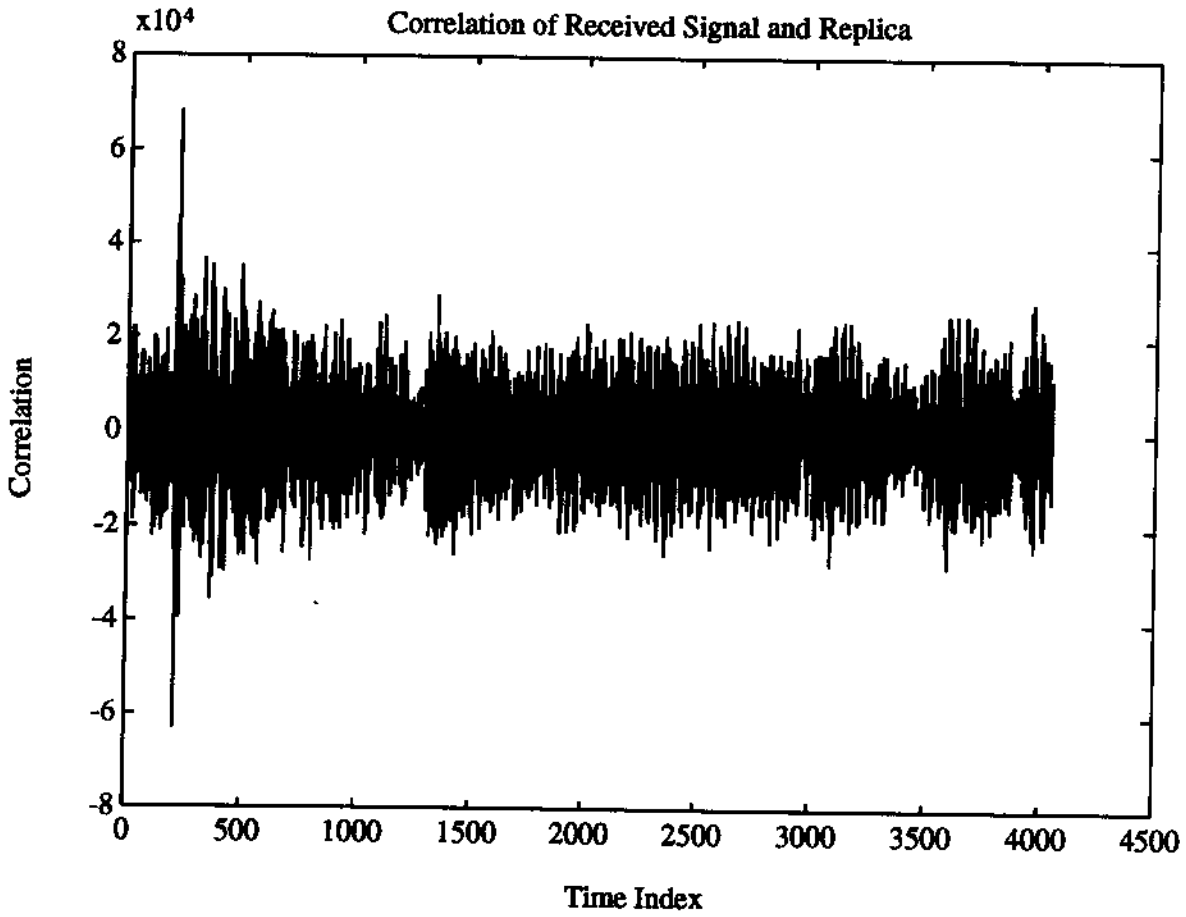

x10^5
Expanded View of Peak
Peak at 302
Correlation
Time Index
3
2
1
0
-1
-2
-3
-4
200
250
300
350
400
450

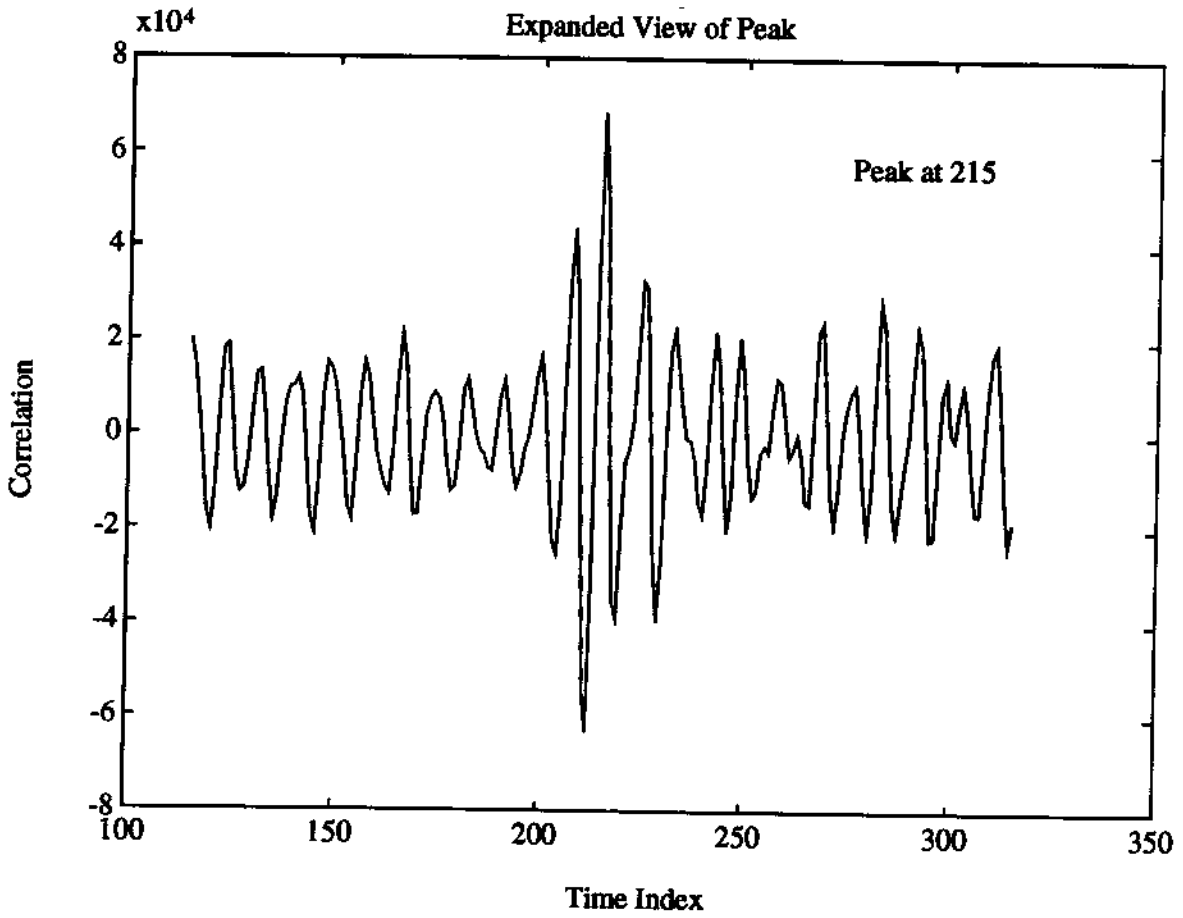

x10^5
Correlation of Received Signal and Replica
Correlation
Time Index
3
2
1
0
-1
-2
-3
-4
0
500
1000
1500
2000
2500
3000
3500
4000
4500

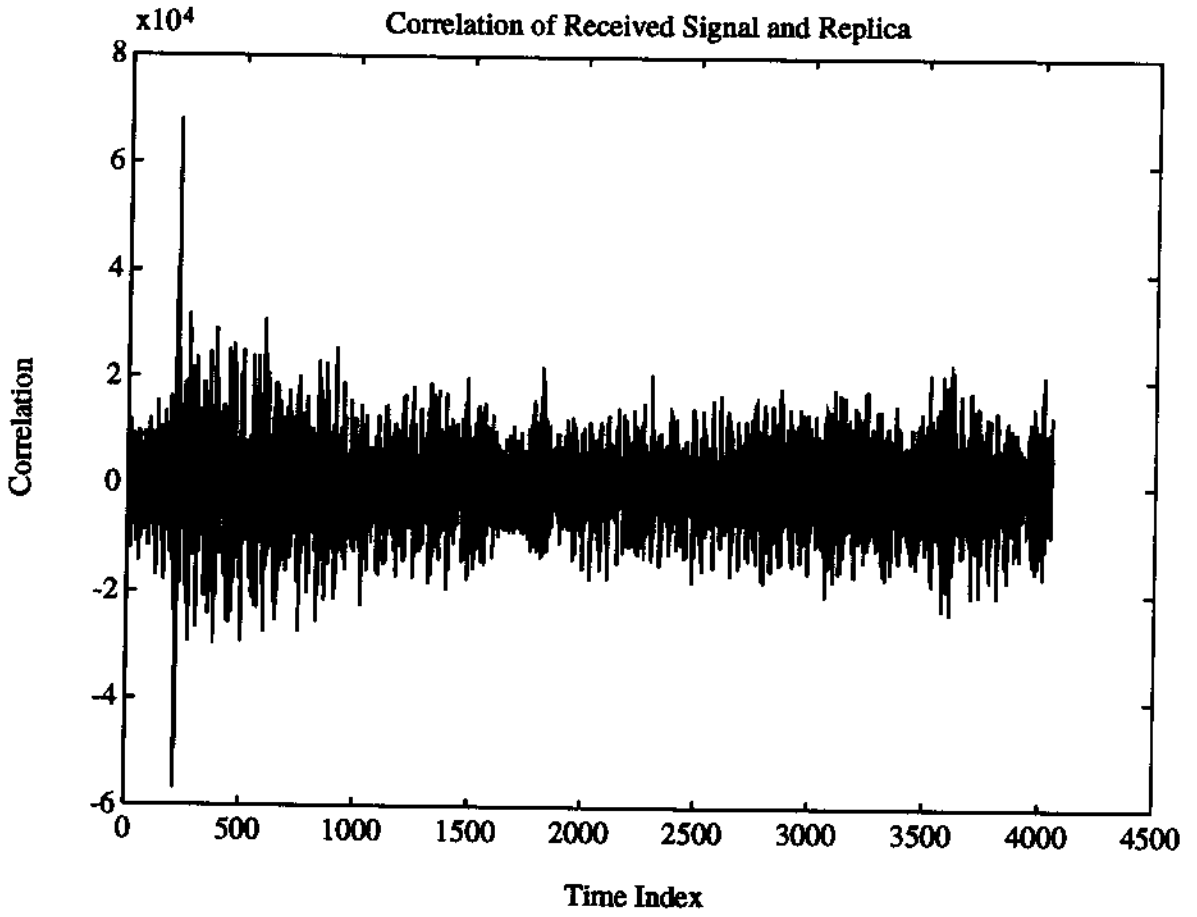

x10^5
Expanded View of Peak
Peak at 303
Correlation
Time Index
3
2
1
0
-1
-2
-3
-4
200
250
300
350
400
450


x10^4
Correlation of Received Signal and Replica
6
4
2
0
-2
-4
-6
Correlation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
Time Index


x10^4
Expanded View of Peak
Peak at 216
6
4
2
0
-2
-4
-6
Correlation
100
150
200
250
300
350
Time Index


x10^4
Correlation of Received Signal and Replica
Correlation
Time Index
8
6
4
2
0
-2
-4
-6
-8
0
500
1000
1500
2000
2500
3000
3500
4000
4500


x10^4
Expanded View of Peak
Peak at 215
Correlation
Time Index
8
6
4
2
0
-2
-4
-6
-8
100
150
200
250
300
350


