M6 SDR Receiver

Hochschule Rhein-Waal

Communication and Information Engineering B.Sc.

CI_5.02 Communication Systems

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Topics to be covered:

- Impairments and available solutions.

- Implementation.

- Analysis on the received signals.

Impairments

- Carrier Frequency and Phase offset.

Fix: Carrier Recovery

Carrier Recovery

- Squared Difference Loop.

- The Phase-Locked Loop.

- The Costas Loop.

Carrier Recovery

- Squared Difference Loop.

- The Phase-Locked Loop.

- The Costas Loop.

Implementation

Determining the Assumed Carrier Frequency

$$f_c = min_k \left| f_{if} + k f_s \right|$$

```
10        k = round(fif/fs);
11        fc = abs(fif - k*fs);                    % carrier frequency
```
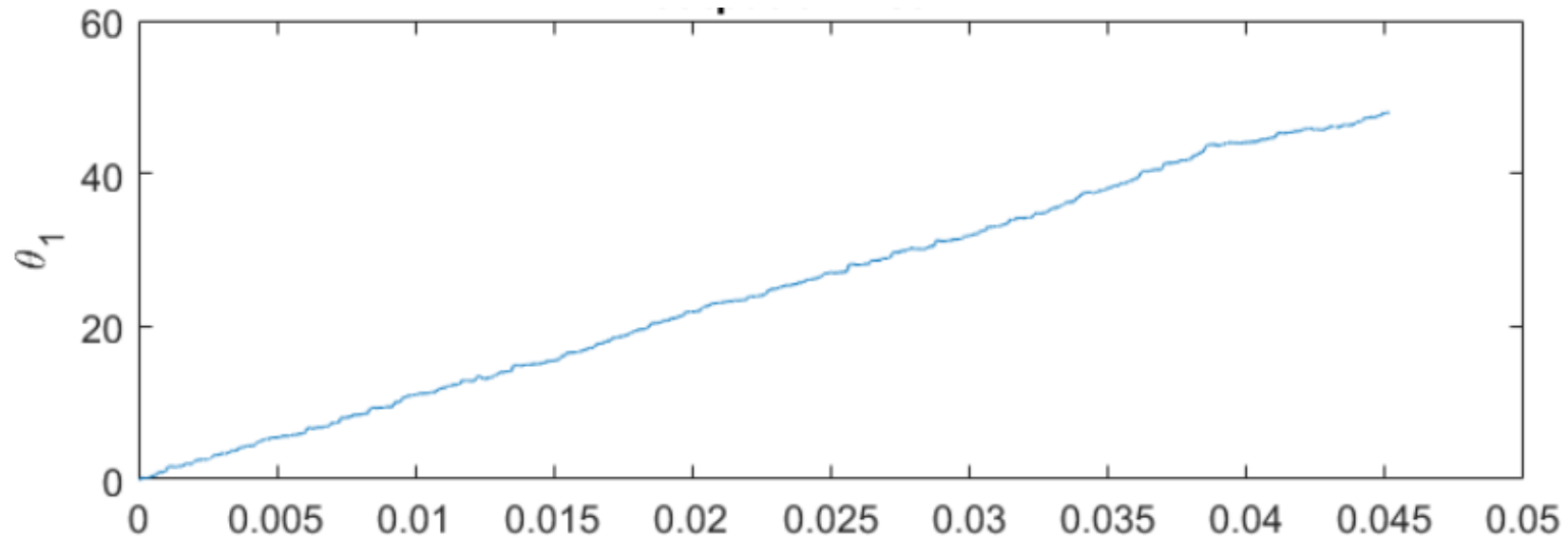
The Costas Loop

- Update function:

- $\theta_1[k + 1] = \theta_1[k] - \mu LPF\{r(kTs)\cos(2\pi f0kTs + \theta_1[k])\} \times LPF\{r(kTs)\sin(2\pi f0kTs + \theta_1[k])\}.$

