ECE 440

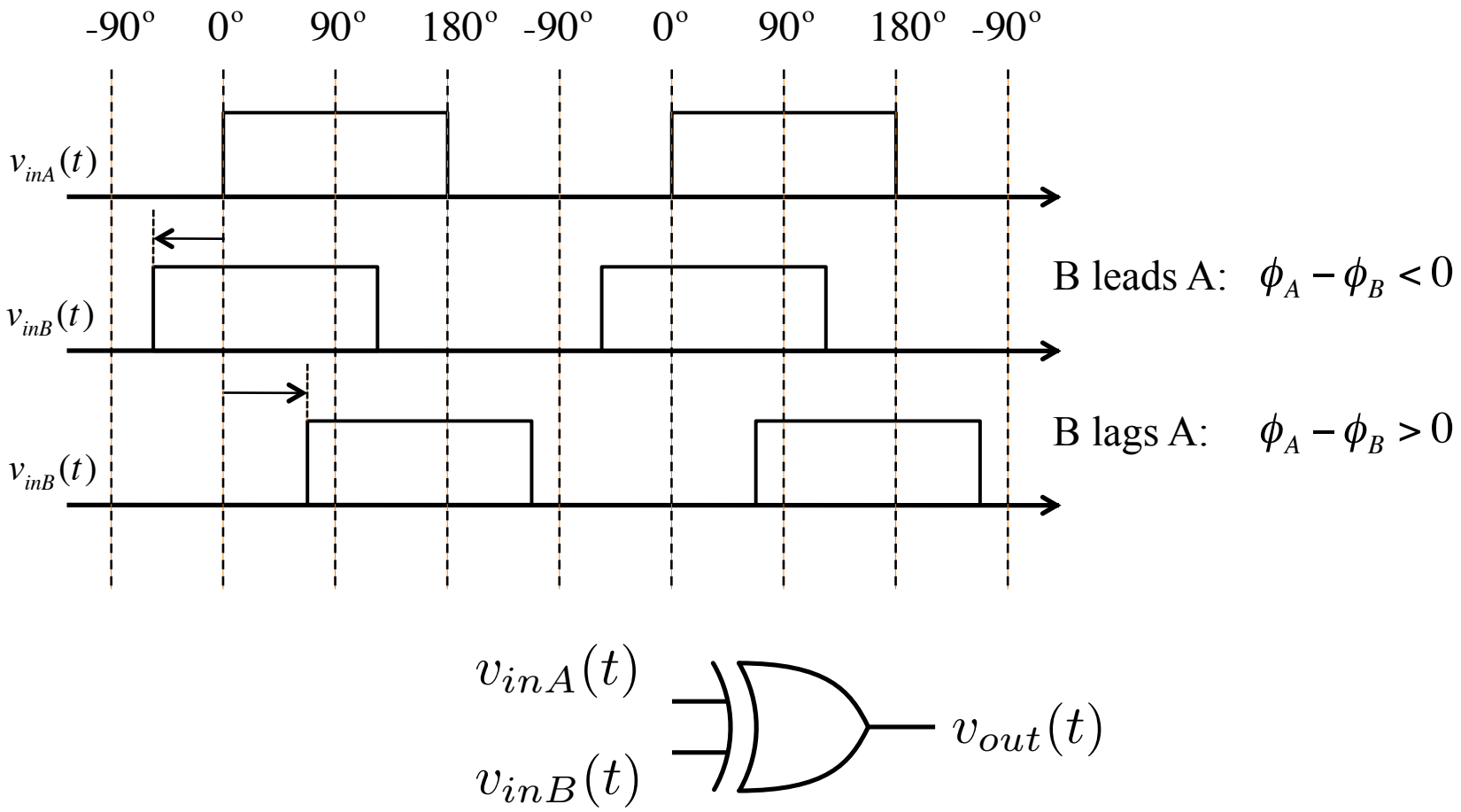
Phase Detectors

J. V. Krogmeier
Purdue University, West Lafayette
September 28, 2012

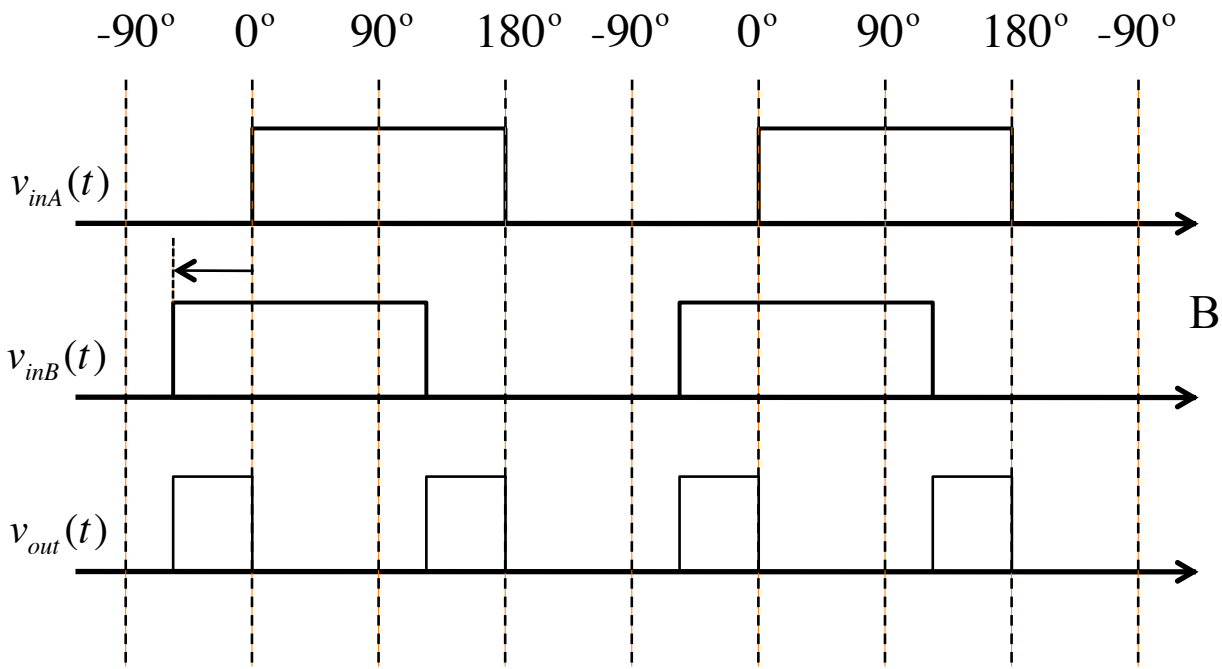
PURDUE UNIVERSITY

CWSA

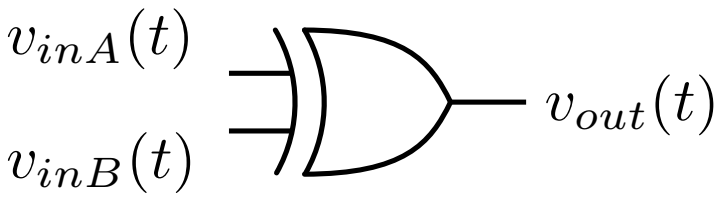