x10^4
Correlation of Received Signal and Replica
8
6
4
2
0
-2
-4
-6
Correlation
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1000
1500
2000
2500
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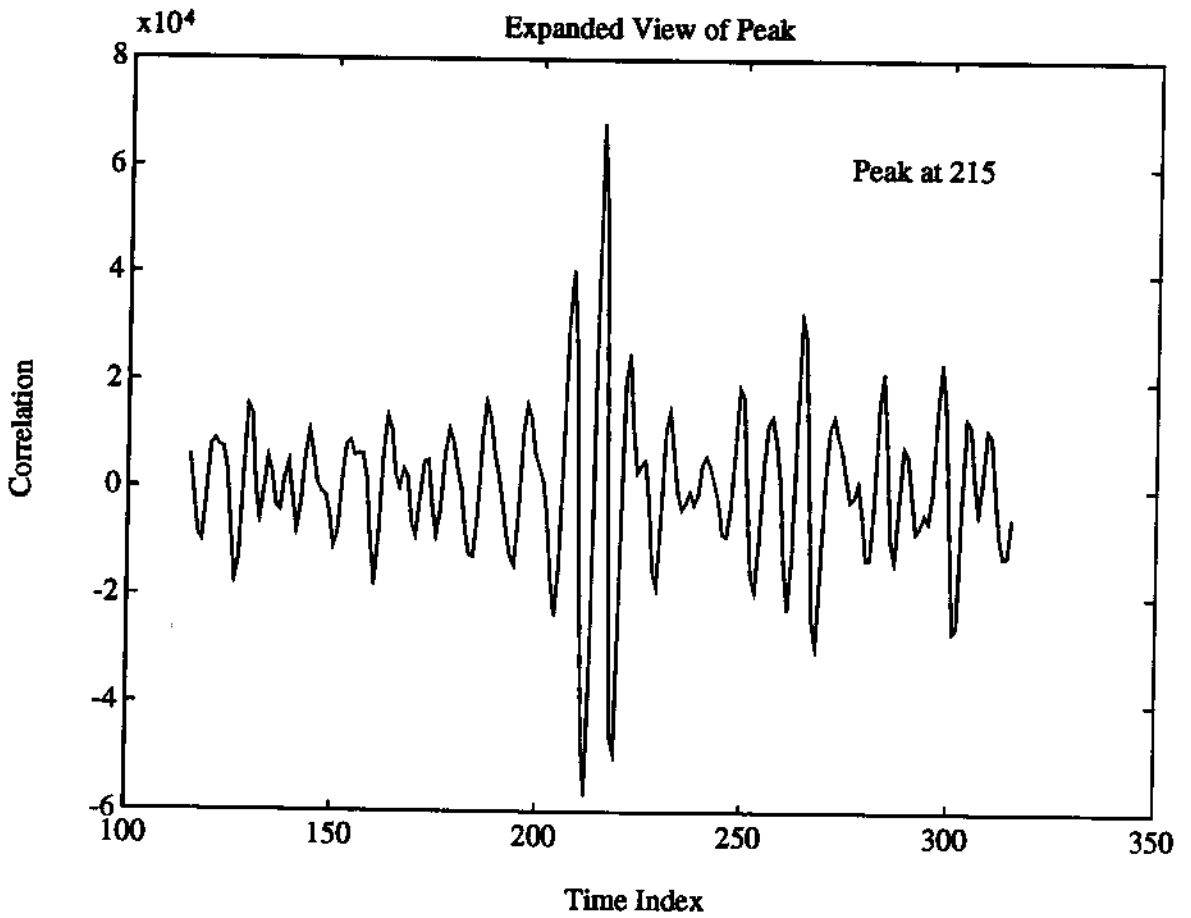
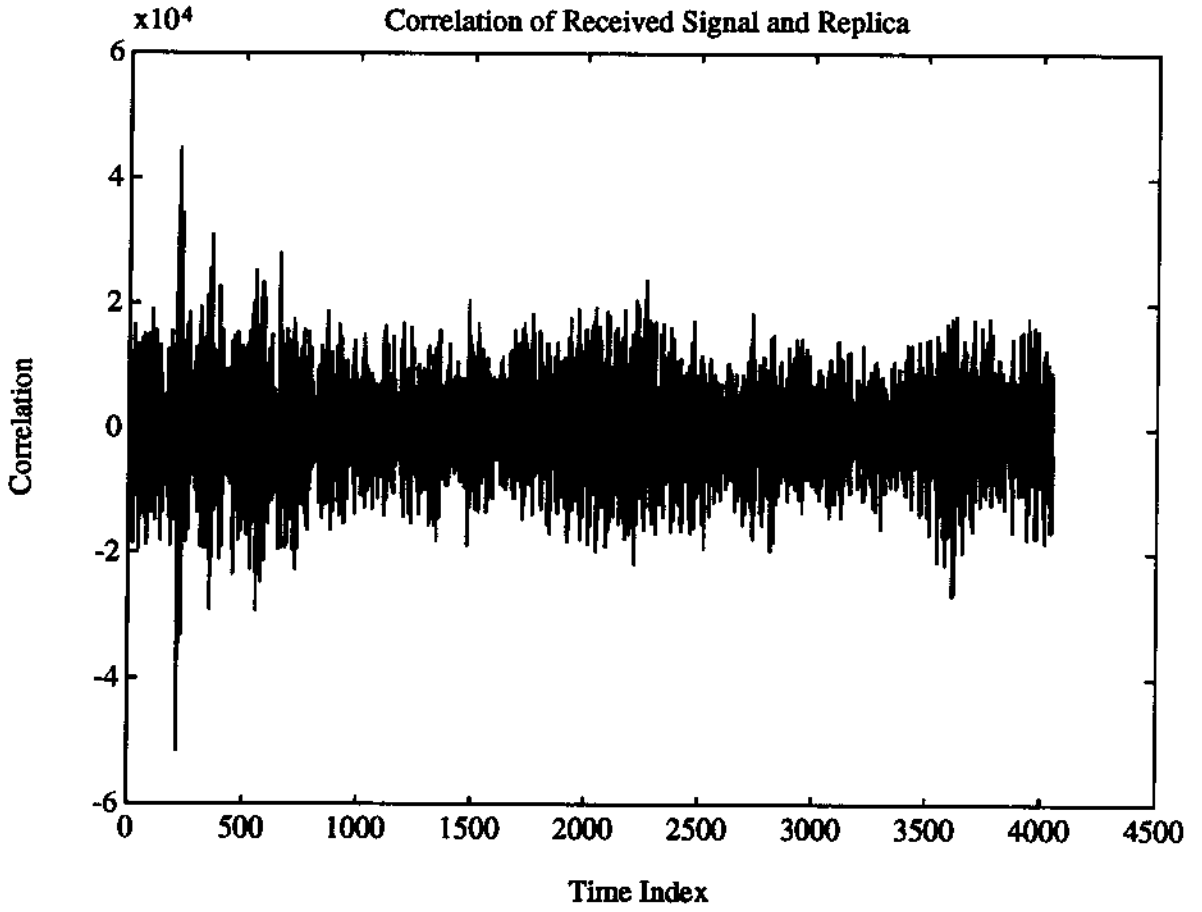
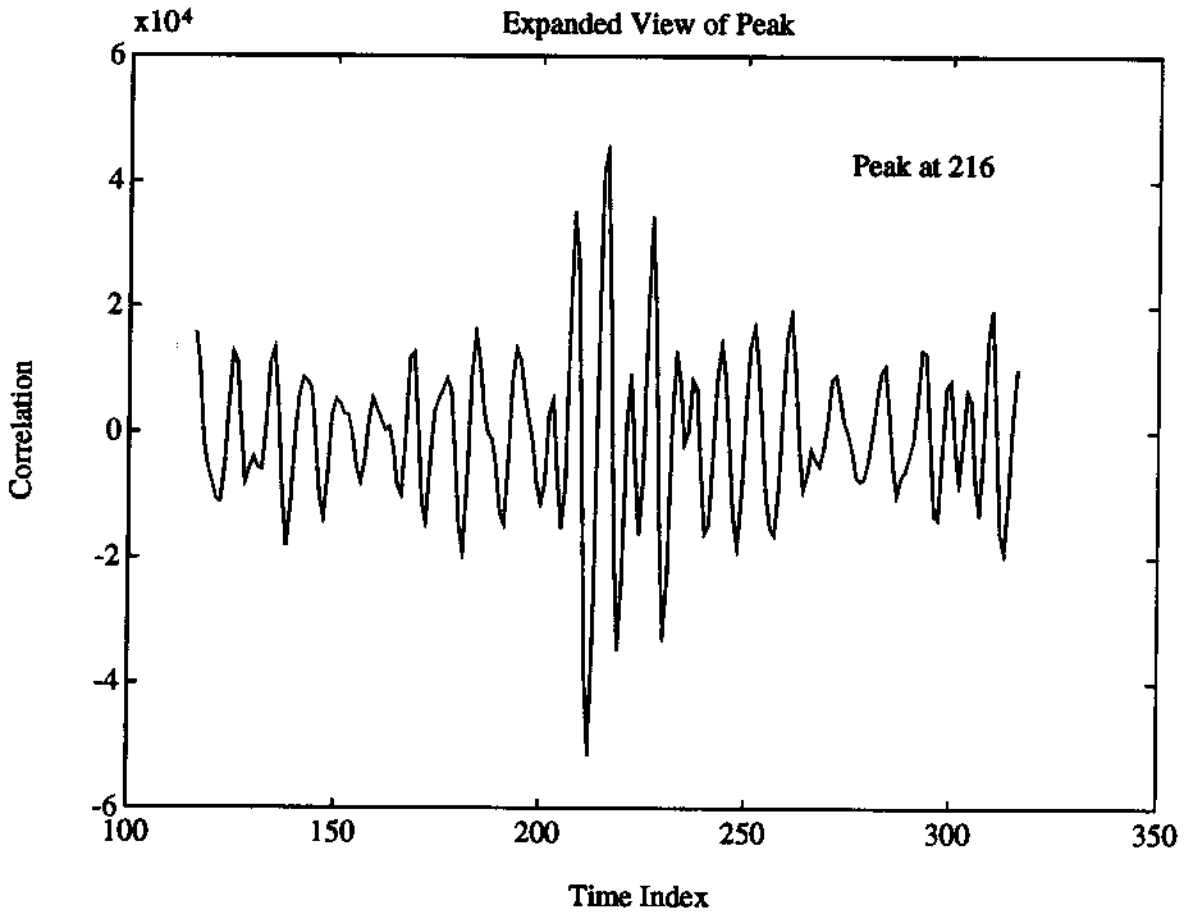
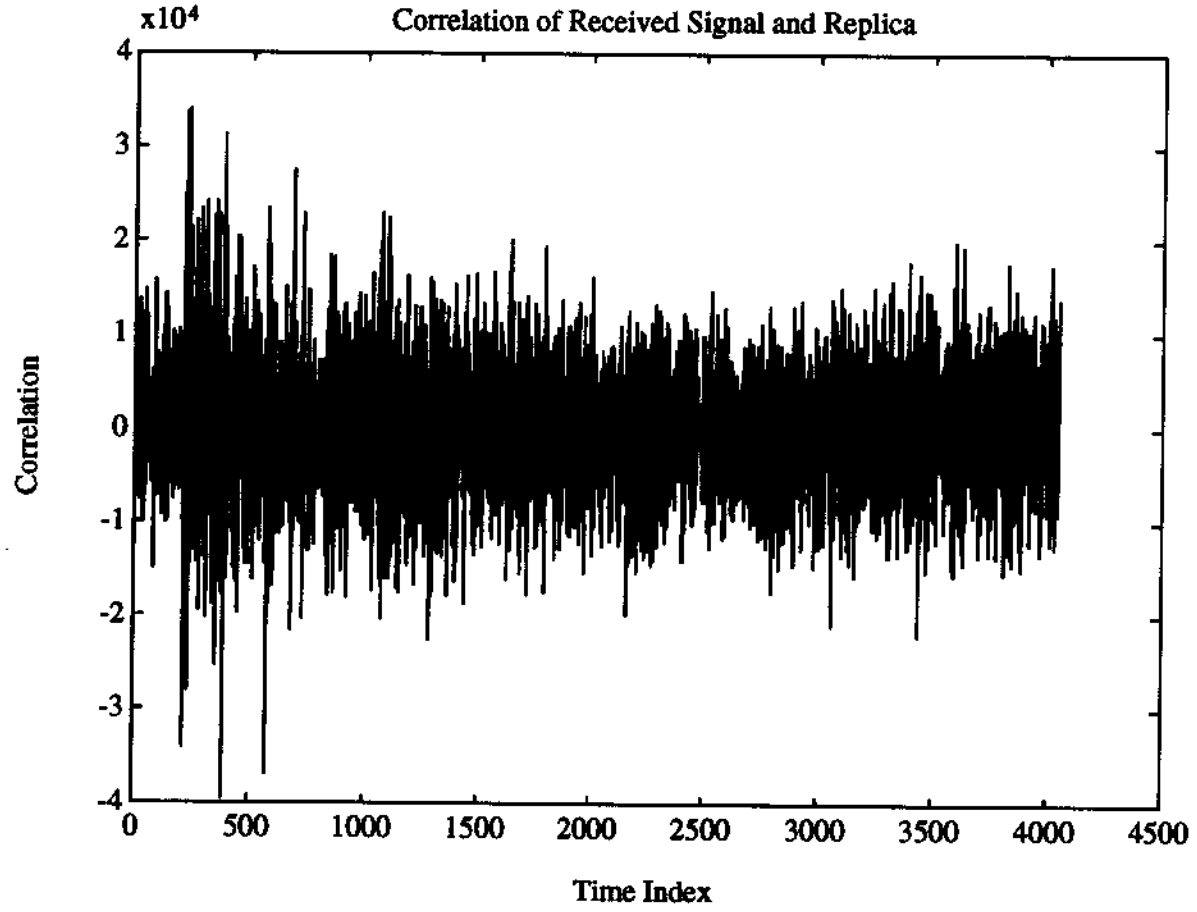
3500
4000
4500
Time Index


x10^4
Expanded View of Peak
Peak at 215
8
6
4
2
0
-2
-4
-6
Correlation
100
150
200
250
300
350
Time Index


x10^4
Correlation of Received Signal and Replica
6
4
2
0
-2
-4
-6
Correlation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
Time Index


x10^4
Expanded View of Peak
Peak at 216
6
4
2
0
-2
-4
-6
Correlation
100
150
200
250
300
350
Time Index


x10^4
Correlation of Received Signal and Replica
Correlation
Time Index
4
3
2
1
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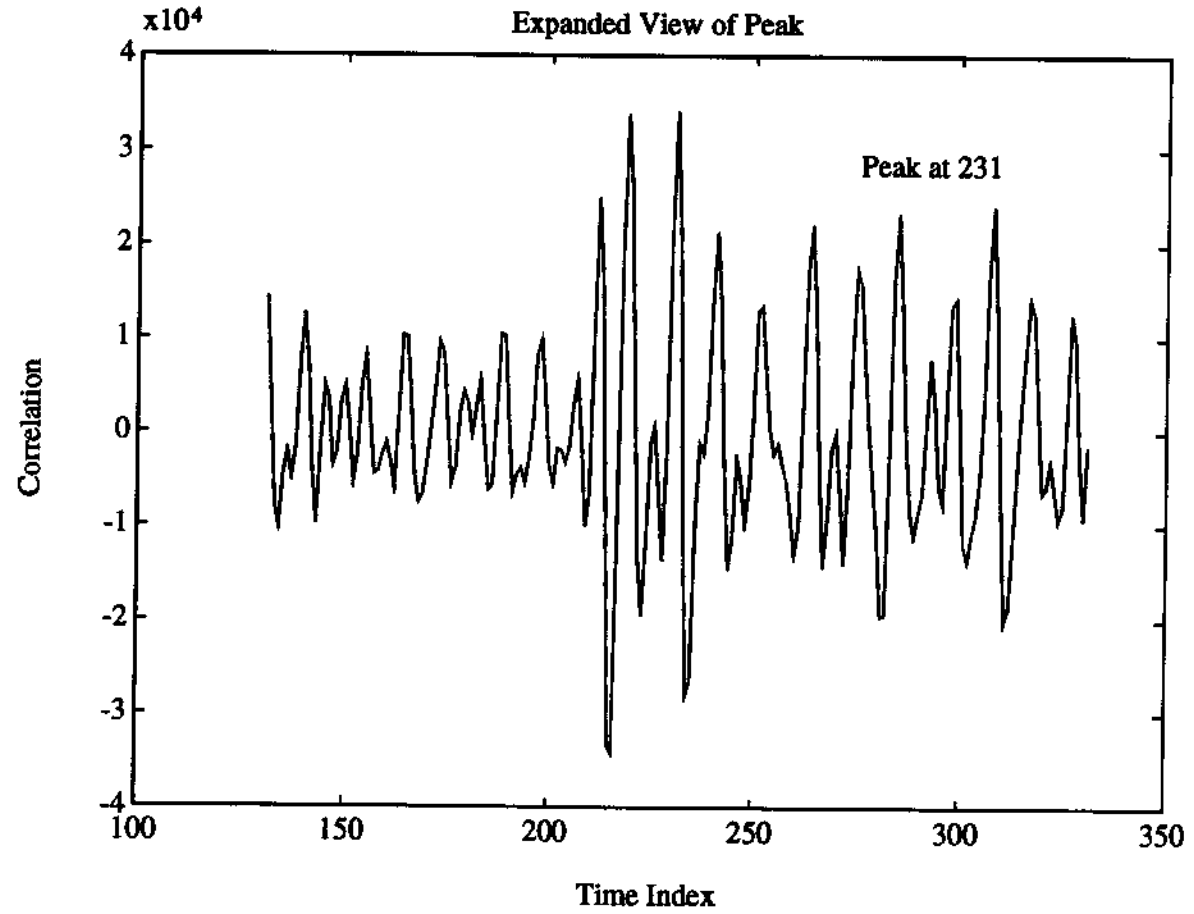
-1
-2
-3
-4
0
500
1000
1500
2000
2500
3000
3500
4000
4500