- $\theta_1[n] \approx \frac{1}{4}s_{avg}^2\cos^2(\emptyset - \theta_1)$
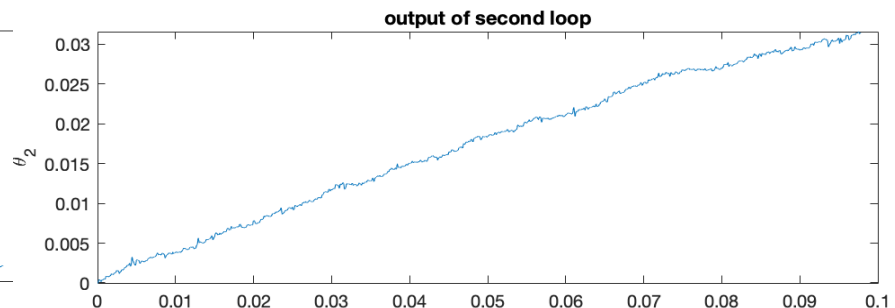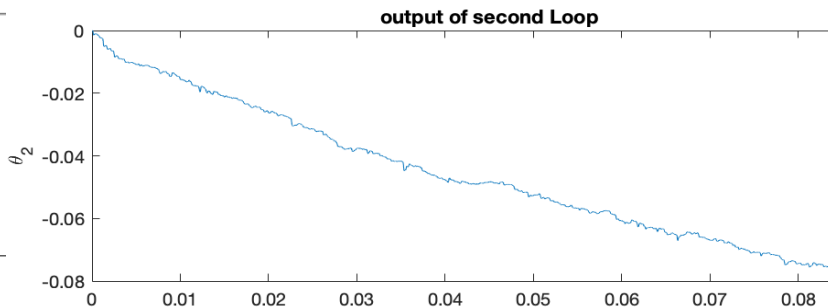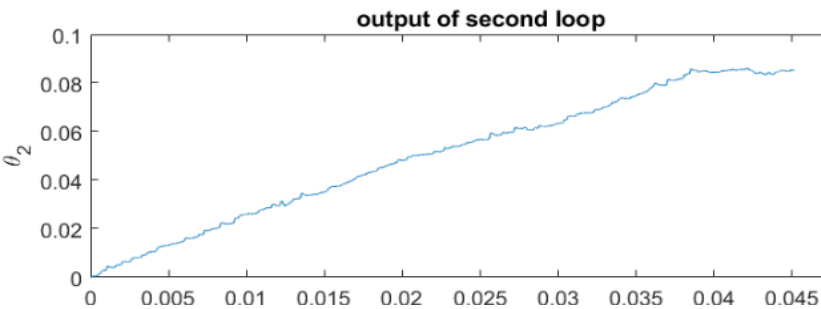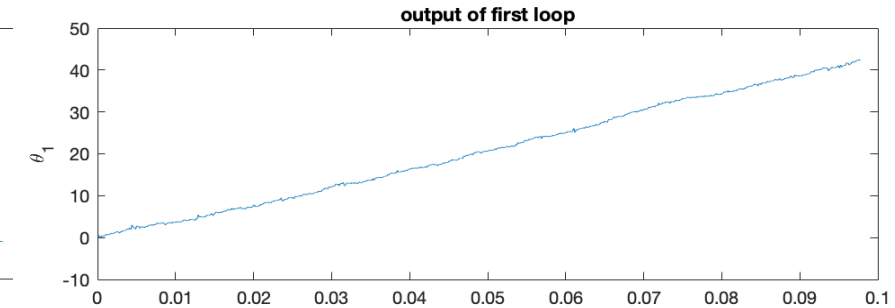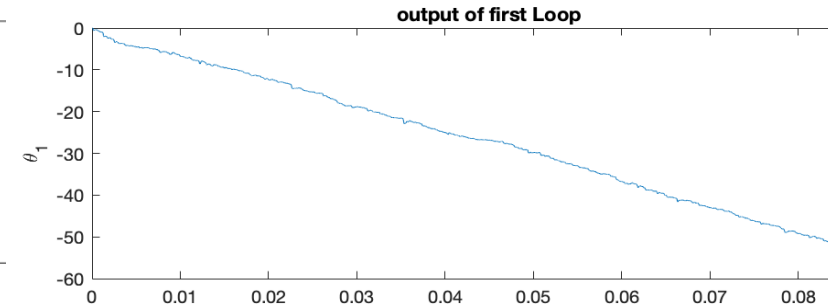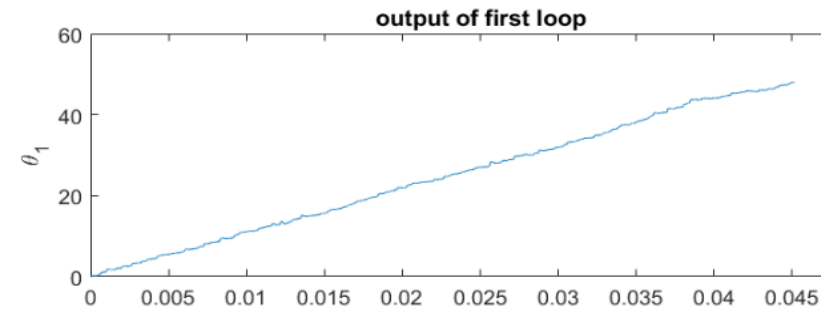
Output of a Single Costas loop
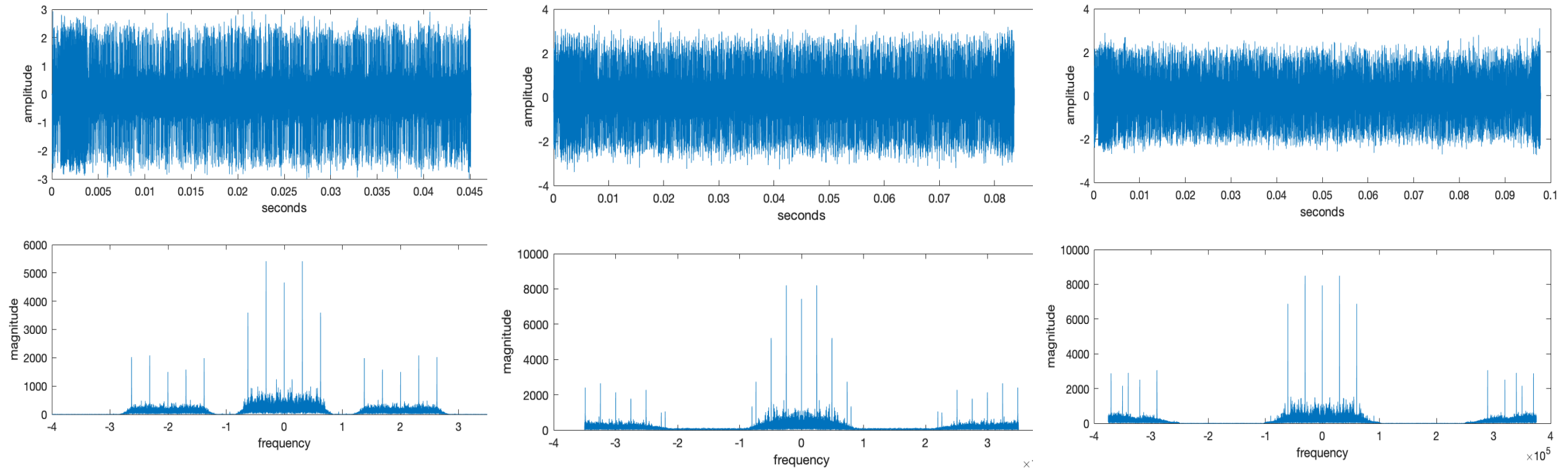