Exclusive-Or Phase Detector



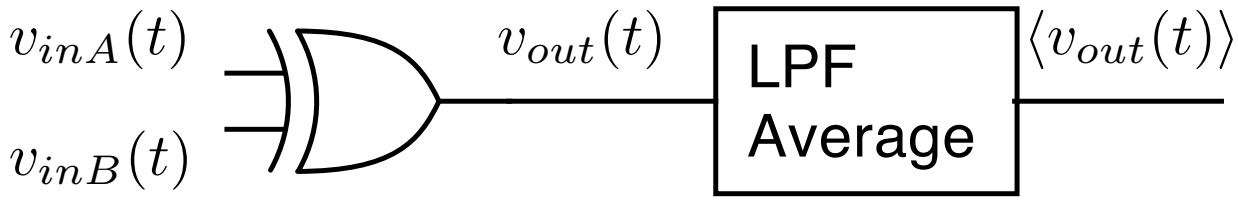
Exclusive-Or Phase Detector

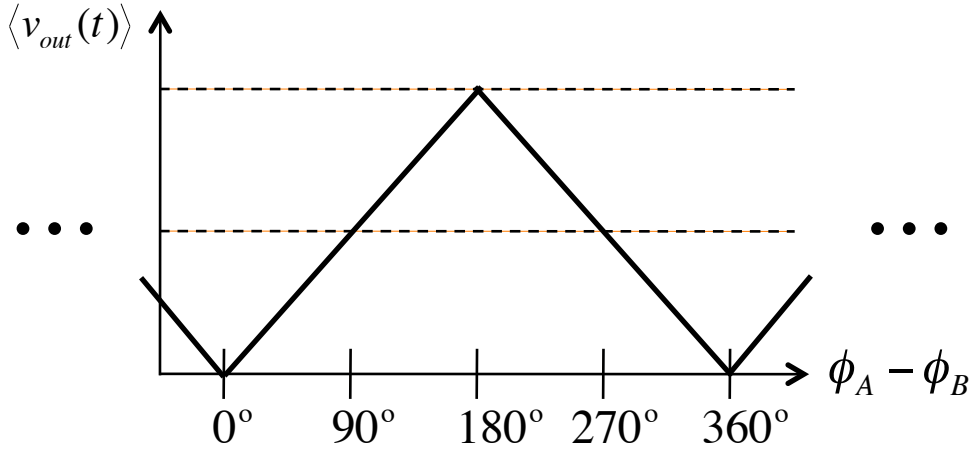


B leads A: $\phi_A - \phi_B < 0$