x10^4
Expanded View of Peak
Peak at 231
Correlation
Time Index
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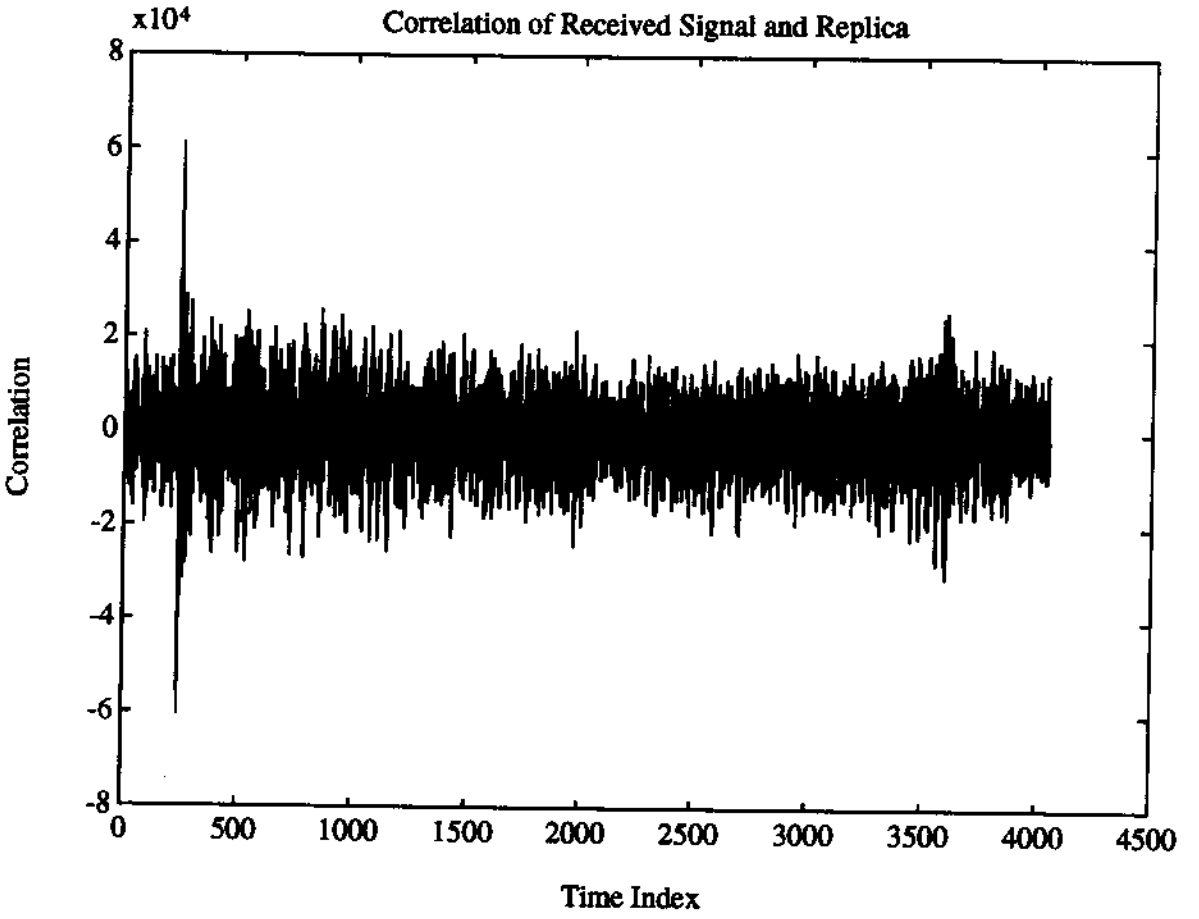
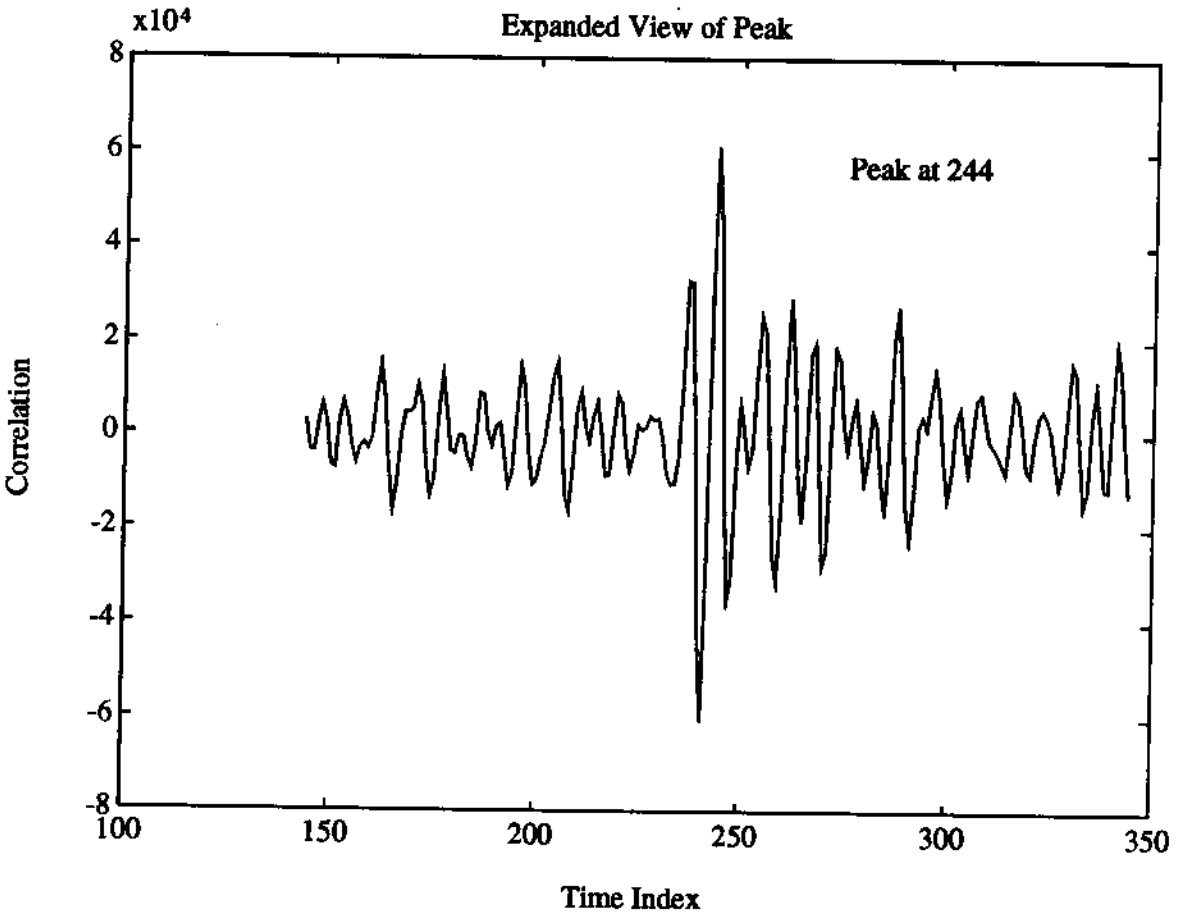
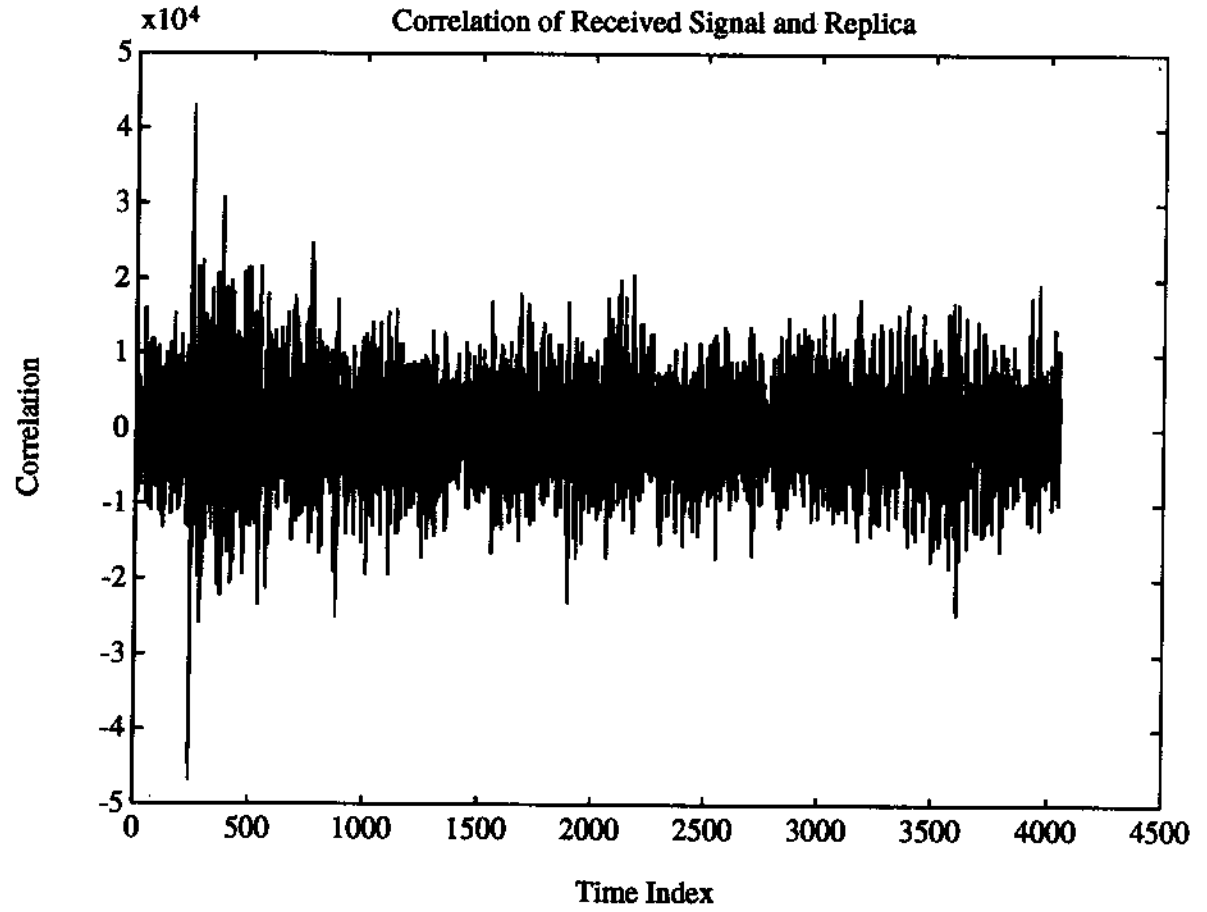
3
2
1
0
-1
-2
-3
-4
100
150
200
250
300
350


x10^4
Correlation of Received Signal and Replica
Correlation
Time Index
8
6
4
2
0
-2
-4
-6
-8
0
500
1000
1500
2000
2500
3000
3500
4000
4500


x10^4
Expanded View of Peak
Peak at 244
Correlation
Time Index
8
6
4
2
0
-2
-4
-6
-8
100
150
200
250
300
350


x10^4
Correlation of Received Signal and Replica
Correlation
Time Index
5
4
3
2
1
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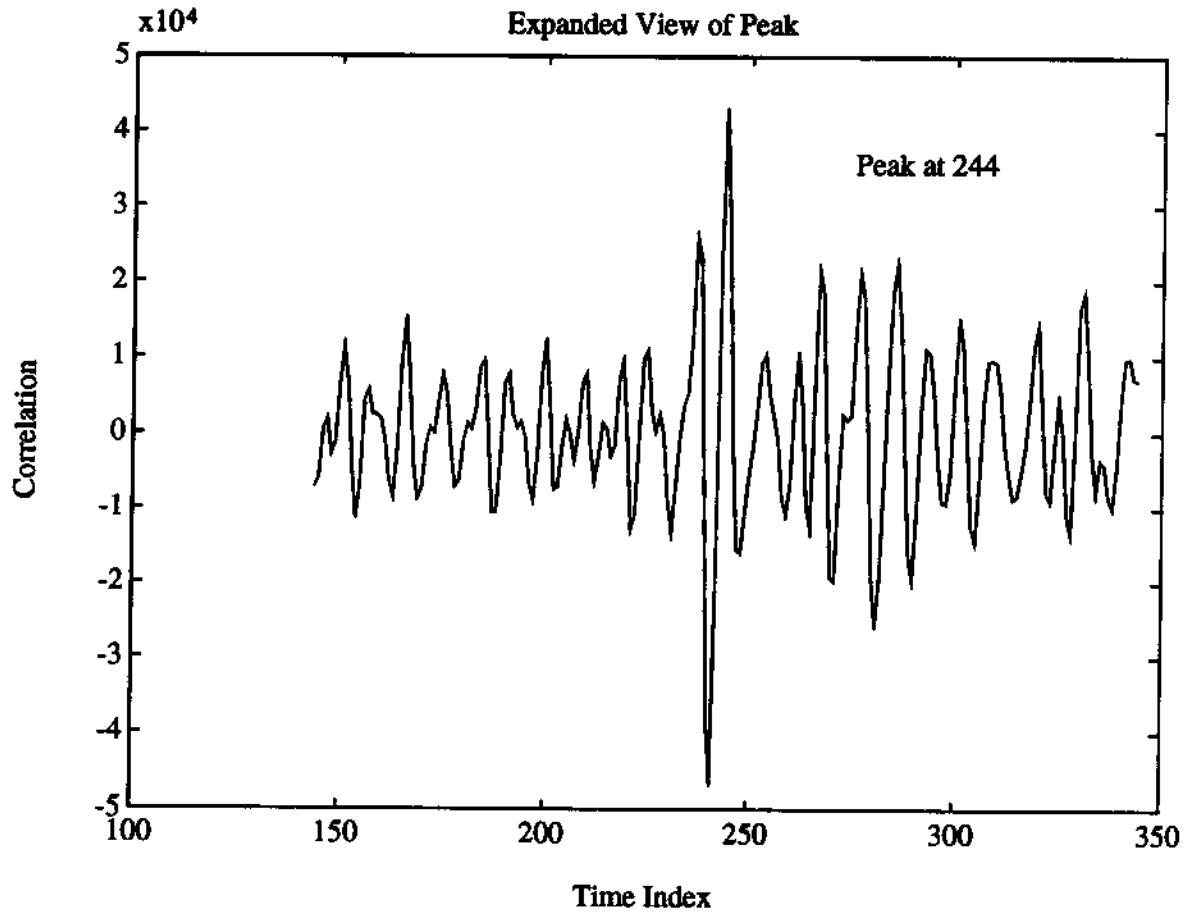
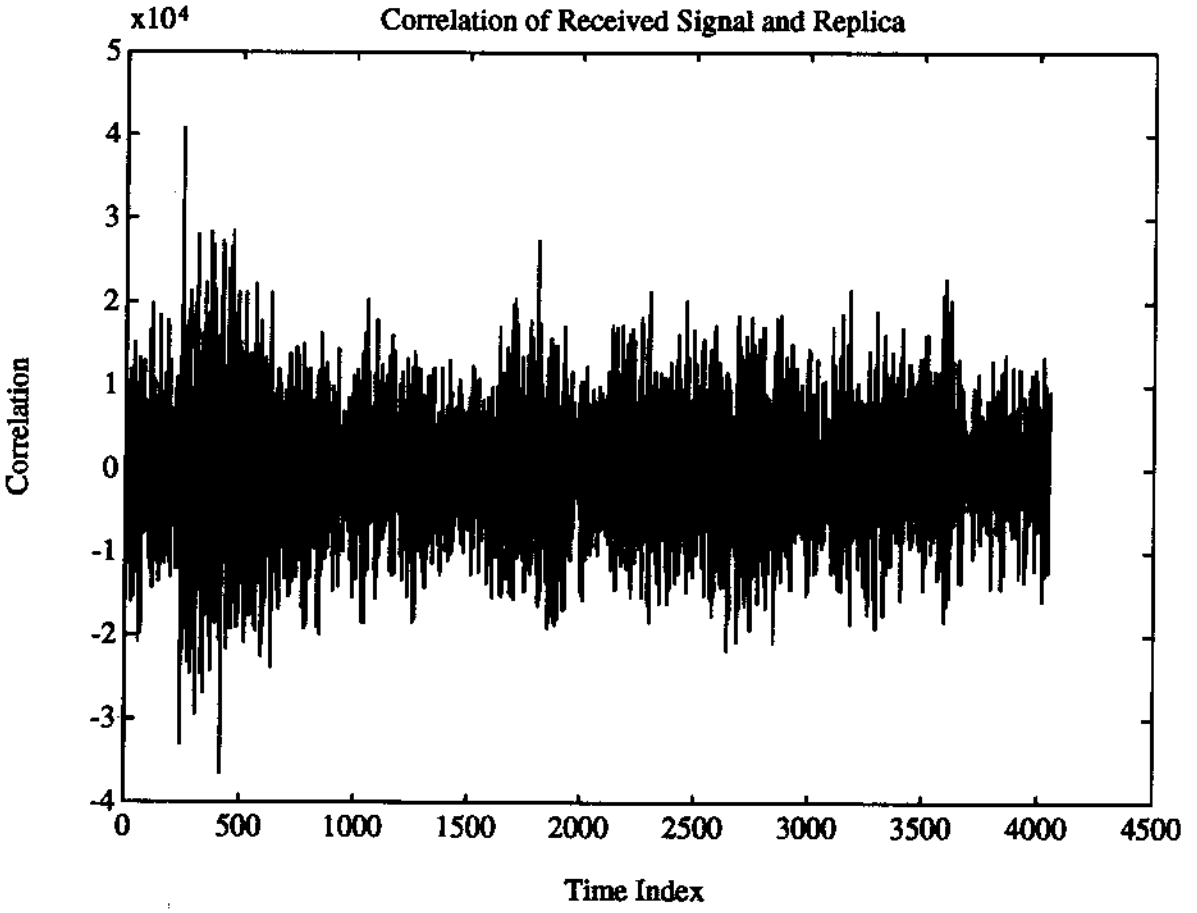
500
1000
1500
2000
2500
3000
3500
4000
4500


x10^4
Expanded View of Peak
Peak at 244
Correlation
Time Index
5
4
3
2
1
0
-1
-2
-3
-4
-5
100
150
200
250
300
350