$$\theta_1[n] = 2\pi(fc - f0)nTs + \emptyset$$

Dual Costas Loop

- $\theta_1[k+1] = \theta_1[k] - \mu \mathrm{LPF}\{r(kTs)\cos(2\pi f0kTs + \theta_1[k])\} \times \mathrm{LPF}\{r(kTs)\sin(2\pi f0kTs + \theta_1[k])\}.$

- $\theta_2[k+1] = \theta_2[k] - \mu \mathrm{LPF}\{r(kTs)\cos(2\pi f0kTs + \theta_1[k] + \theta_2[k])\} \times \mathrm{LPF}\{r(kTs)\sin(2\pi f0kTs + \theta_1[k] + \theta_2[k])\}$

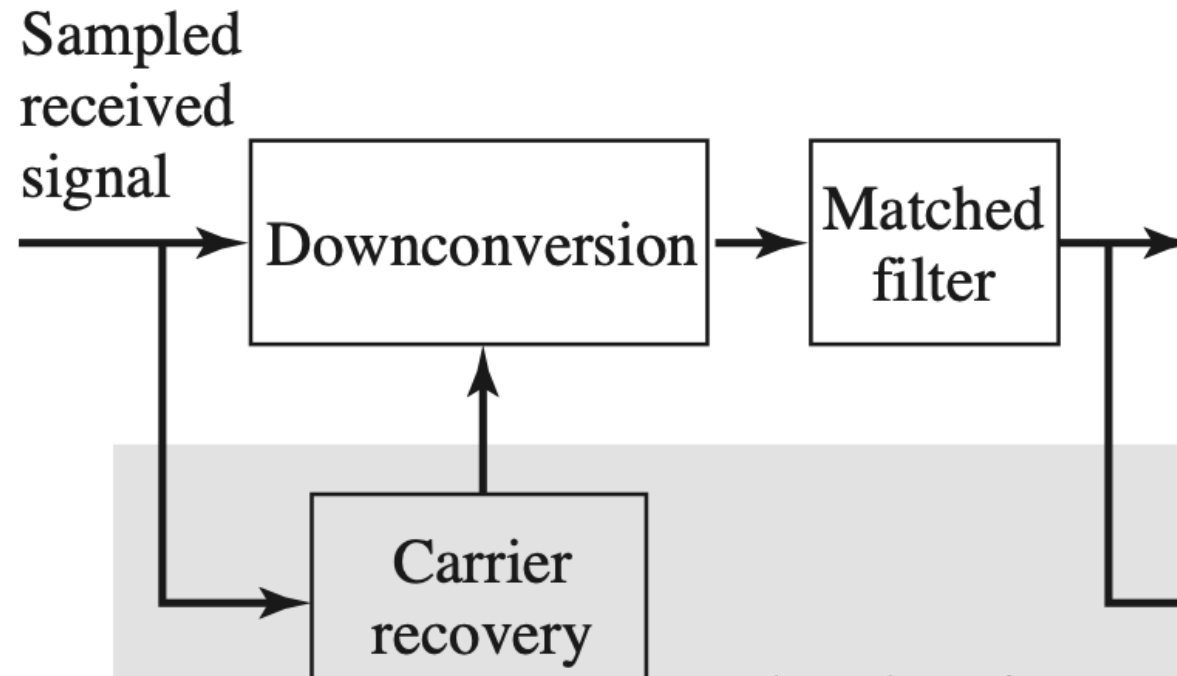- $\theta_2[n] \approx \frac{1}{4}s_{avg}^2\cos^2(\emptyset - \theta_1)$
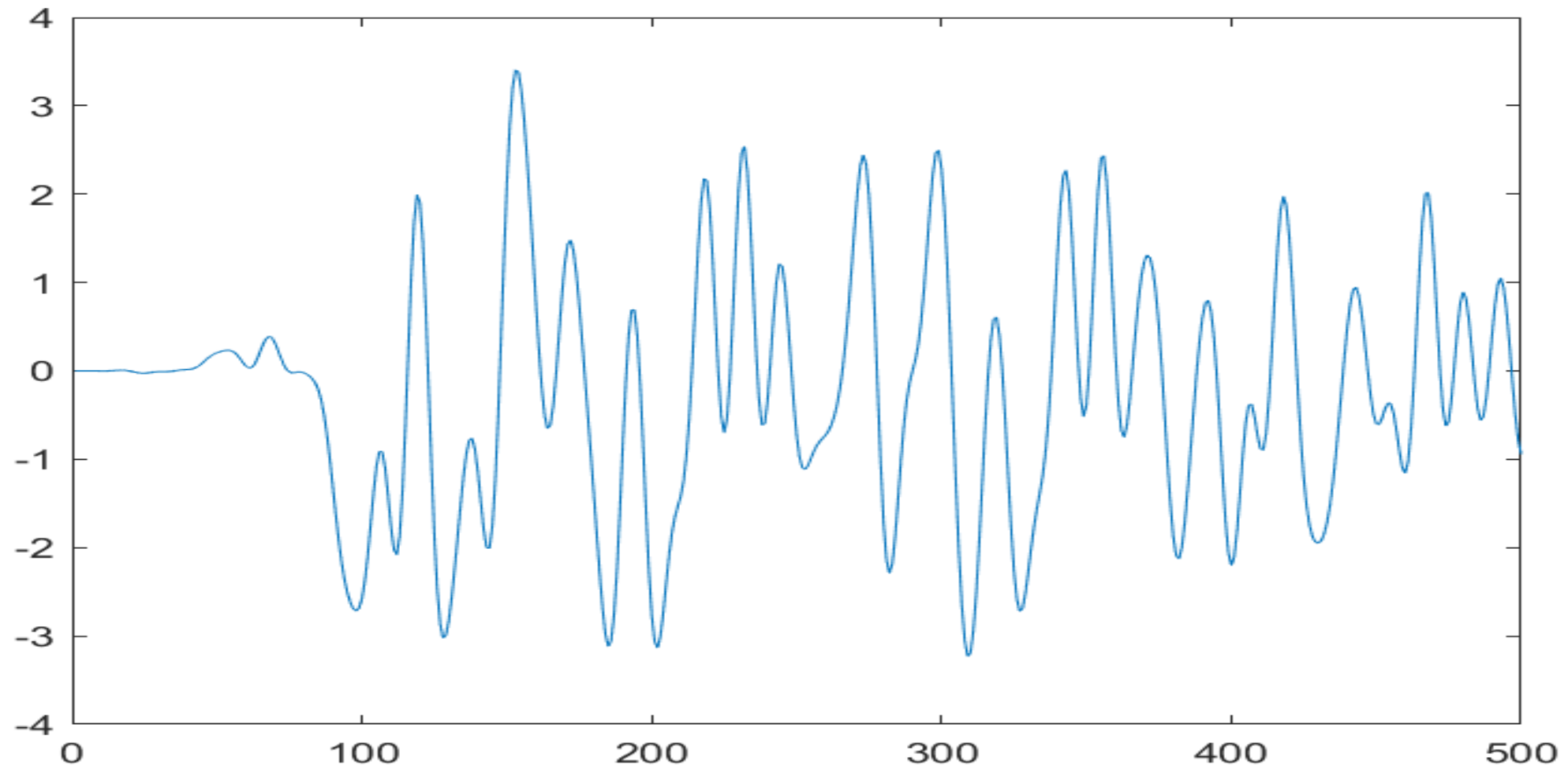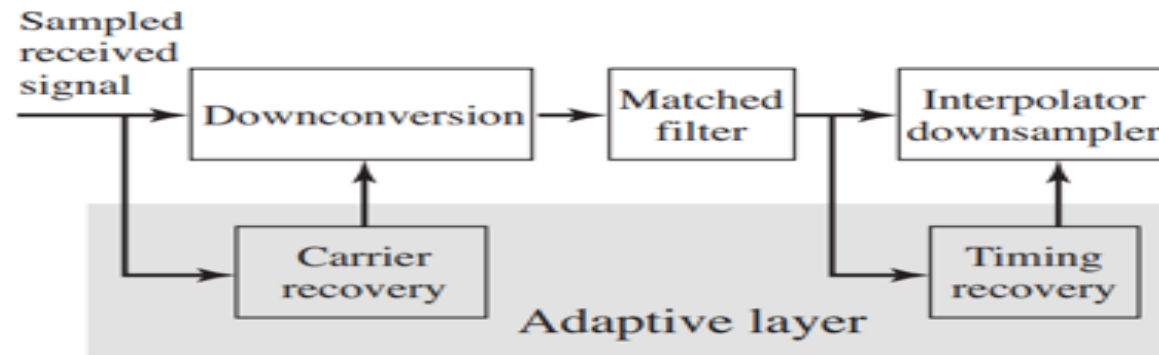
Outputs of a Dual Costas loop