Ideal Phase Error to Average Output Voltage Characteristic for XOR PD

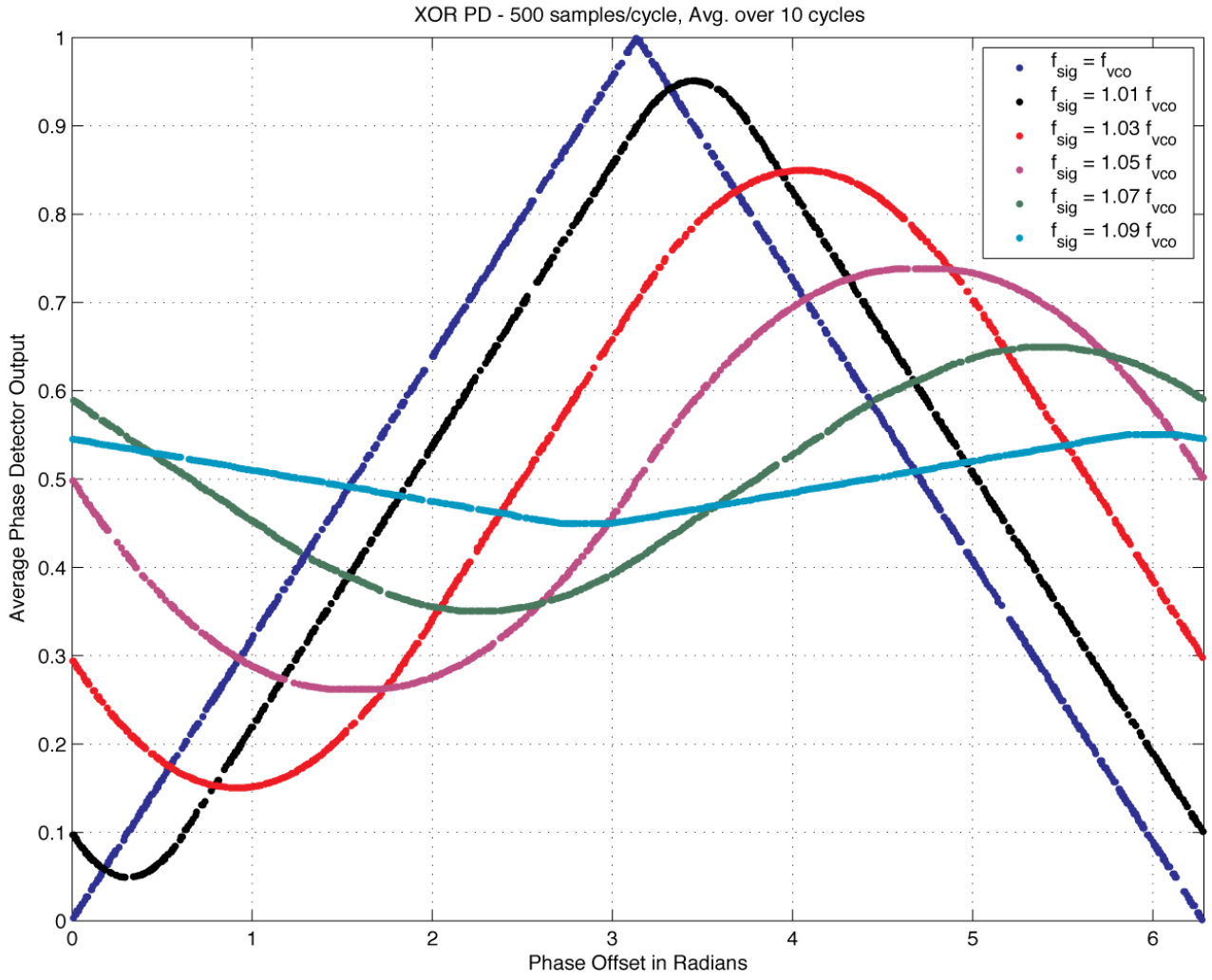




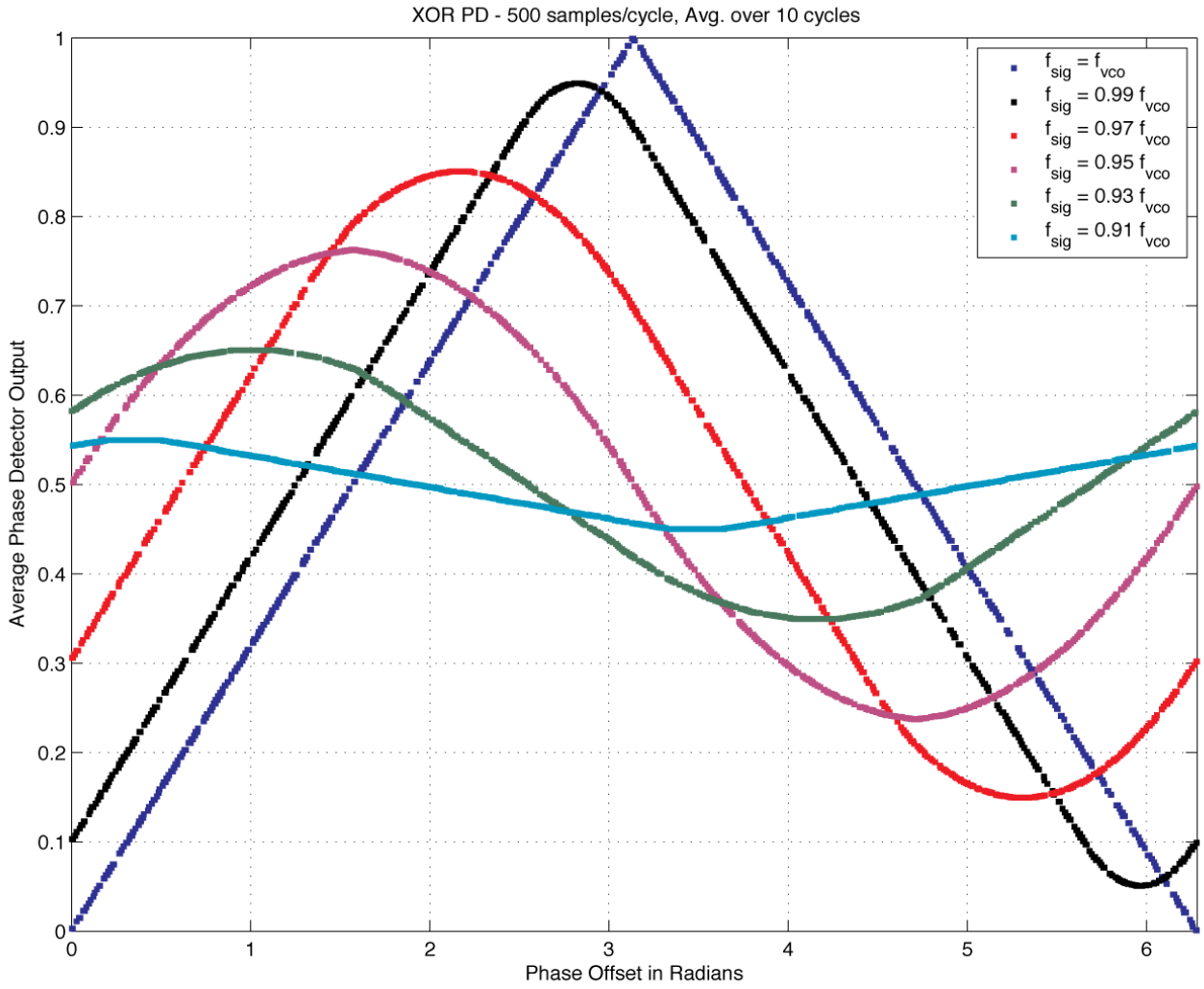
Matlab Code for XOR Experiments

- Code used is:
  - `test_pd.m`
    - A script for testing which generates random phase offsets for reproducing the phase detector characteristic.
    - Frequency offsets can be included.
    - Important parameters are the number of samples per cycle and the number of cycles over which average output is calculated. Effect of frequency offsets depends on length of interval over which average is computed.
  - `xor_pd.m`
    - Function computing output phase pulses. Inputs are hard limited inside the function.