x10^4
Correlation of Received Signal and Replica
Correlation
Time Index
5
4
3
2
1
0
-1
-2
-3
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500
1000
1500
2000
2500
3000
3500
4000
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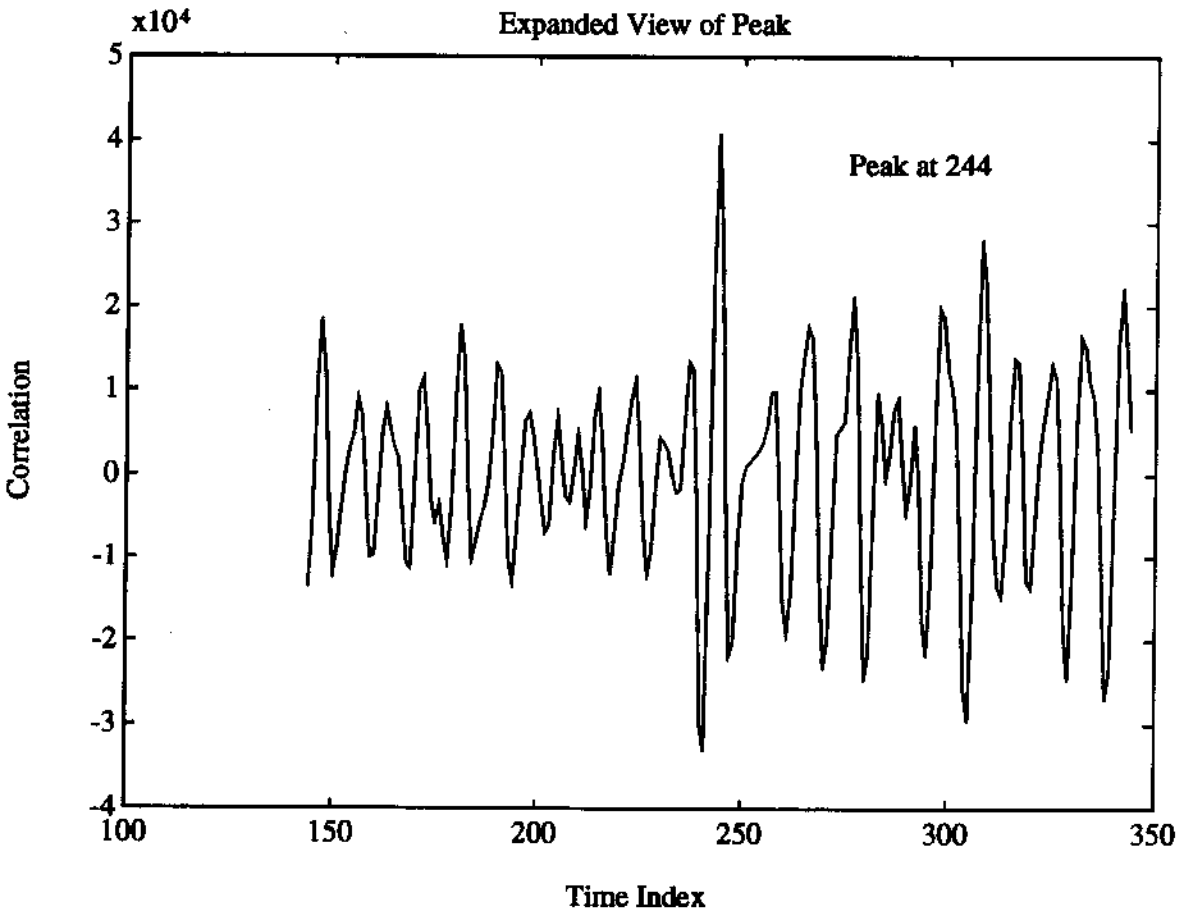
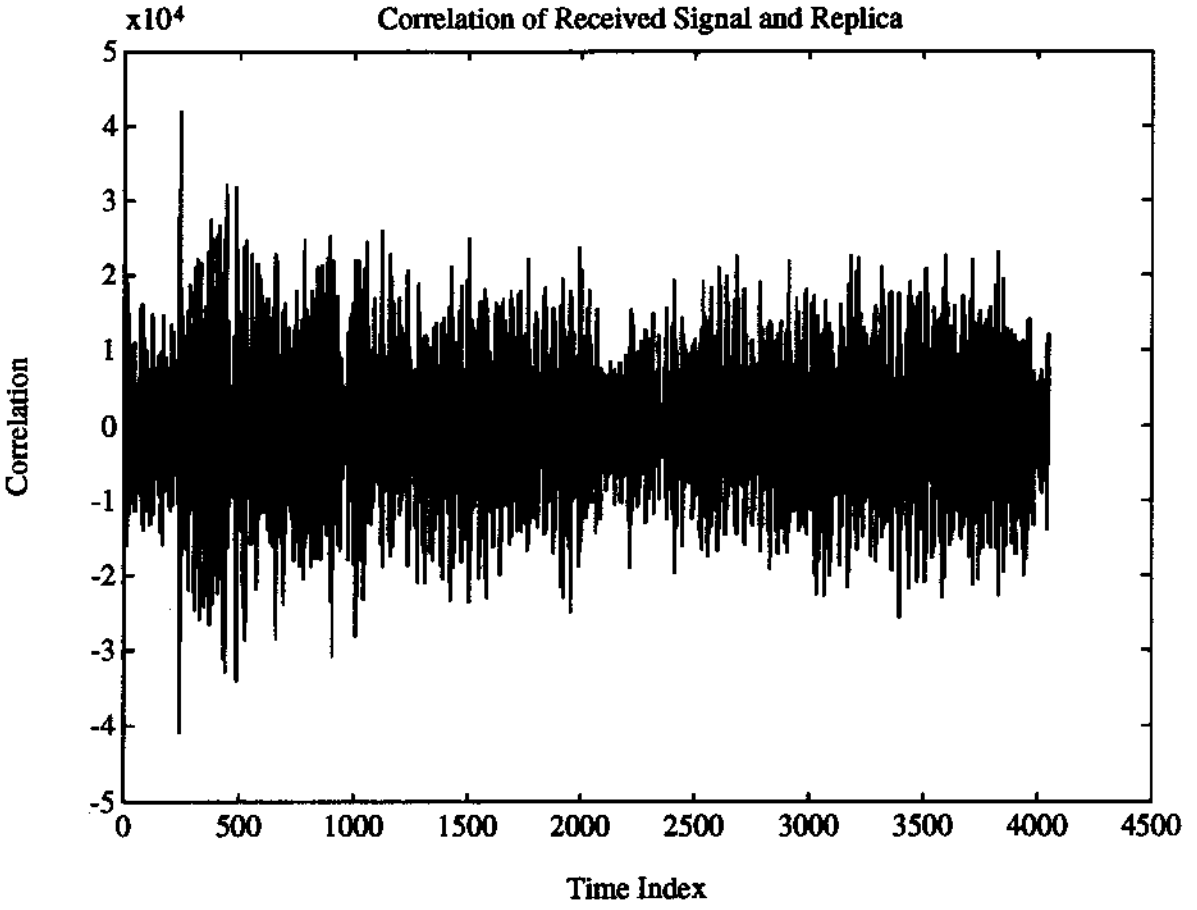
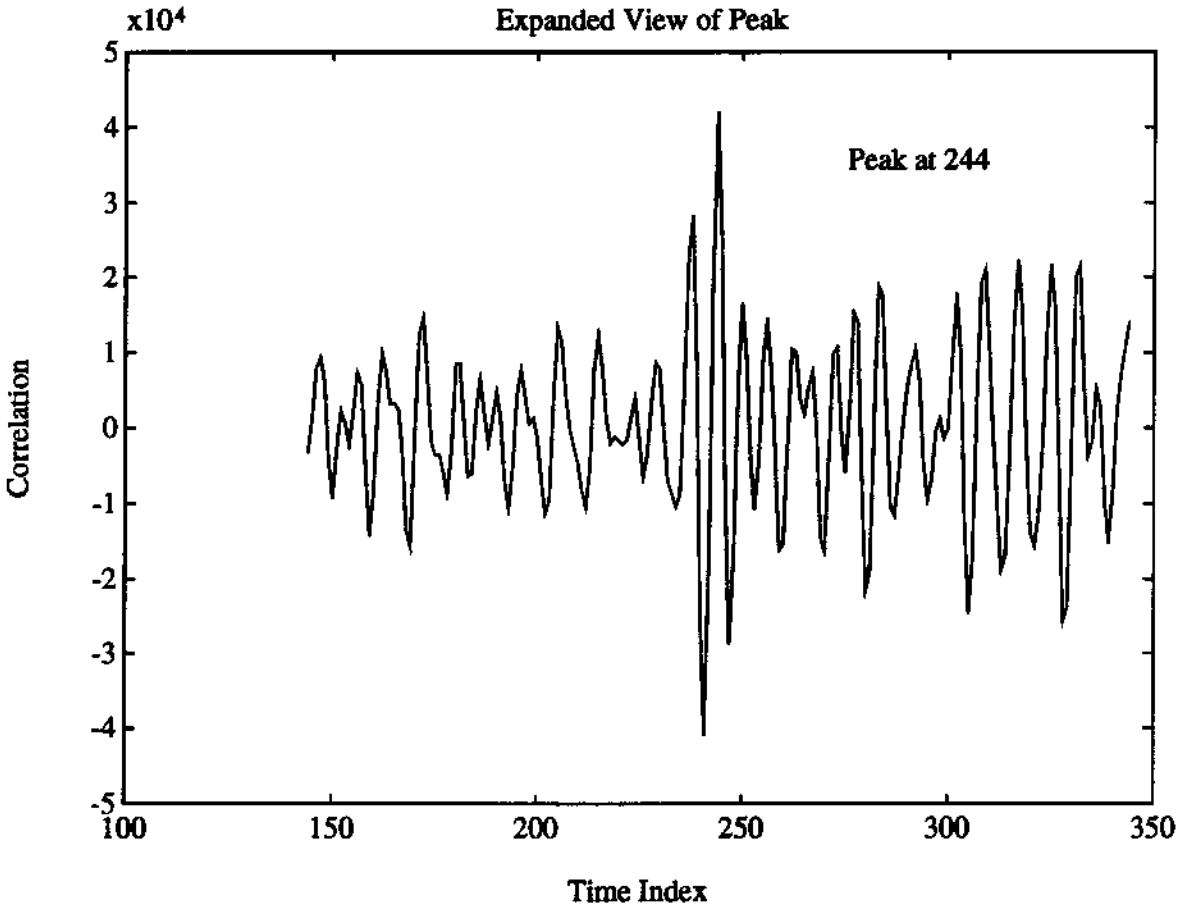
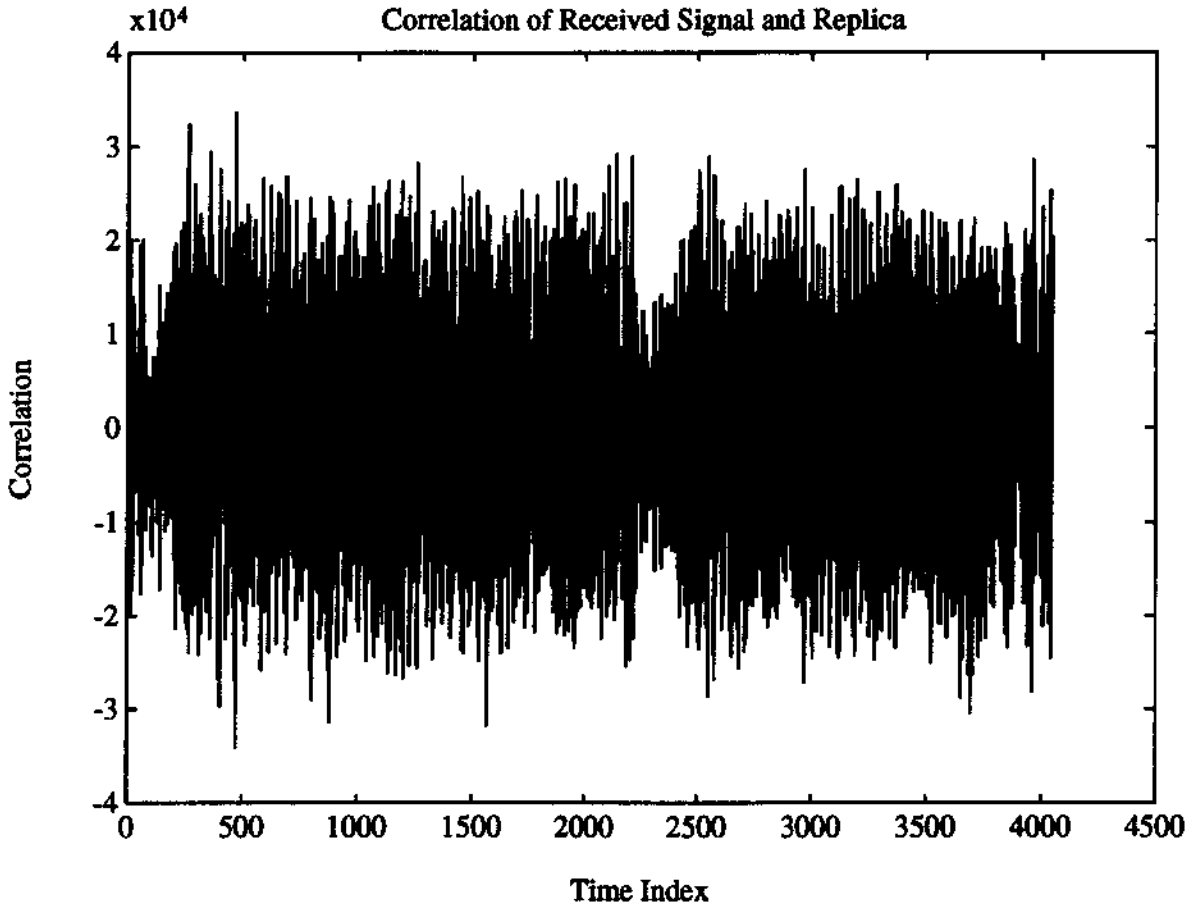
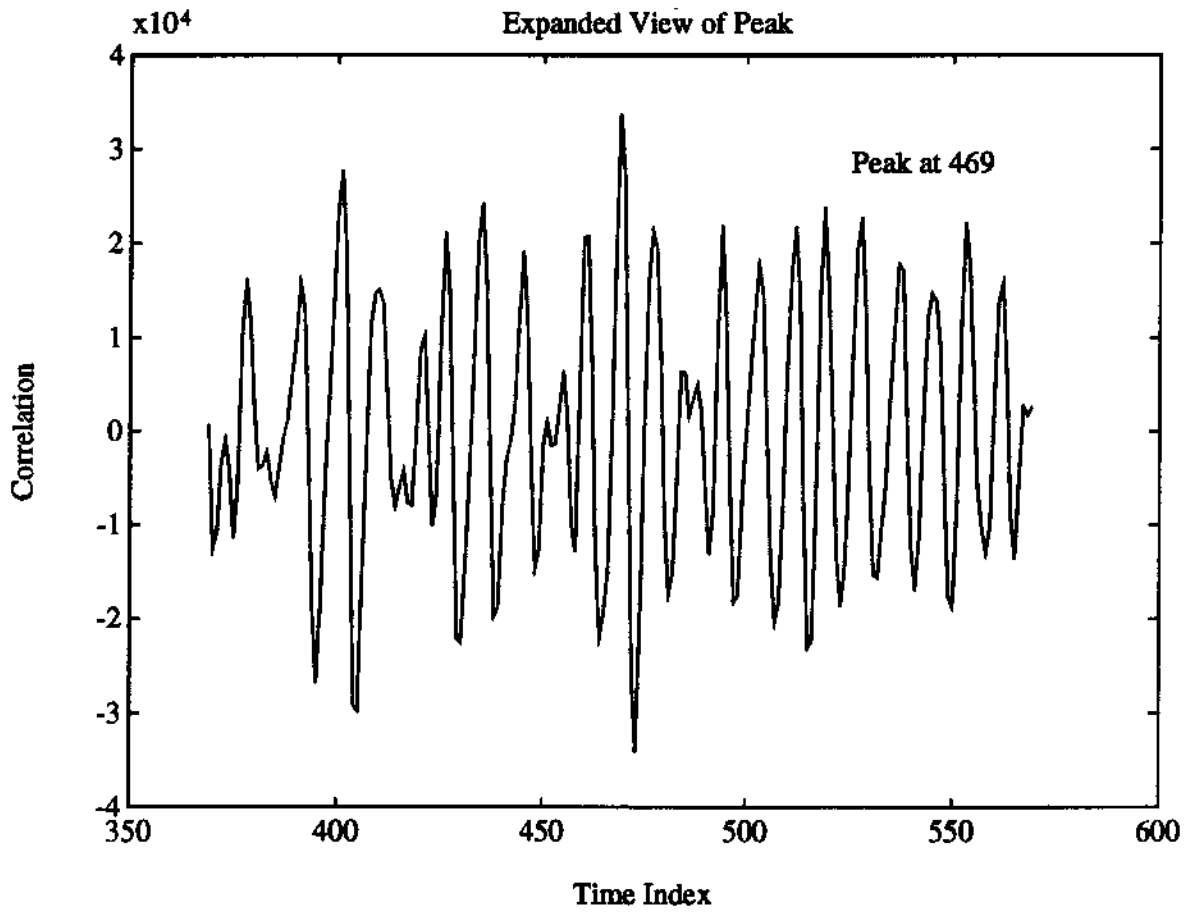
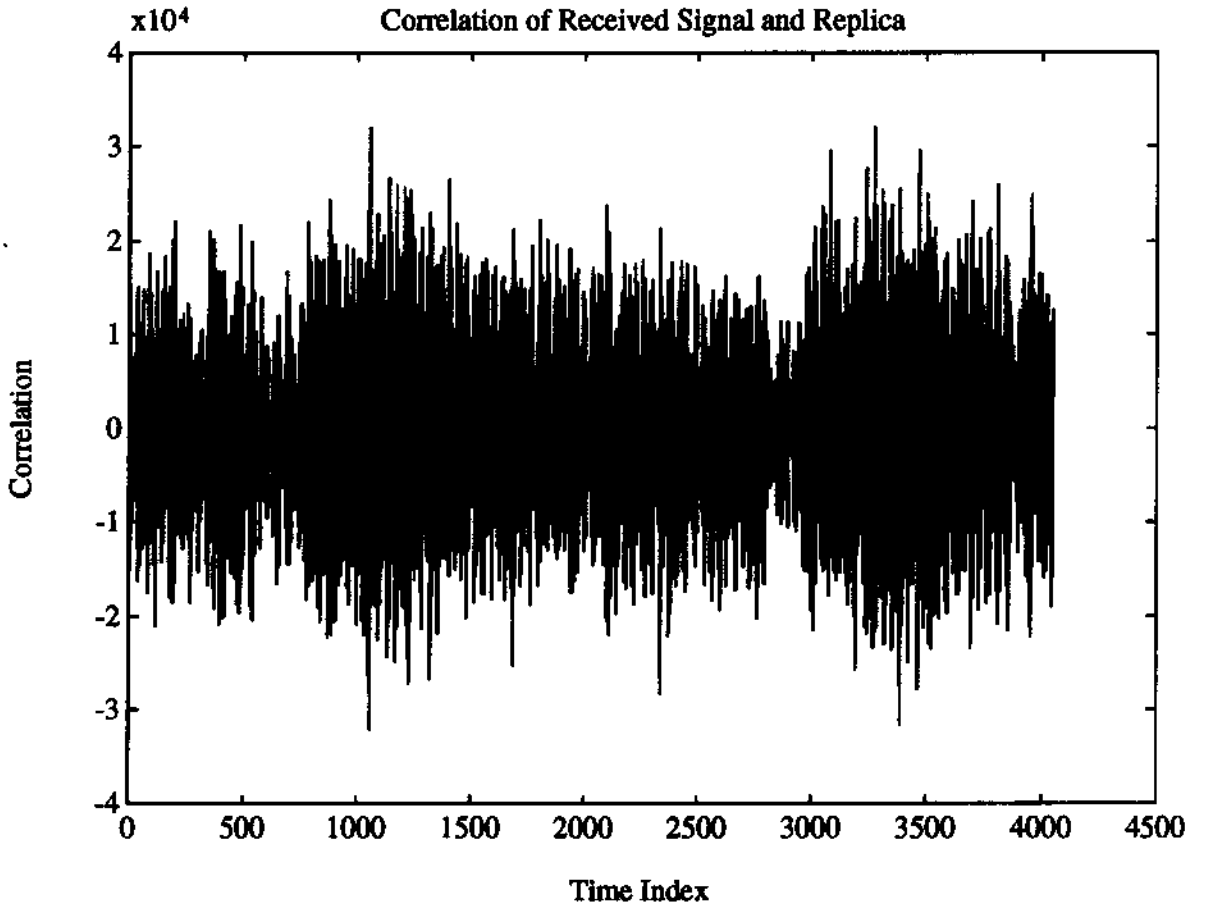

x10^4
Expanded View of Peak
Peak at 244
Correlation
Time Index
5
4
3
2
1
0
-1
-2
-3
-4
100
150
200
250
300
350


x10^4
Correlation of Received Signal and Replica
Correlation
Time Index
5
4
3
2
1
0
-1
-2
-3
-4
-5
0
500
1000
1500
2000
2500
3000
3500
4000
4500


x10^4
Expanded View of Peak
Peak at 244
Correlation
Time Index
5
4
3
2
1
0
-1
-2
-3
-4
-5
100
150
200
250
300
350