Output after mixing

Plotted by plotspec.m

Matched filter

Matched filter

Clock recovery

Options:
Decision Directed Algorithm
Output Power Maximizing Algorithm

C. Richard Johnson, Jr, Cornell University, New York William A. Sethares, University of Wisconsin, Madison Andrew G. Klein,(2011). Software Receiver Design. Cambridge University Press. p. 345. ISBN 9781107007529

Clock recovery

Considered factor:
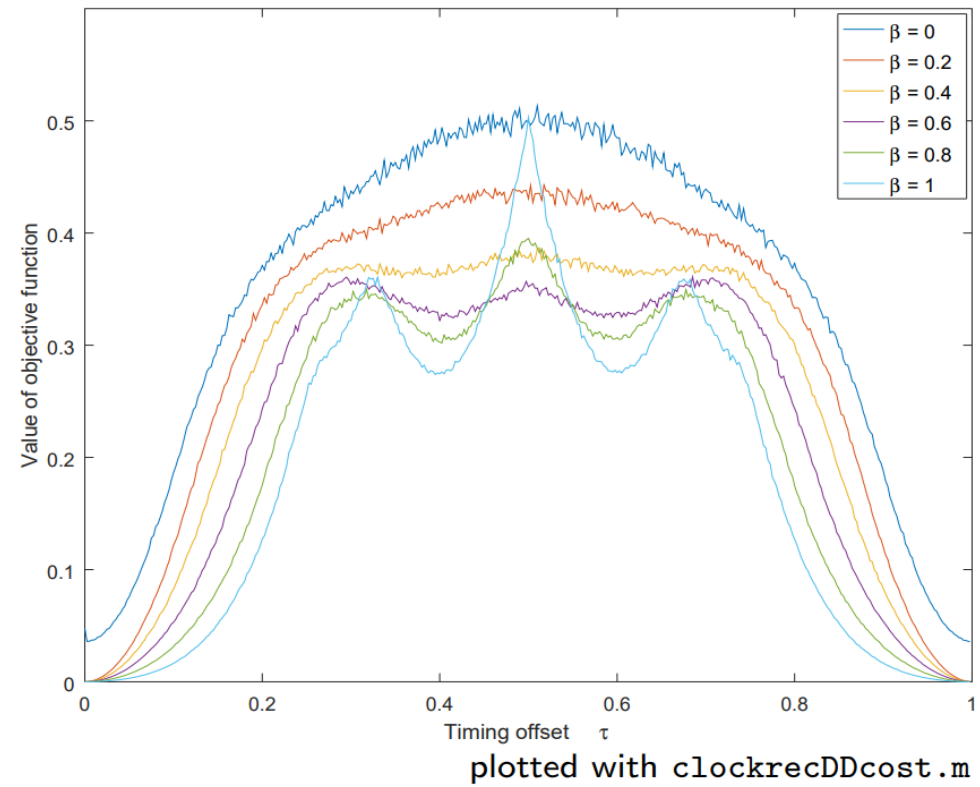 SRRC Rolloff factor for the three signals respectively are
0.4, 0.9 and 0.5

C. Richard Johnson, Jr, Cornell University, New York William A. Sethares, University of Wisconsin, Madison Andrew G. Klein,(2011). Software Receiver Design. Cambridge University Press. p. 345. ISBN 9781107007529