XOR PD for f_sig > f_vco



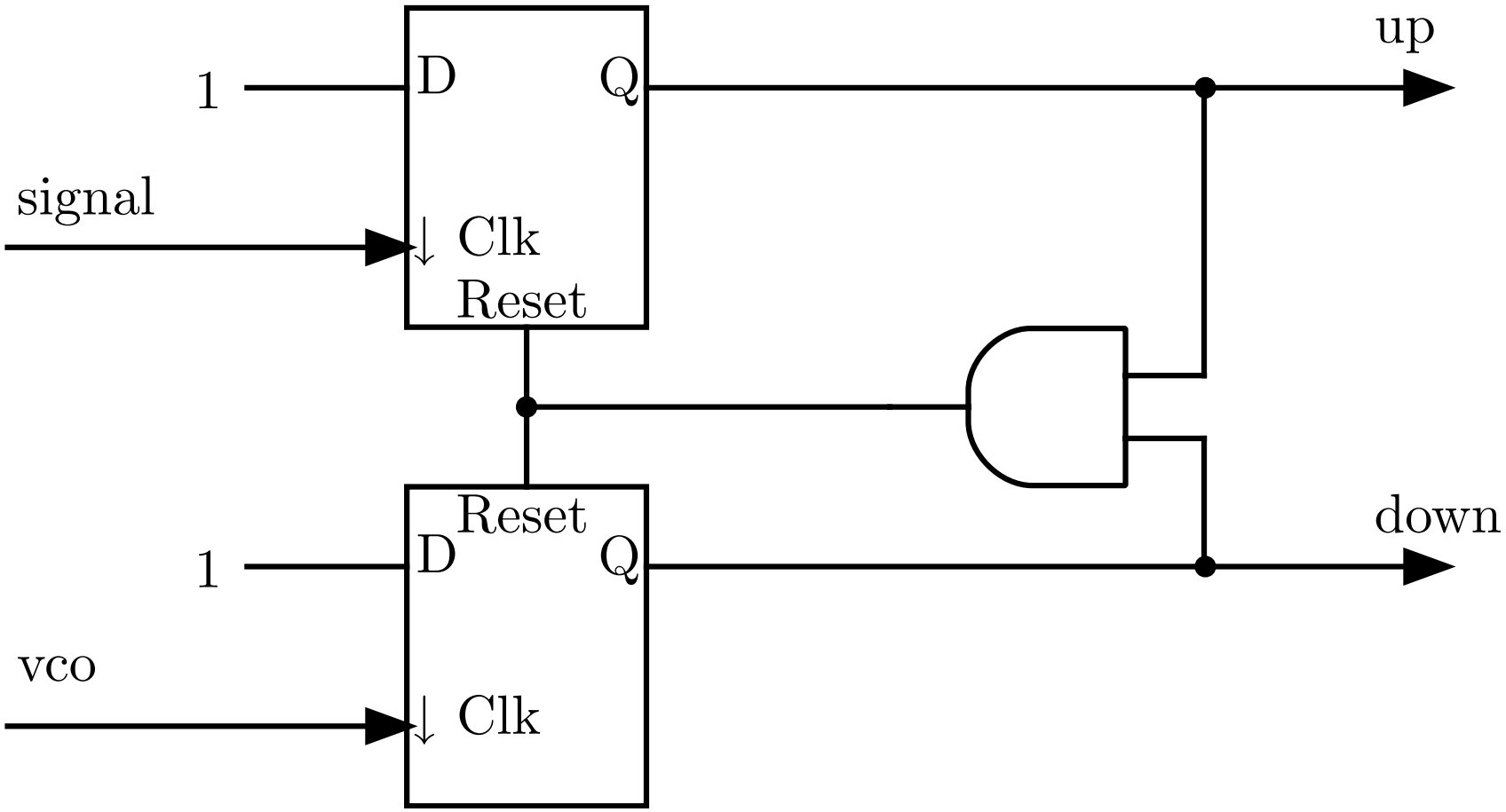
XOR PD for f_sig < f_vco



Conclusions from XOR PD Test

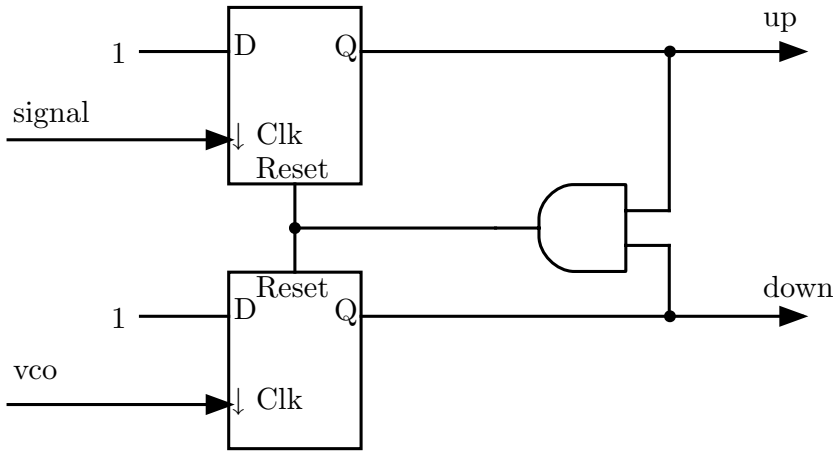
- XOR PD can handle modest frequency offsets and still create a lockable phase error characteristic.
- However, note that if average these characteristics over all possible phase offsets there is no residual frequency offset related signal. Hence is only a PD not a PD/FD.
- Can see how the phase error in lock must move in order to lock in presence of frequency offset.