x10^4
Correlation of Received Signal and Replica
Correlation
Time Index
4
3
2
1
0
-1
-2
-3
-4
0
500
1000
1500
2000
2500
3000
3500
4000
4500


x10^4
Expanded View of Peak
Peak at 469
Correlation
Time Index
4
3
2
1
0
-1
-2
-3
-4
350
400
450
500
550
600


x10^4
Correlation of Received Signal and Replica
Correlation
Time Index
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-1
-2
-3
-4
0
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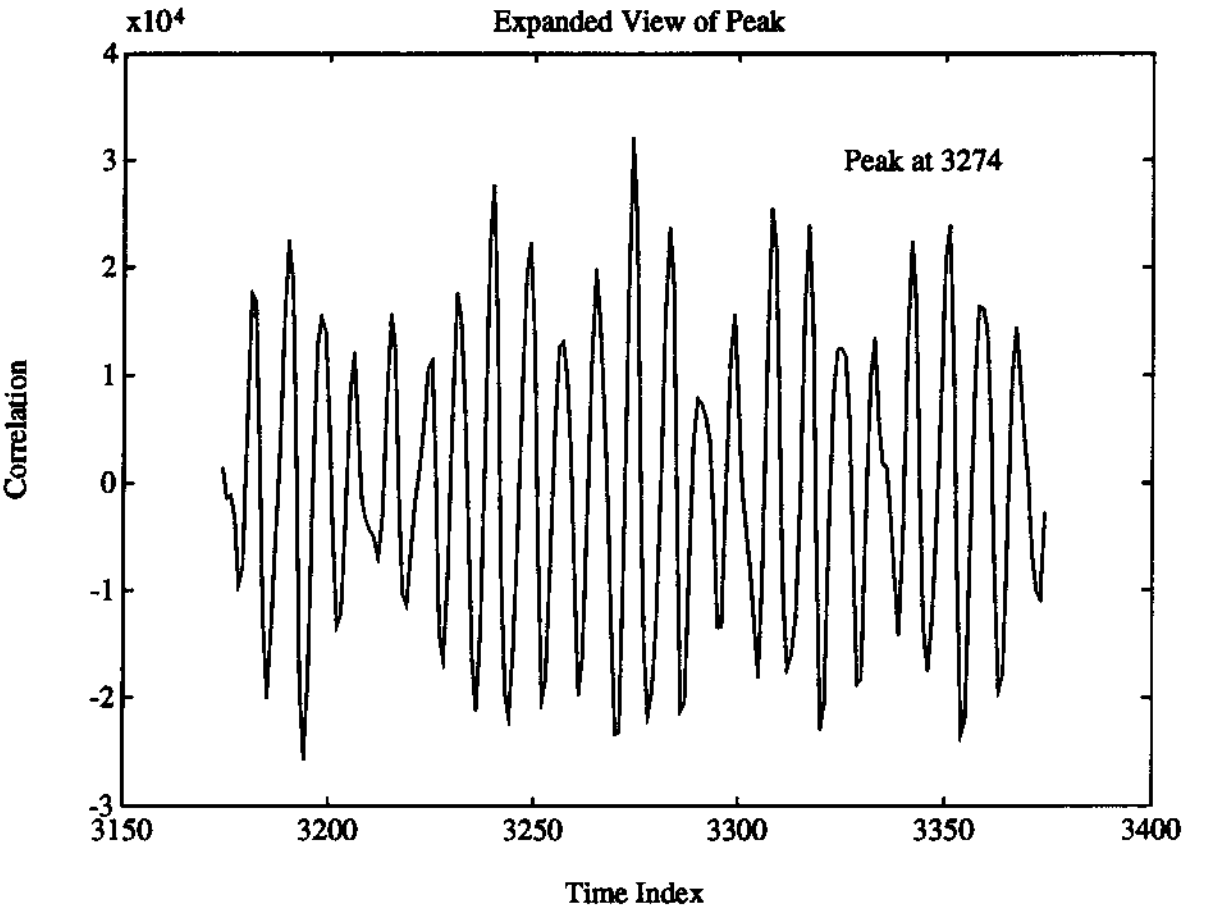
1500
2000
2500
3000
3500
4000
4500


x10^4
Expanded View of Peak
Peak at 3274
Correlation
Time Index
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1
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-2
-3
3150
3200
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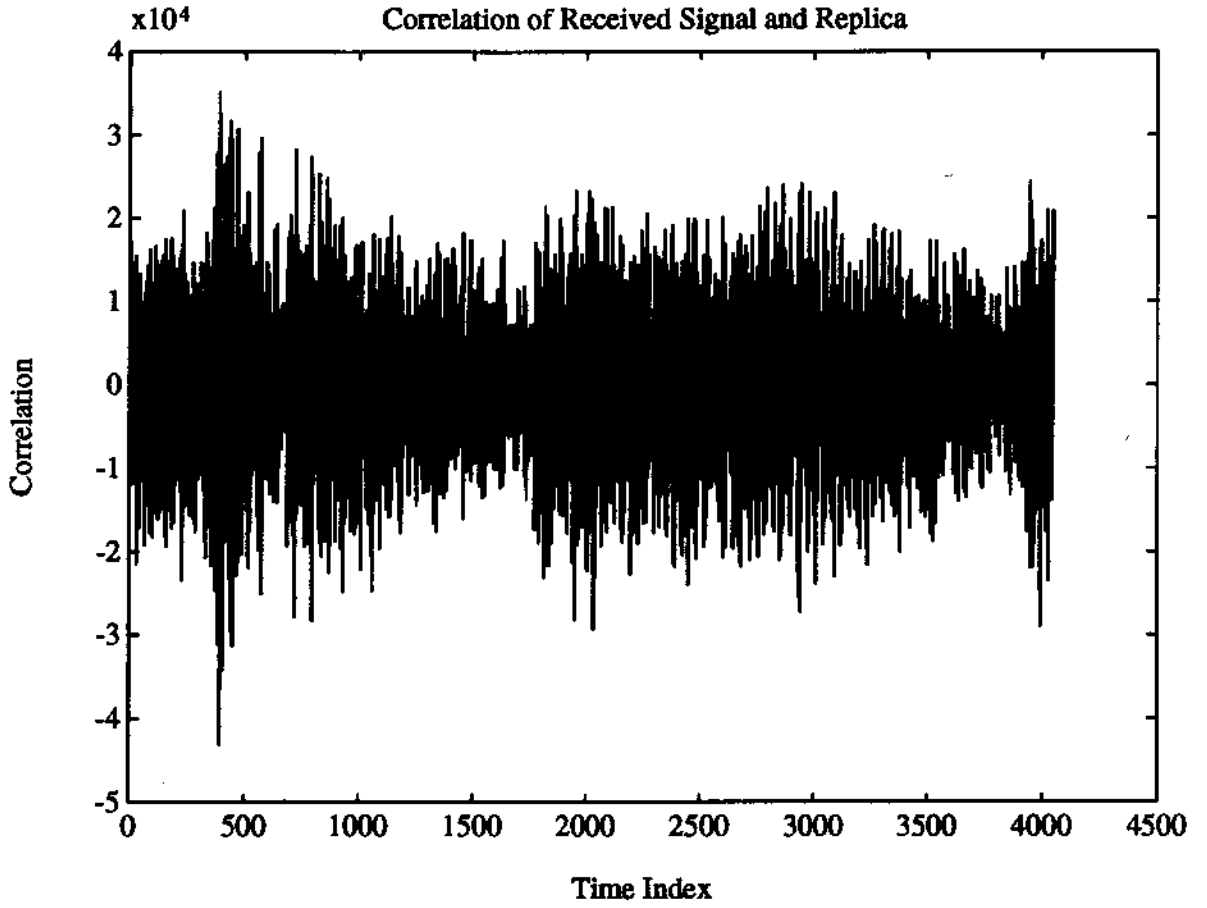
3300
3350
3400


x10^4
Correlation of Received Signal and Replica
Correlation
Time Index
4
3
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1
0
-1
-2
-3
-4
-5
0
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1500
2000
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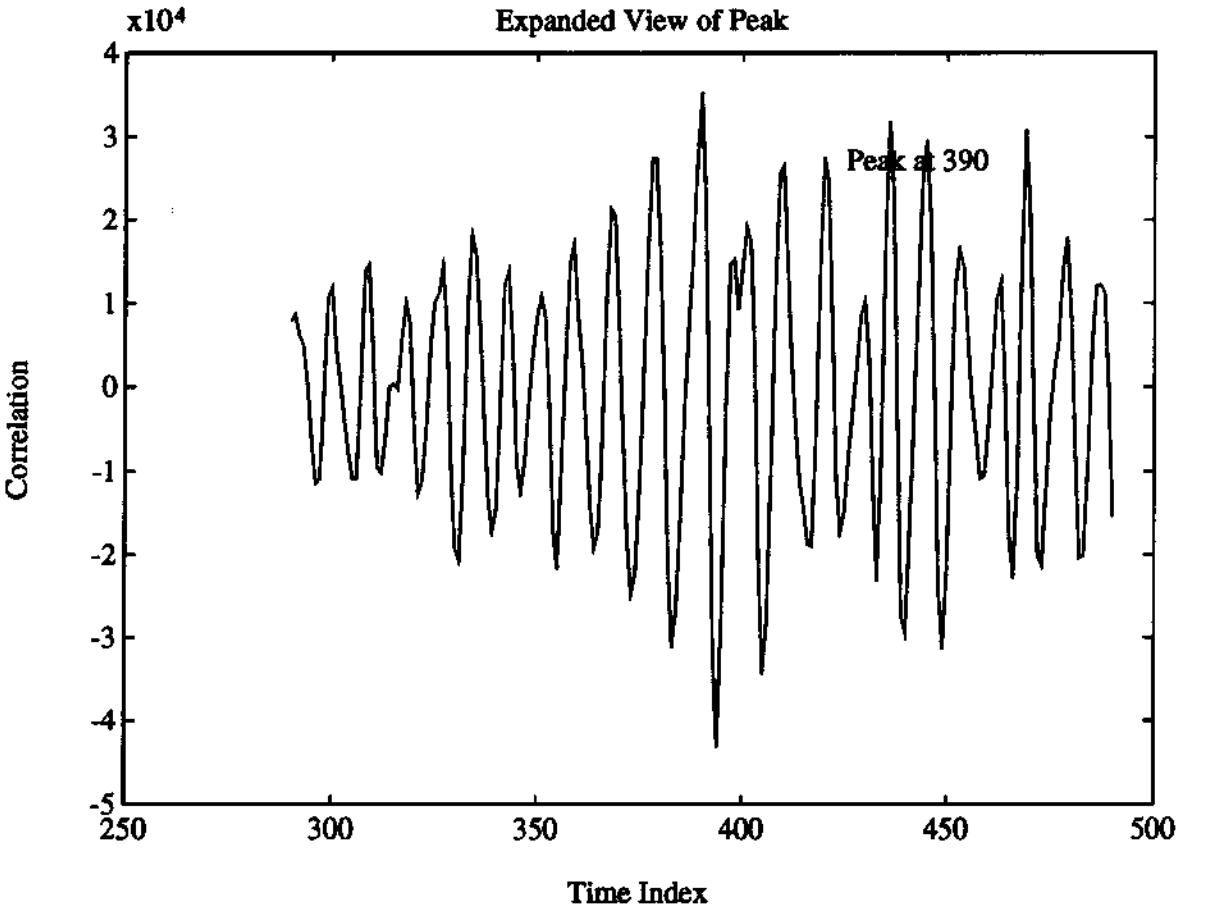
3500
4000
4500


x10^4
Expanded View of Peak
Peak at 390
Correlation
Time Index
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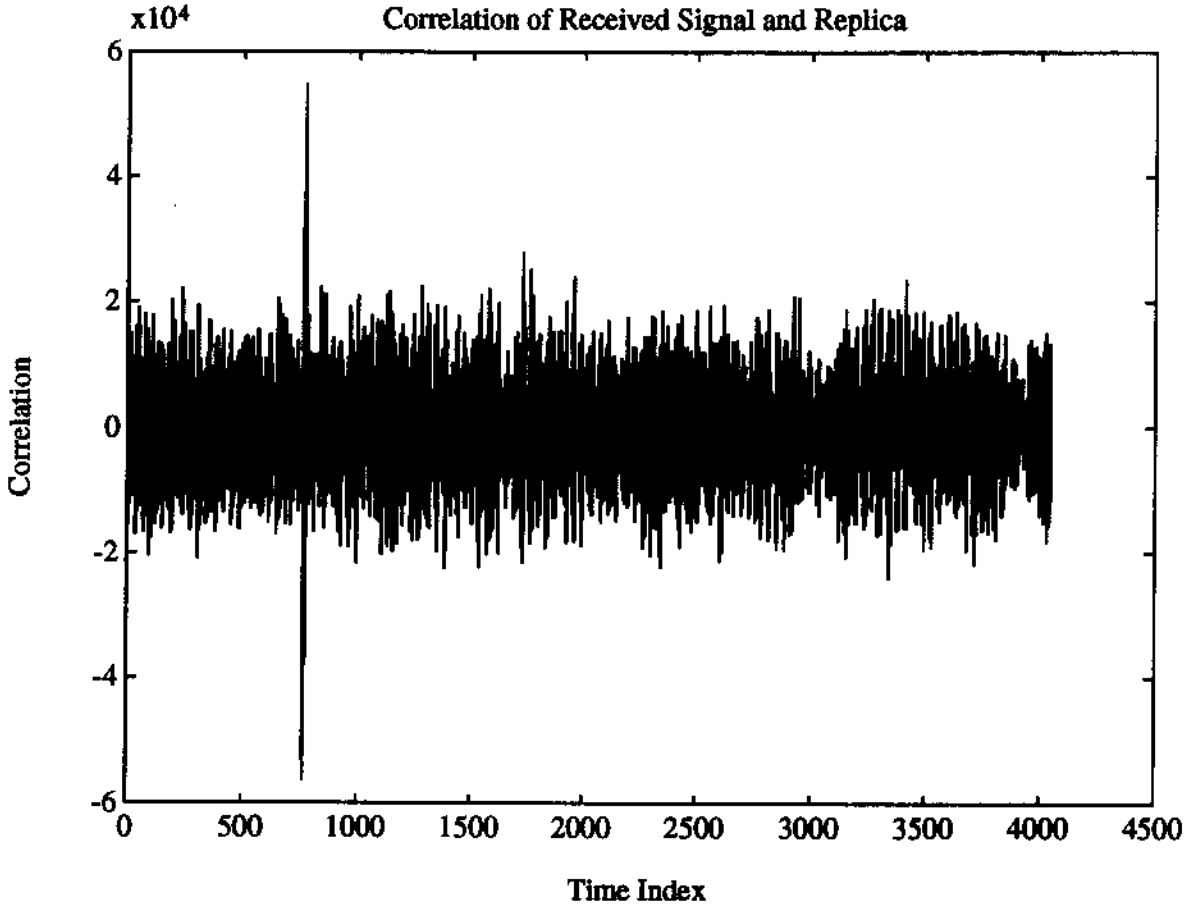
3
2
1
0
-1
-2
-3
-4
-5
250
300
350
400
450
500