Clock recovery

Decision Directed Error surface

plotted with clockrecDDcost.m

Clock recovery

Output Power Maximizing Error surface
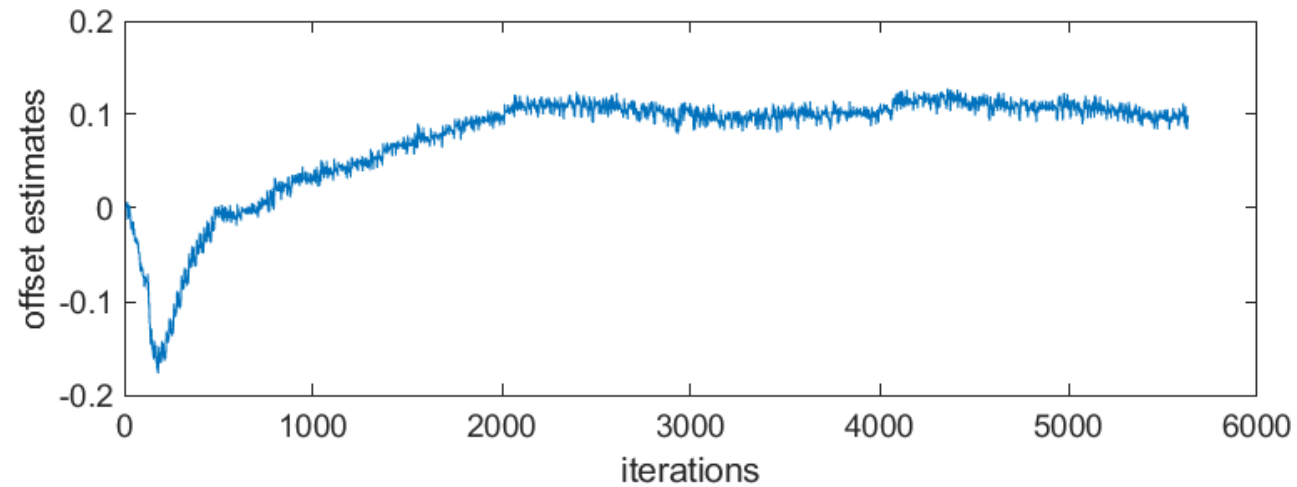

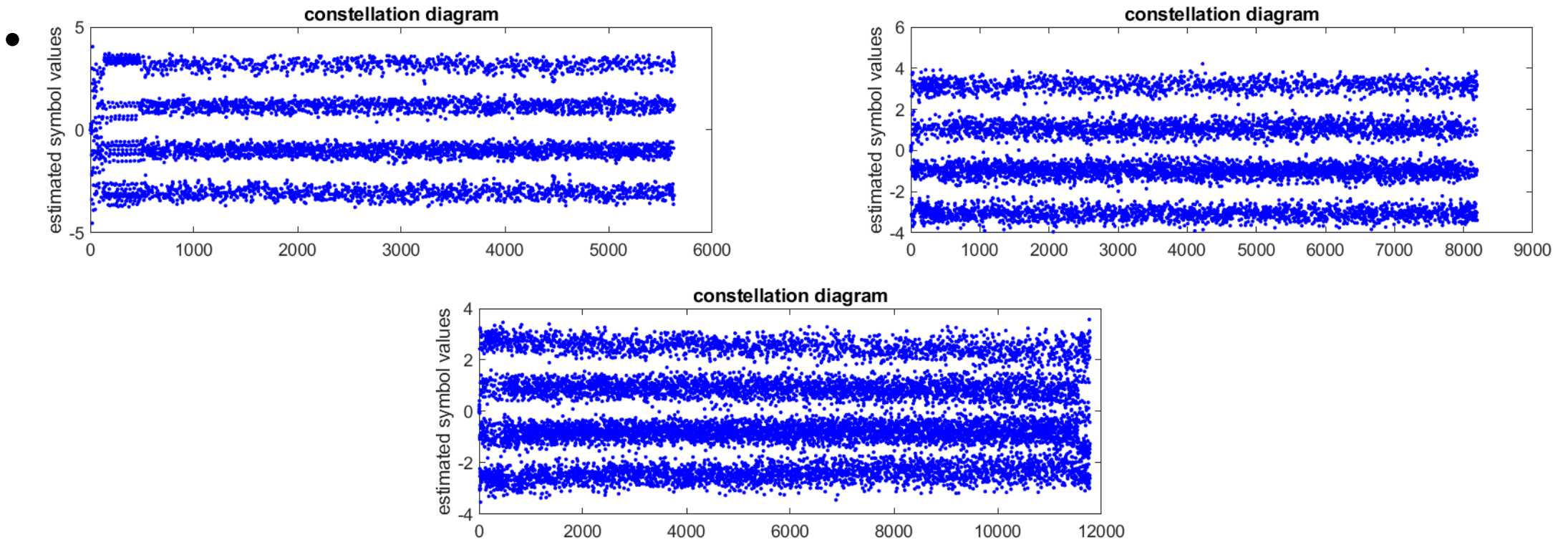plotted with clockrecDDcost.m
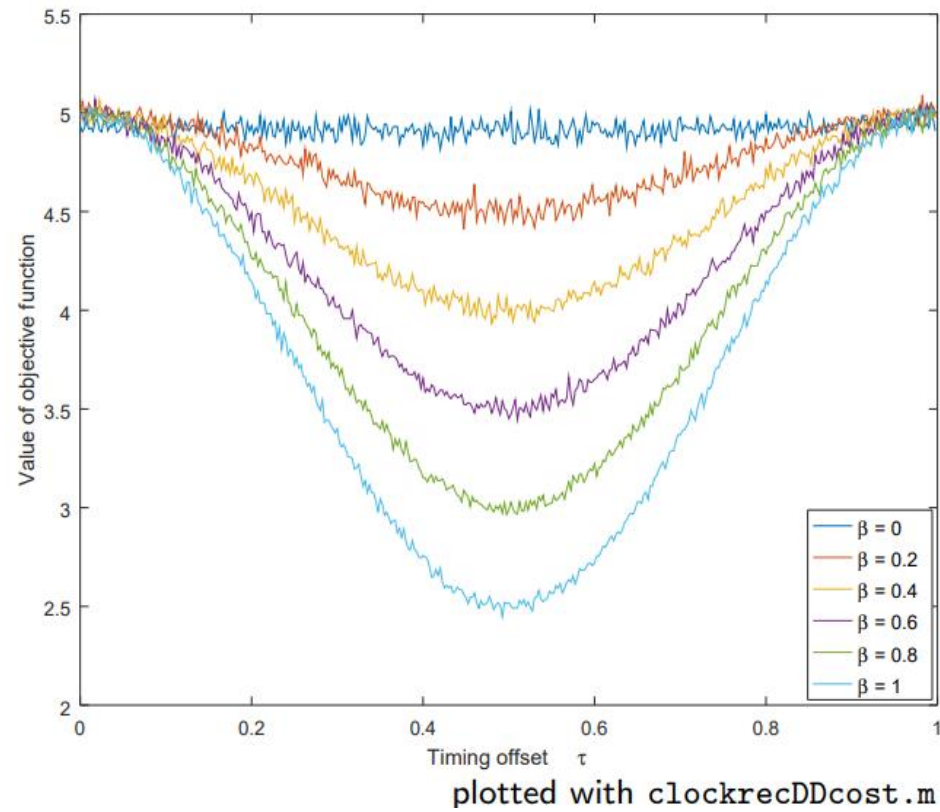
Clock recovery