x10^4
Correlation of Received Signal and Replica
Correlation
Time Index
6
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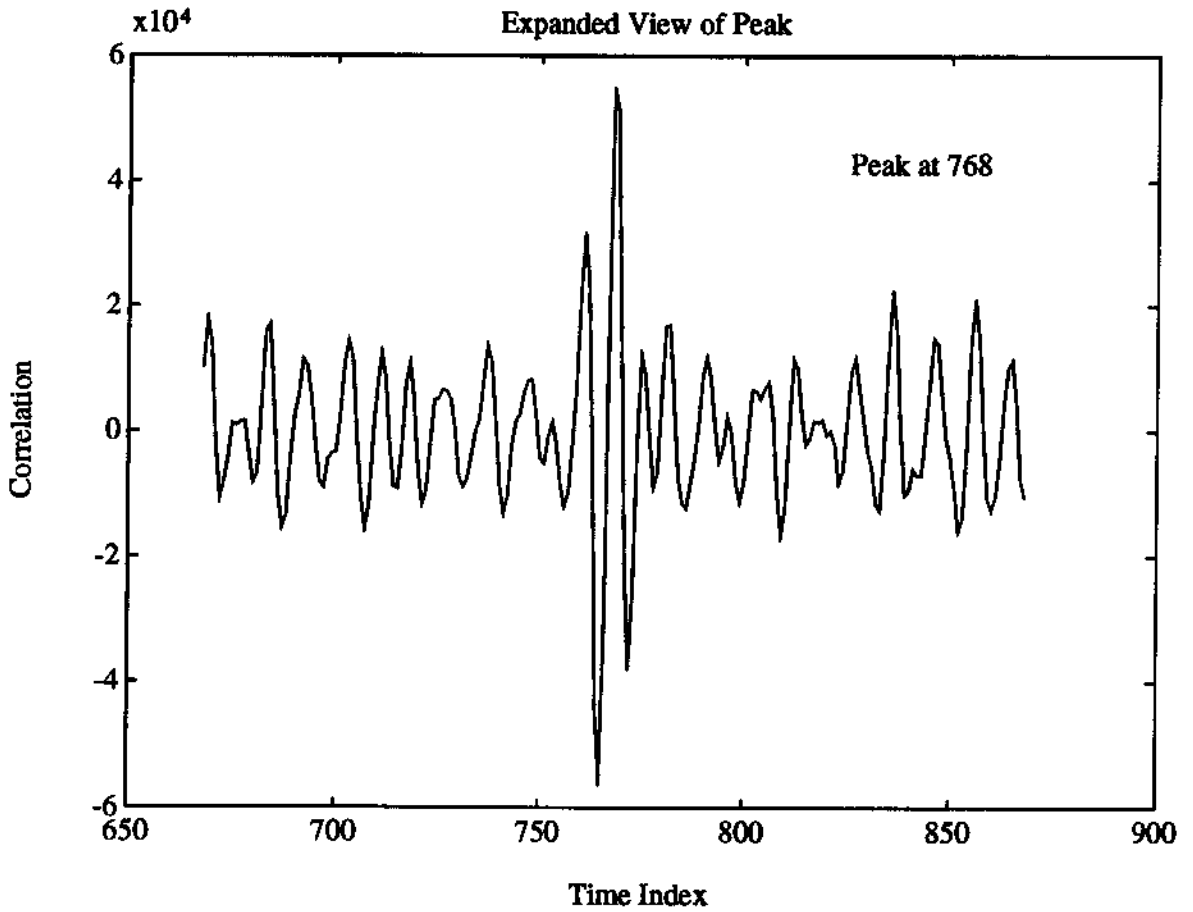
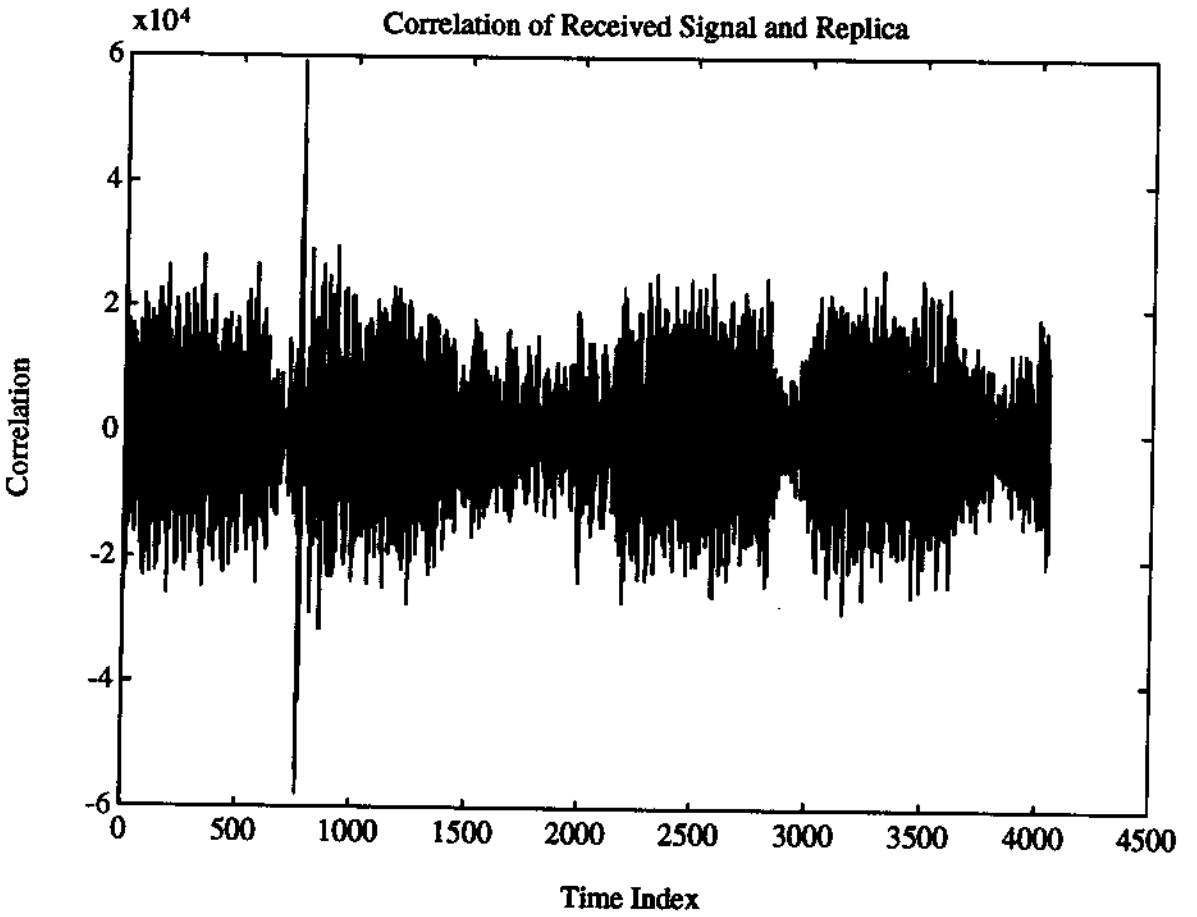
2
0
-2
-4
-6
0
500
1000
1500
2000
2500
3000
3500
4000
4500


x10^4
Expanded View of Peak
Peak at 768
Correlation
Time Index
6
4
2
0
-2
-4
-6
650
700
750
800
850
900


x10^4
Correlation of Received Signal and Replica
6
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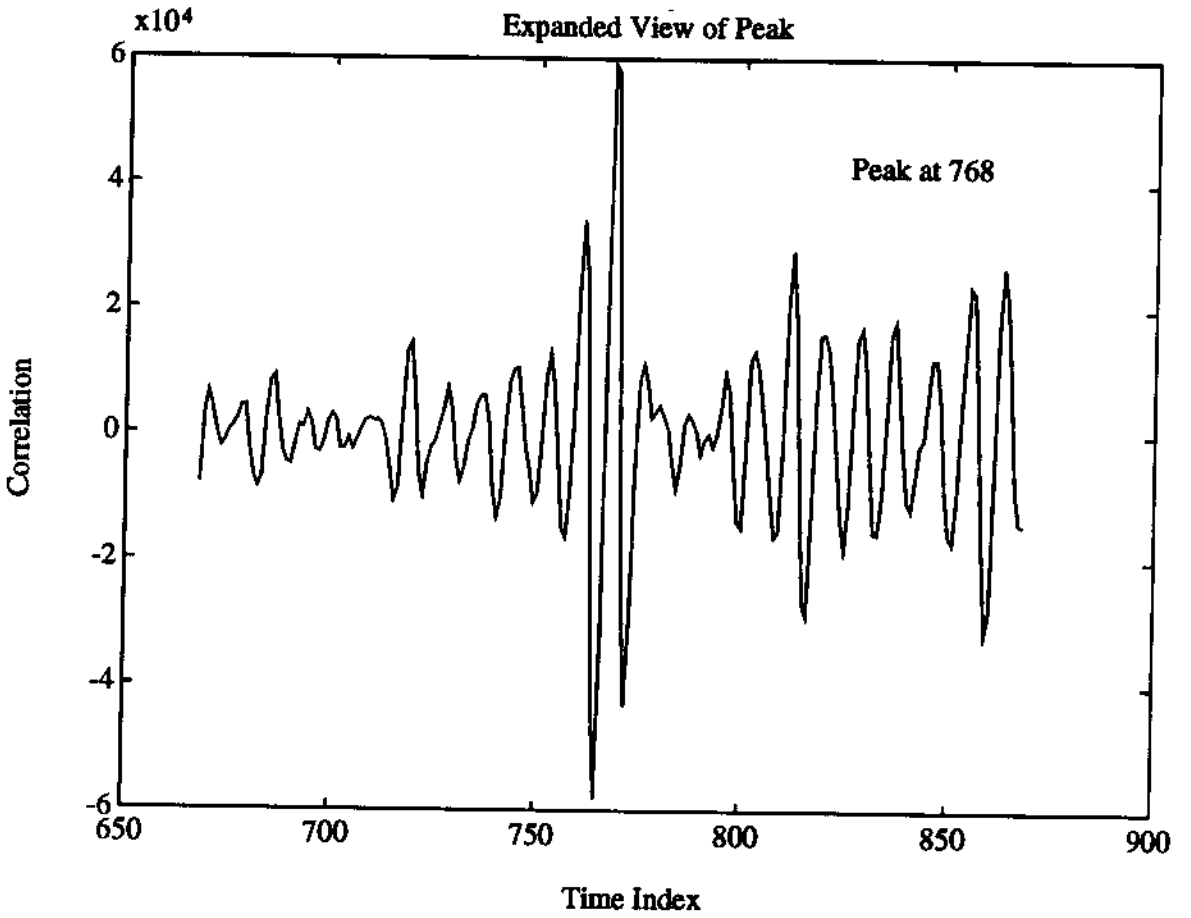
-2
-4
-6
Correlation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
Time Index


x10^4
Expanded View of Peak
Peak at 768
6
4
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-2
-4
-6
Correlation
650
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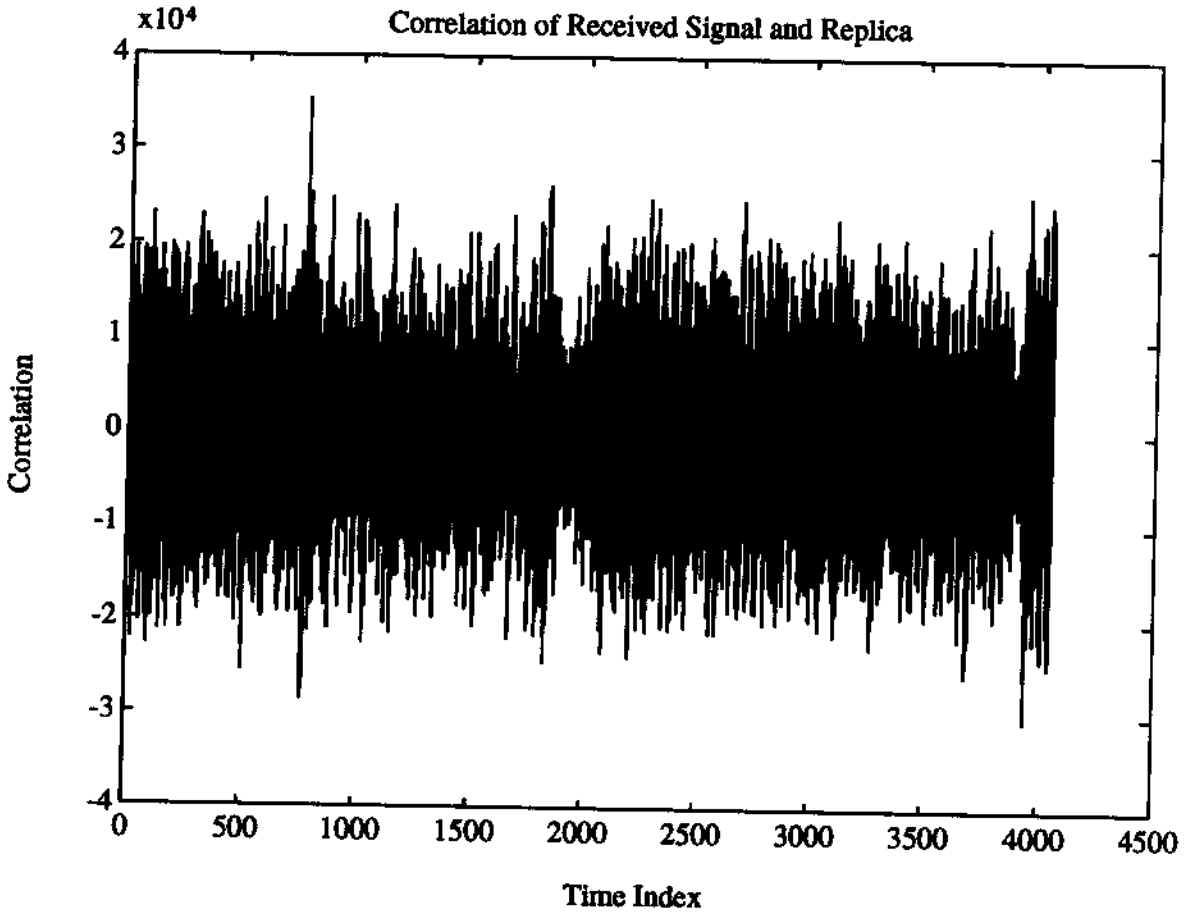
800
850
900
Time Index


x10^4
Correlation of Received Signal and Replica
Correlation
Time Index
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-4
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1500
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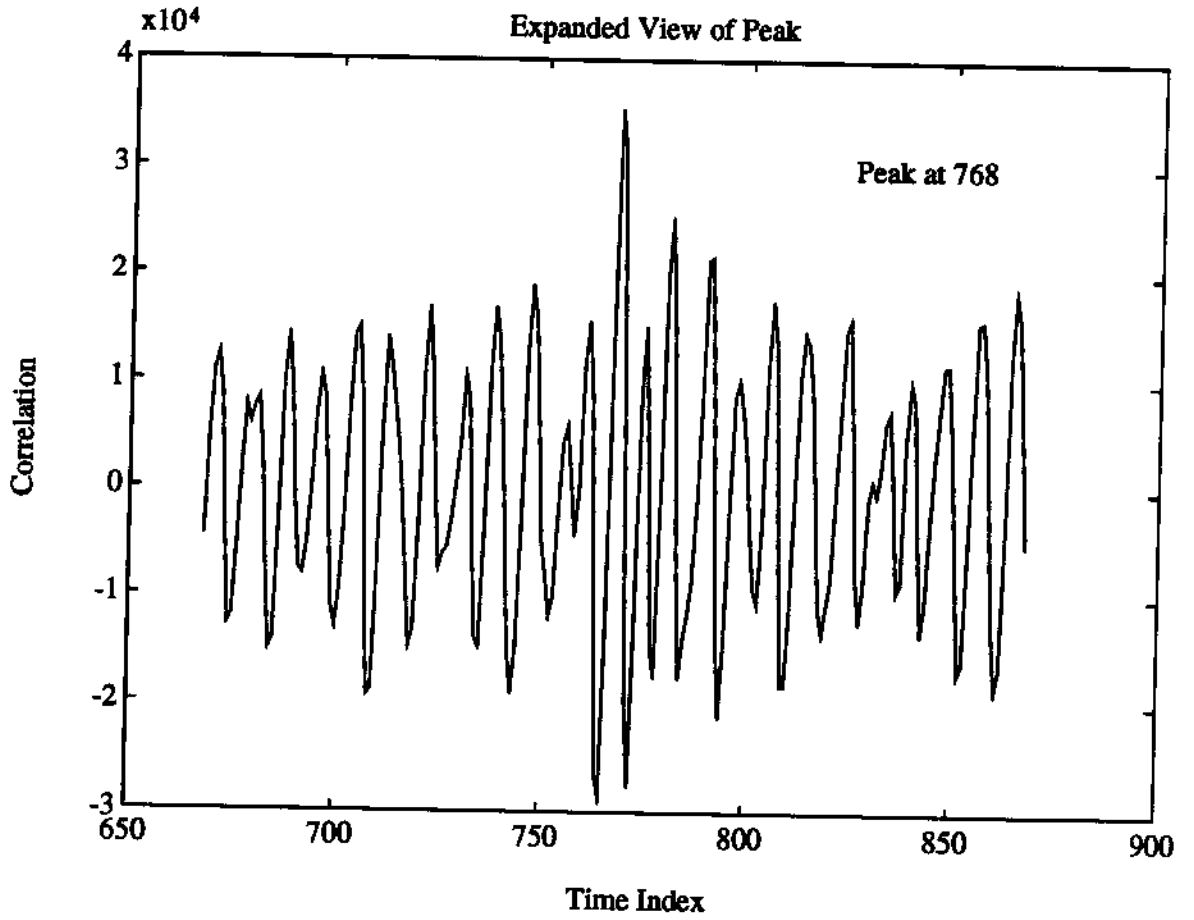
2500
3000
3500
4000
4500


x10^4
Expanded View of Peak
Peak at 768
Correlation
Time Index
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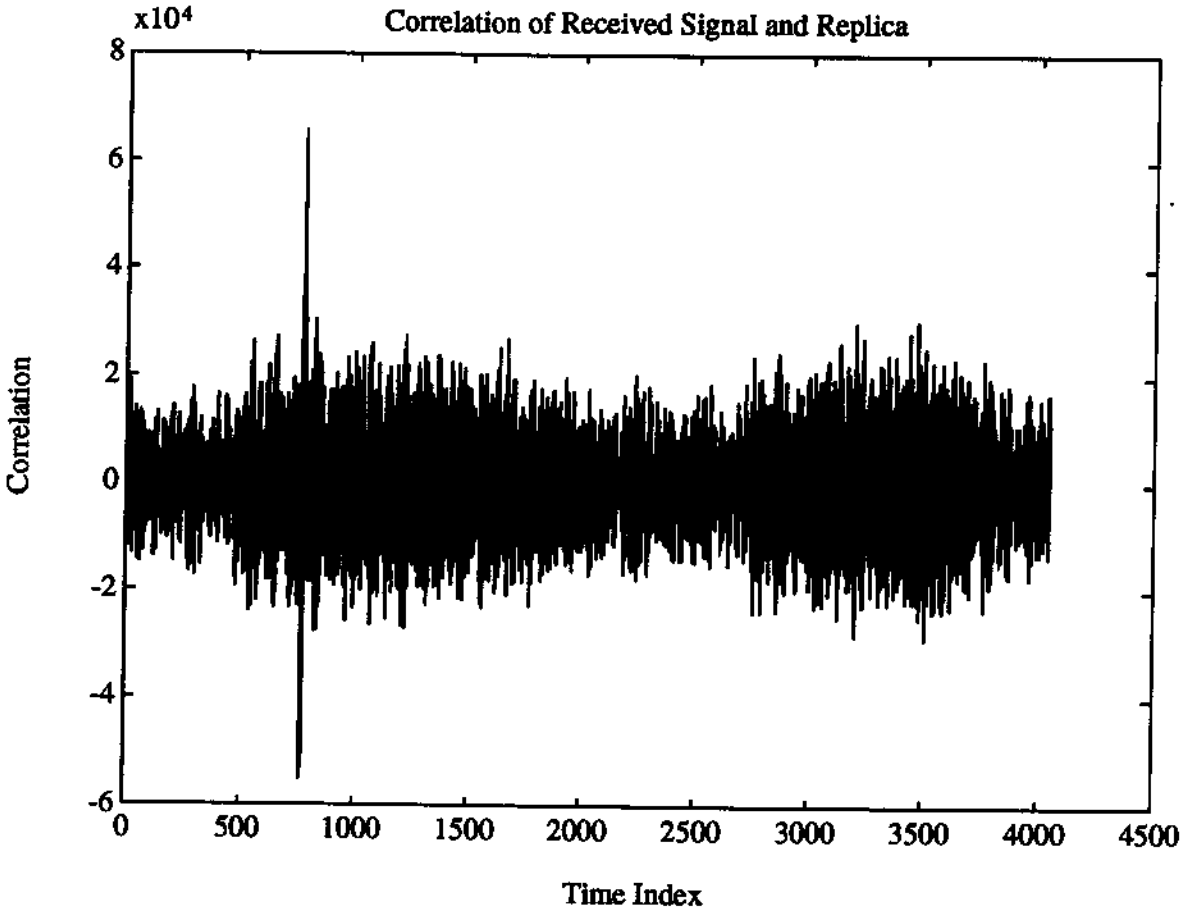
3
2
1
0
-1
-2
-3
650
700
750
800
850
900


x10^4
Correlation of Received Signal and Replica
Correlation
Time Index
8
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2
0
-2
-4
-6
0
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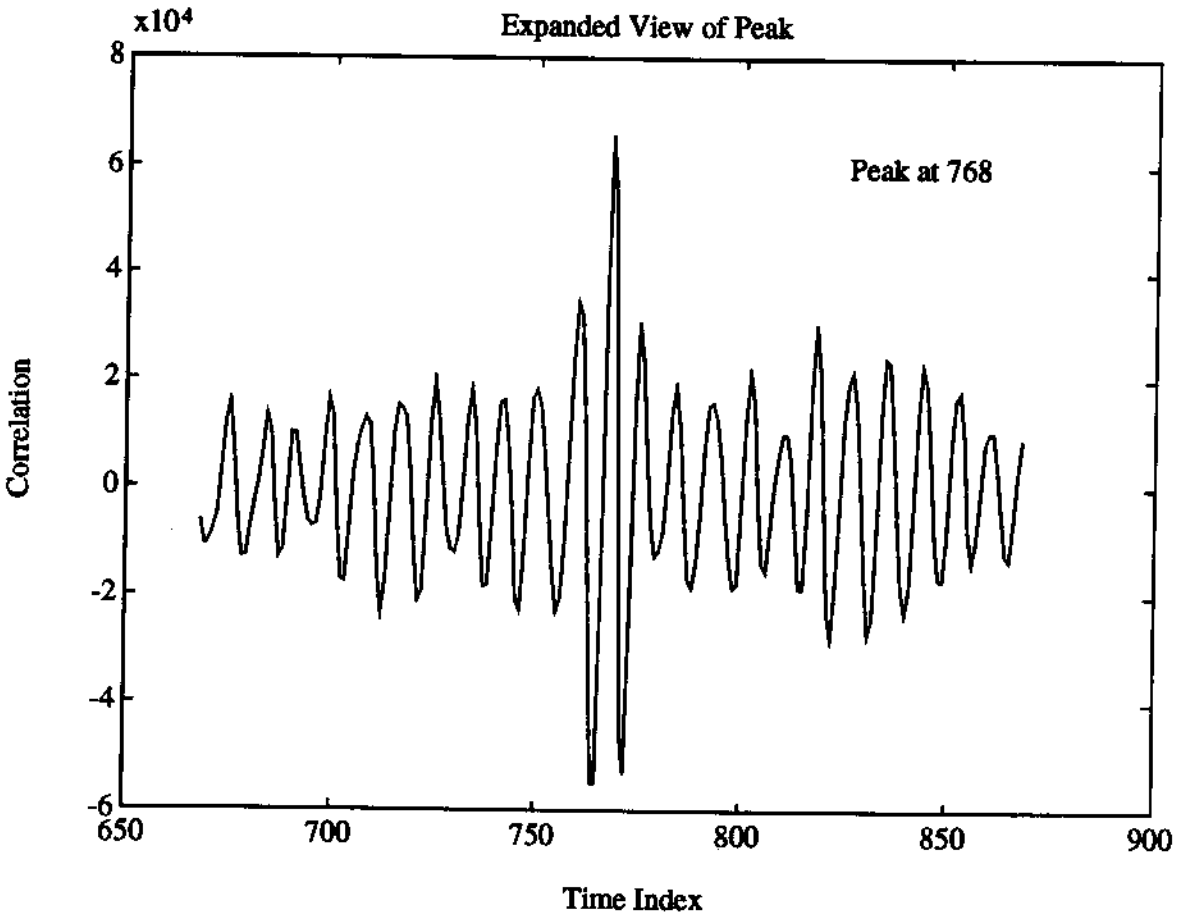
1000
1500
2000
2500
3000
3500
4000
4500


x10^4
Expanded View of Peak
Peak at 768
Correlation
Time Index
8
6
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0
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-4
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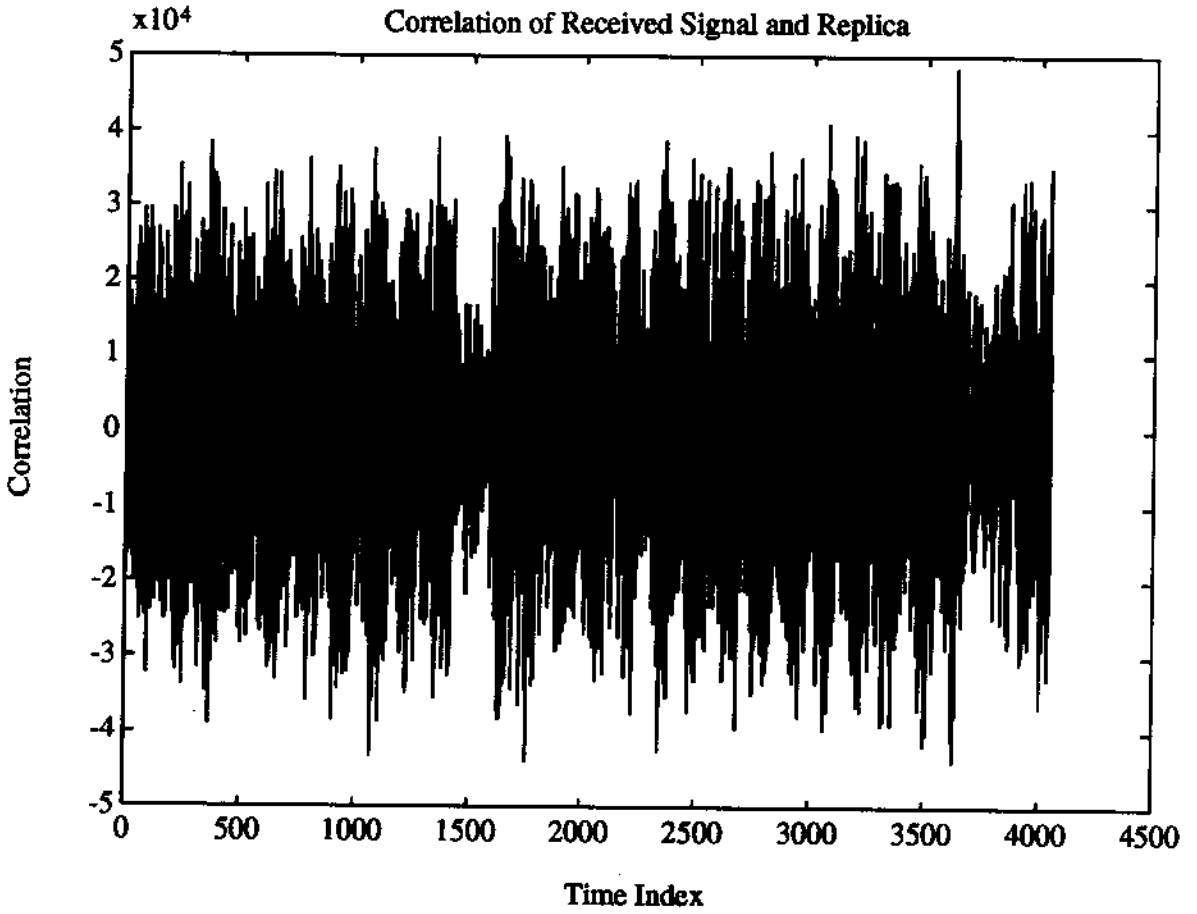
750
800
850
900


x10^4
Correlation of Received Signal and Replica
Correlation
Time Index
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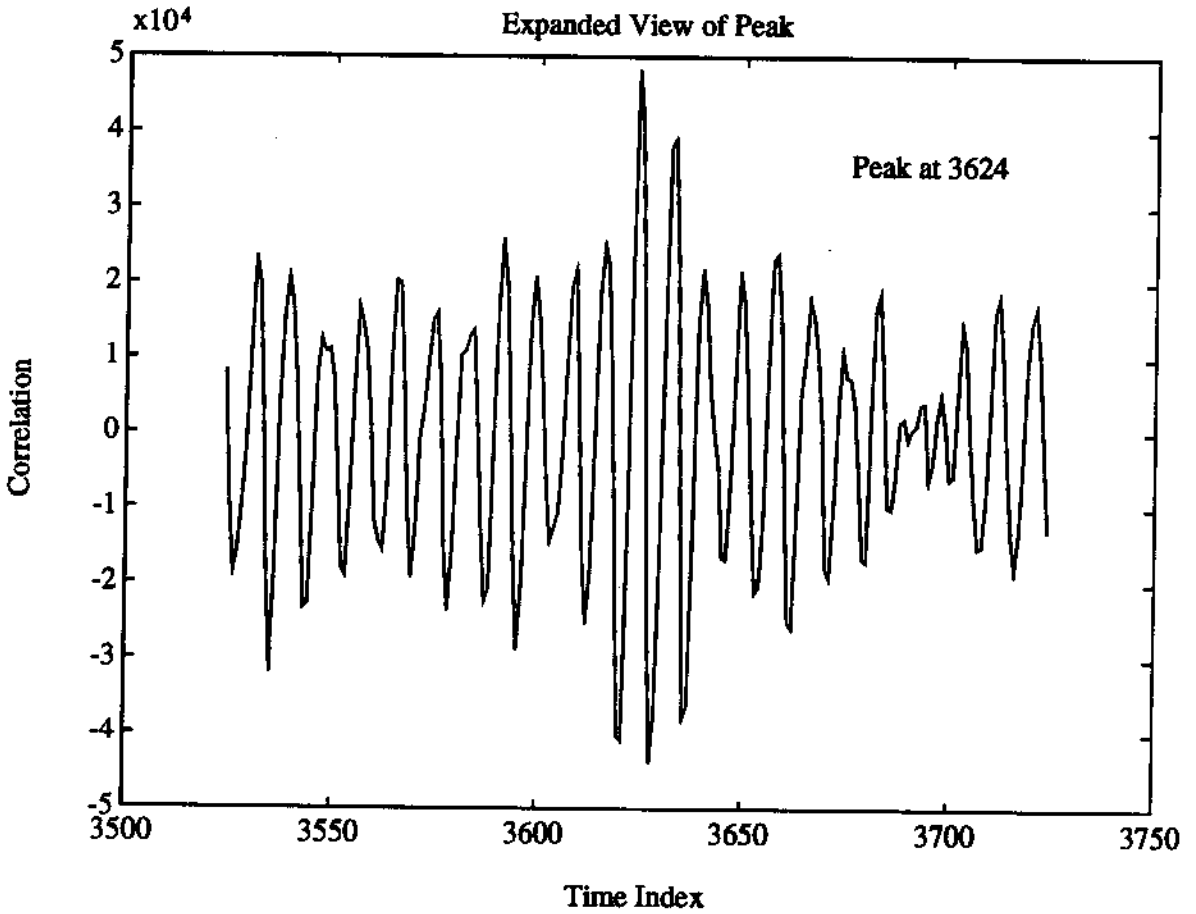
x10^4
Expanded View of Peak
Peak at 3624
Correlation
Time Index
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3500
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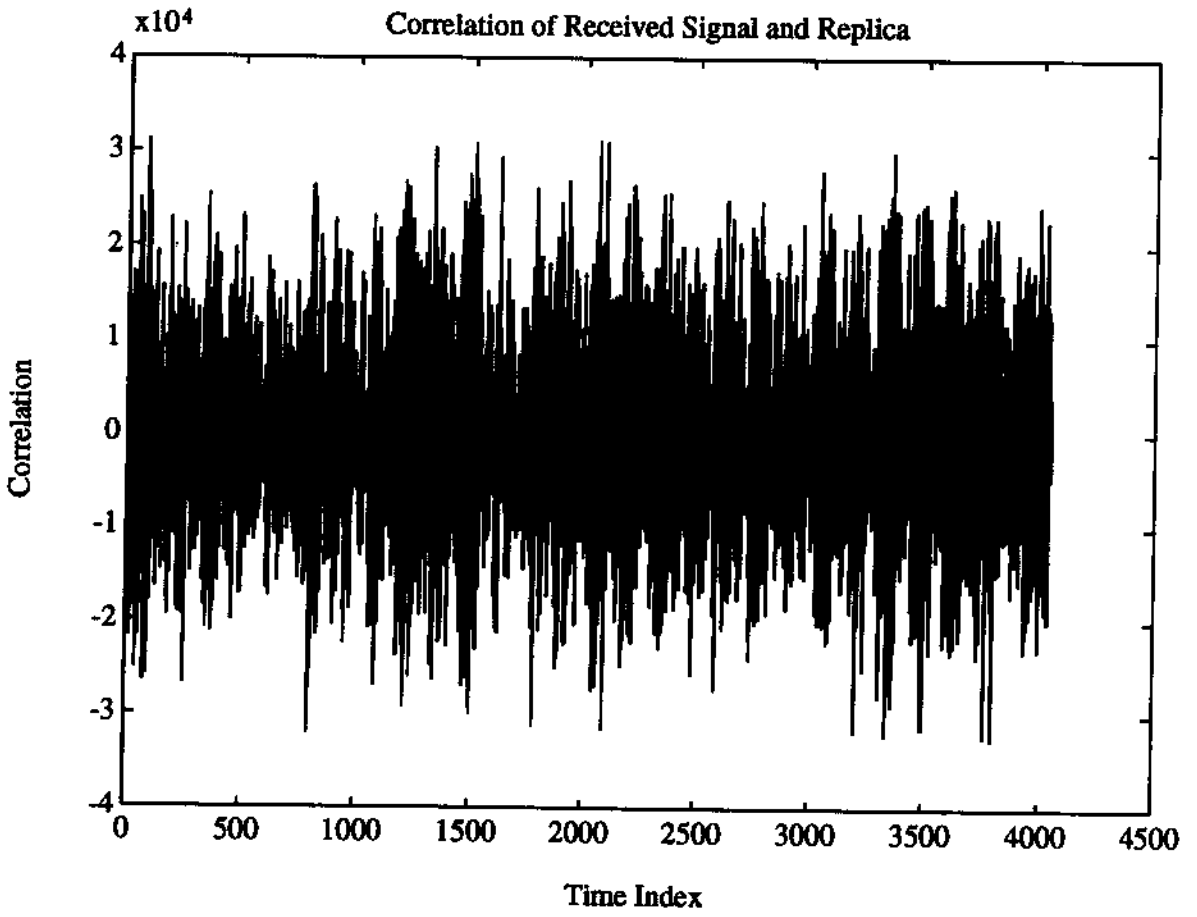
3600
3650
3700
3750