tau over iterations for mysteryA
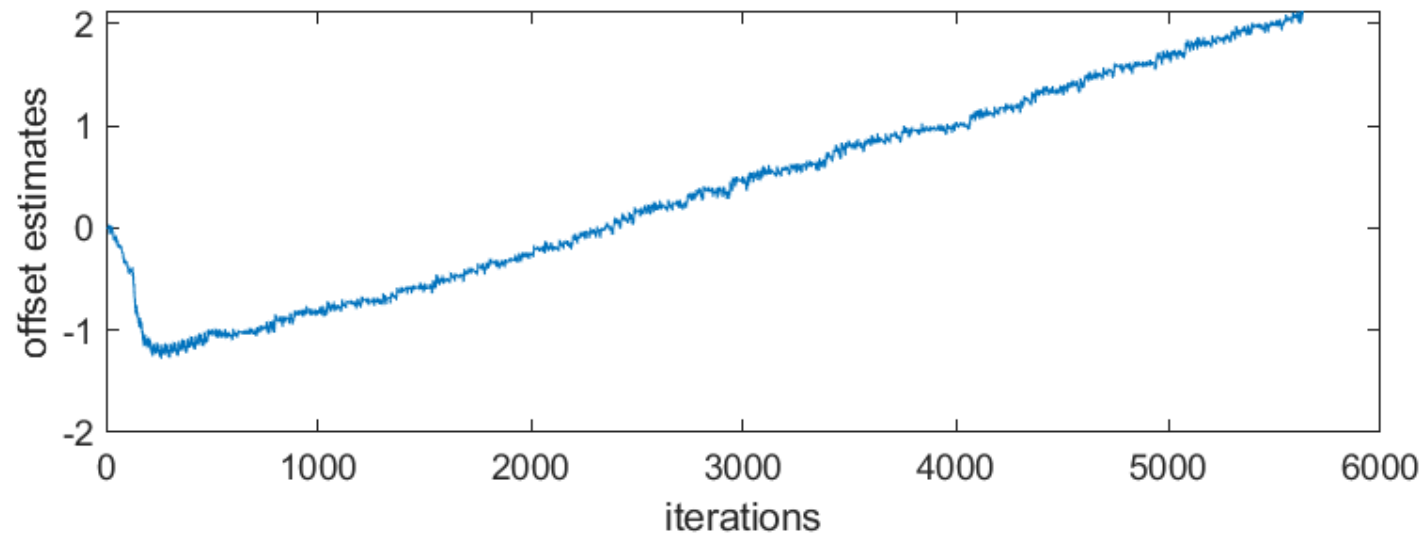
Clock recovery

- Dual Output Power Maximizing Algorithm.