x10^4
Correlation of Received Signal and Replica
Correlation
Time Index
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-4
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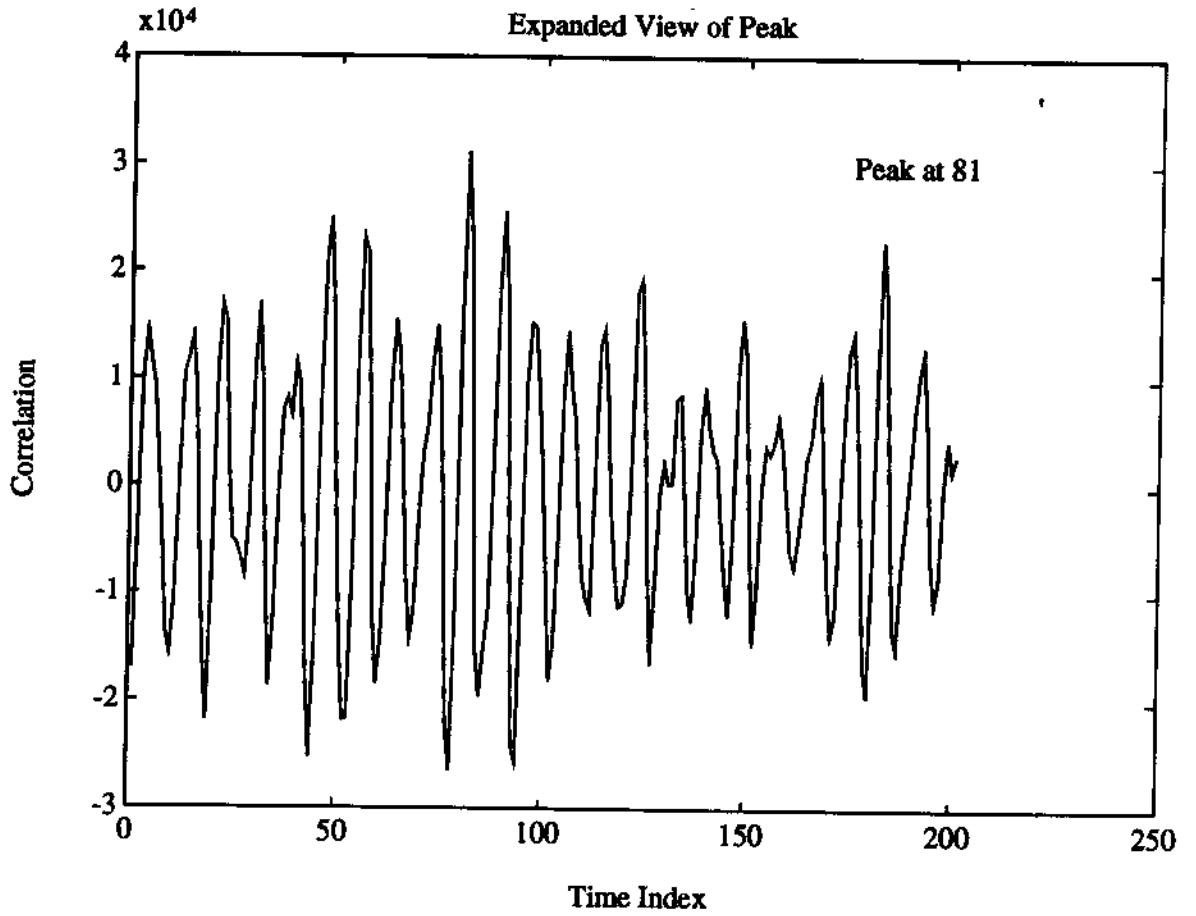
2000
2500
3000
3500
4000
4500


x10^4
Expanded View of Peak
Peak at 81
Correlation
Time Index
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1
0
-1
-2
-3
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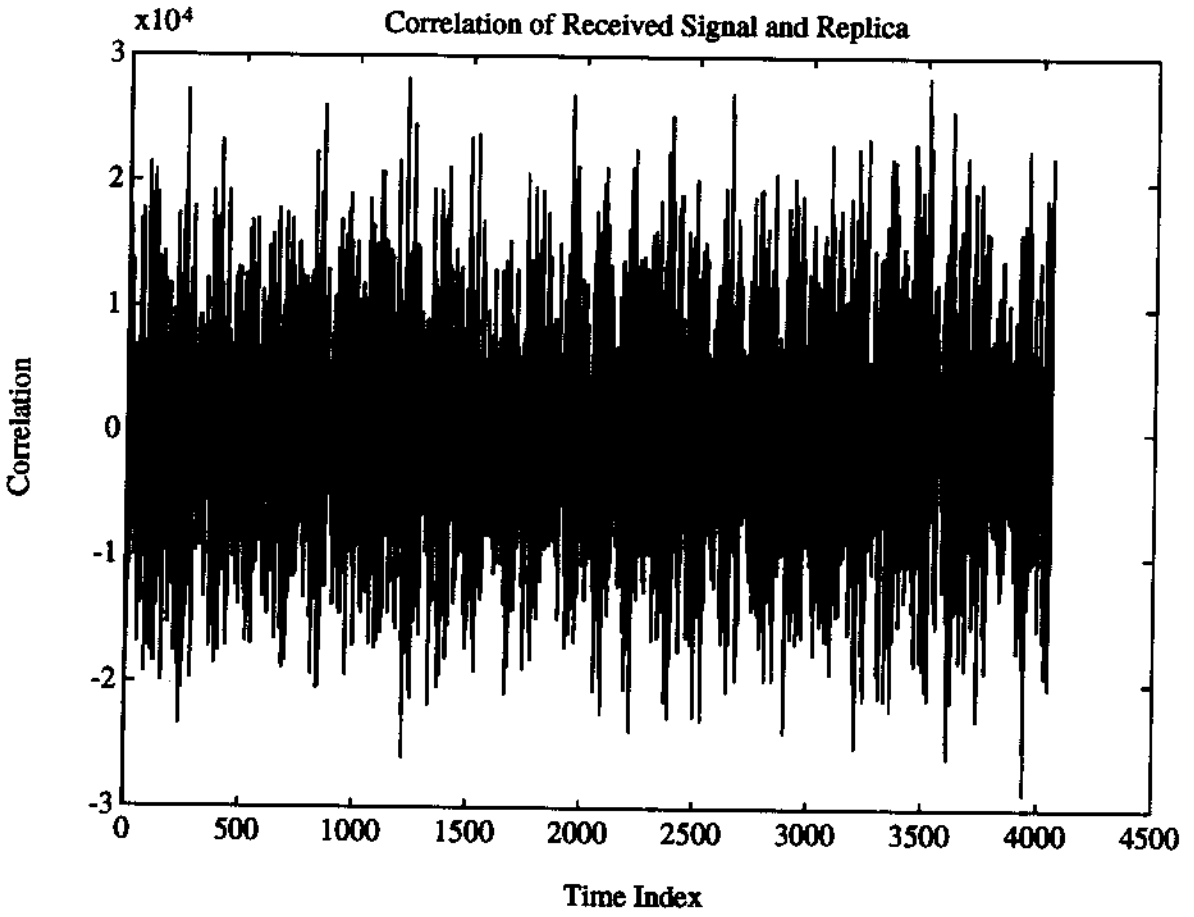
100
150
200
250


x10^4
Correlation of Received Signal and Replica
3
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-1
-2
-3
Correlation
0
500
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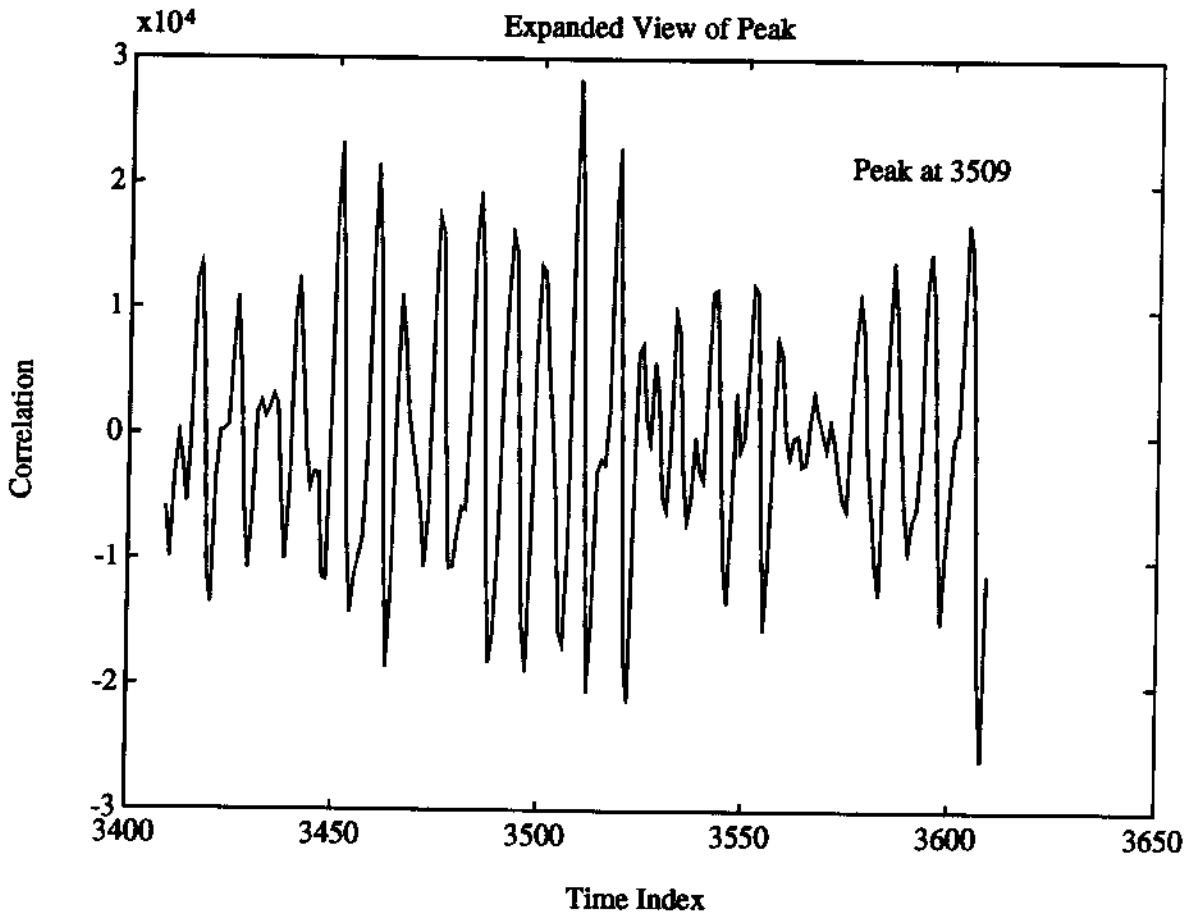
1500
2000
2500
3000
3500
4000
4500
Time Index


x10^4
Expanded View of Peak
Peak at 3509
3
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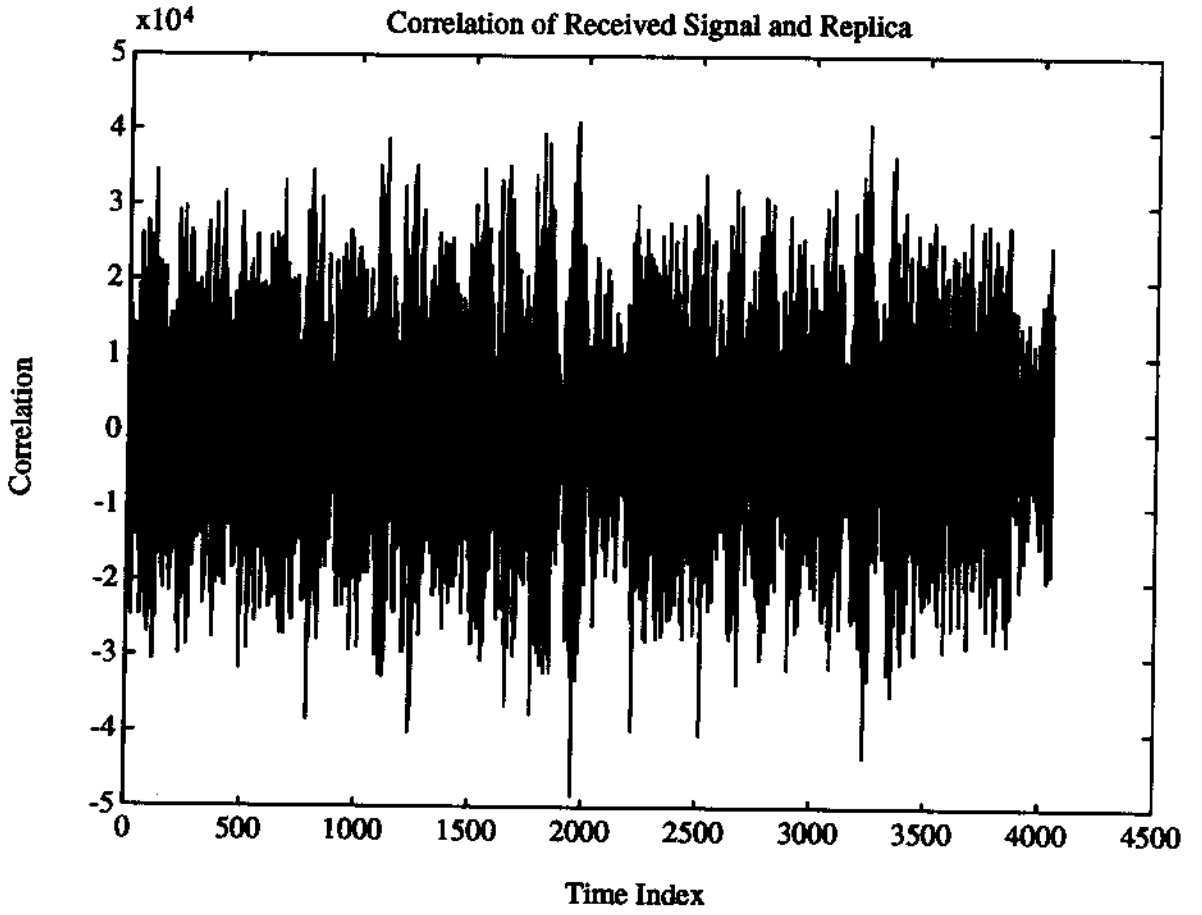
1
0
-1
-2
-3
Correlation
3400
3450
3500
3550
3600
3650
Time Index


x10^4
Correlation of Received Signal and Replica
Correlation
Time Index
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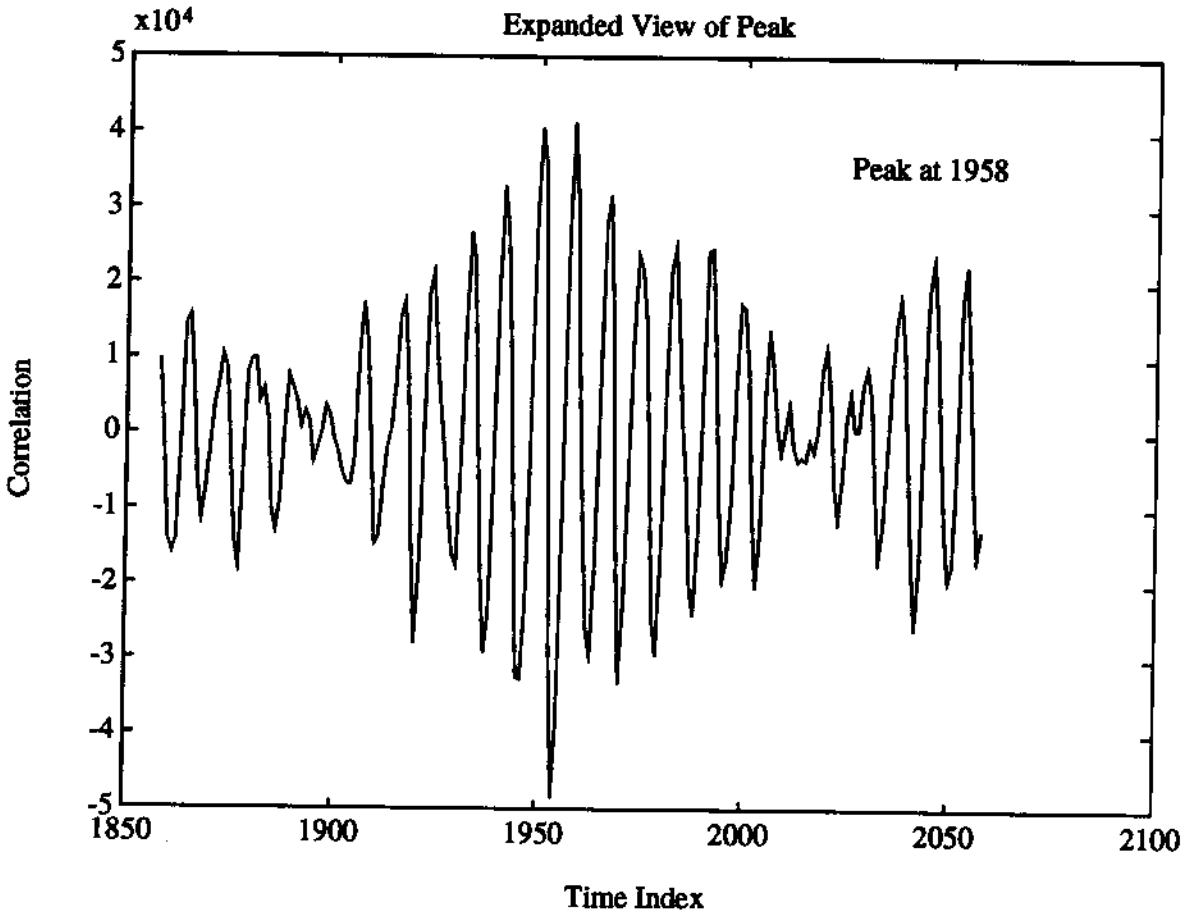
x10^4
Expanded View of Peak
Peak at 1958
Correlation
Time Index
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4
3
2
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0
-1
-2
-3
-4
-5
1850
1900
1950
2000
2050
2100

Summary of Tests

Feb 11	Proposed Chirping	
Feb 20	Frosh Pond Test Single Frequency	~1m
May 9	Analog Chirper In Air Test	~.023m
May 13	Analog Chirper Frosh Pond Test	~.2m
June 7	Digital Chirper Union Bay Test	~1cm