-

Clock recovery

- Dual Output Power Maximizing Algorithm.
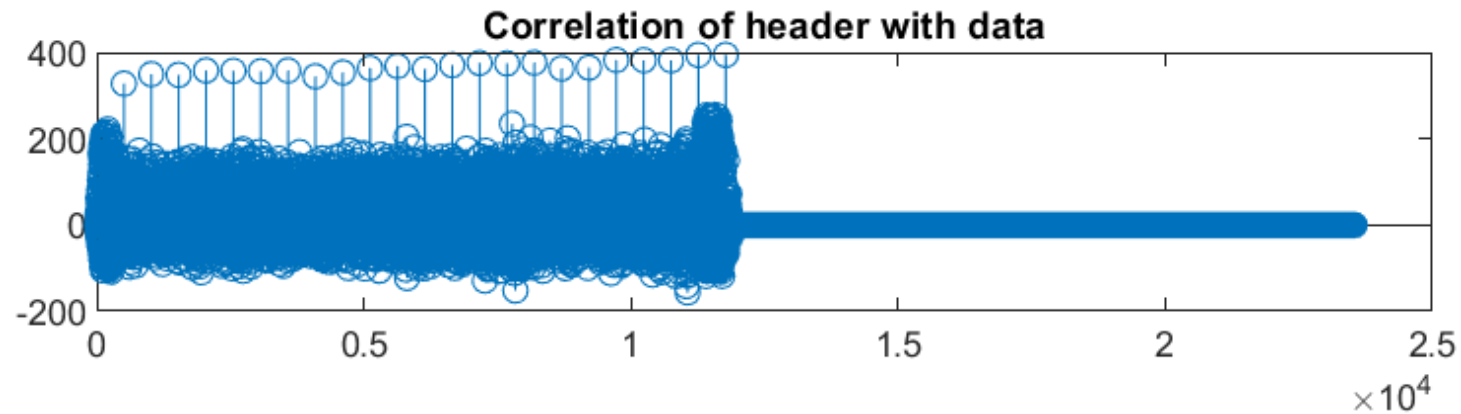

estimated symbol values — constellation diagram

estimated symbol values — constellation diagram

estimated symbol values — constellation diagram

Correlation

- head = 'A0Oh well whatever Nevermind'

Correlation of header with data

Correlation

- head = 'A0Oh well whatever Nevermind'

Correlation of header with data
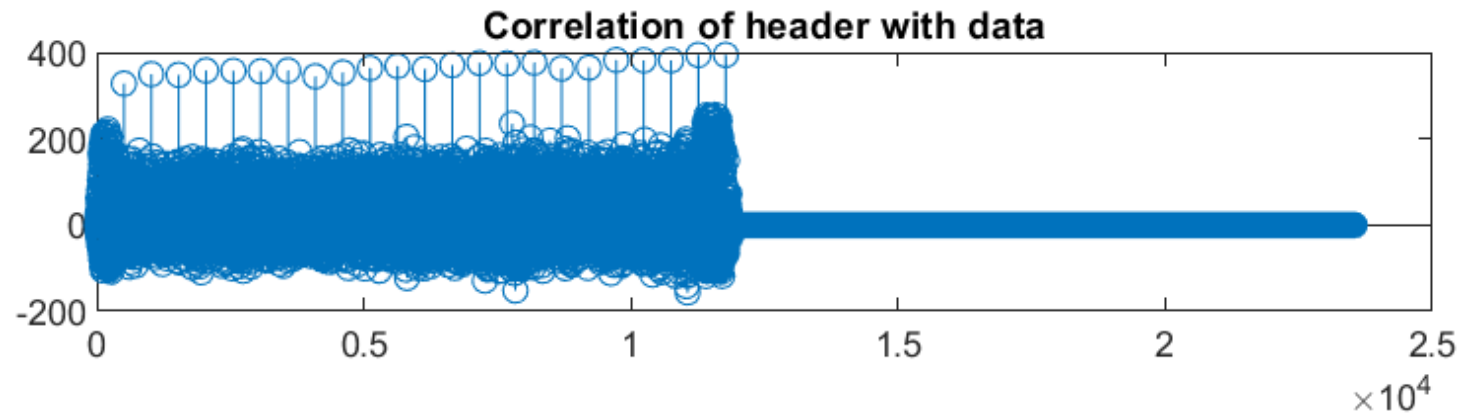
- headstart=length(y)-ind+1
- headstart = mod(headstart, (112+400))

Decoding

mysteryA: An den Mond, Johann Wolfgang von Goethe, 1749-1832

mysteryB: Prometheus, Johann Wolfgang von Goethe, 1749-1832

mysteryC: Der getreue Eckart, Johann Wolfgang von Goethe- 1749-1932