A Phase Detector / Frequency Detector



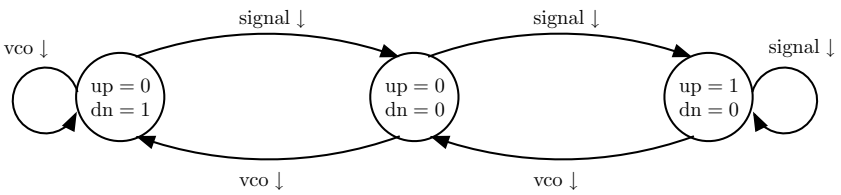
A Phase Detector / Frequency Detector

- Inputs `signal` and `vco` are hard limited.
- Transitions of FFs occur on falling clk edges.
- Output `up` is “1” to speed up vco, `down` is “1” to slow down vco.

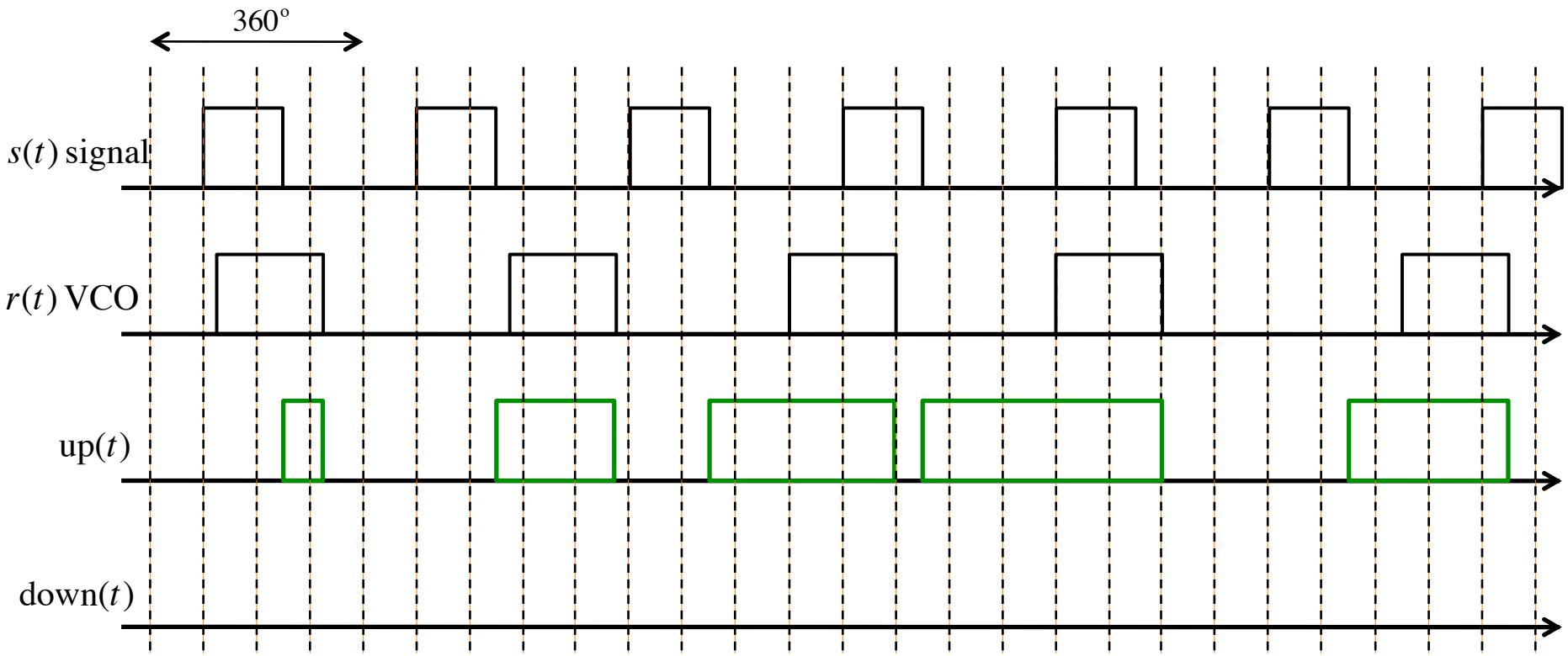


A Phase Detector / Frequency Detector

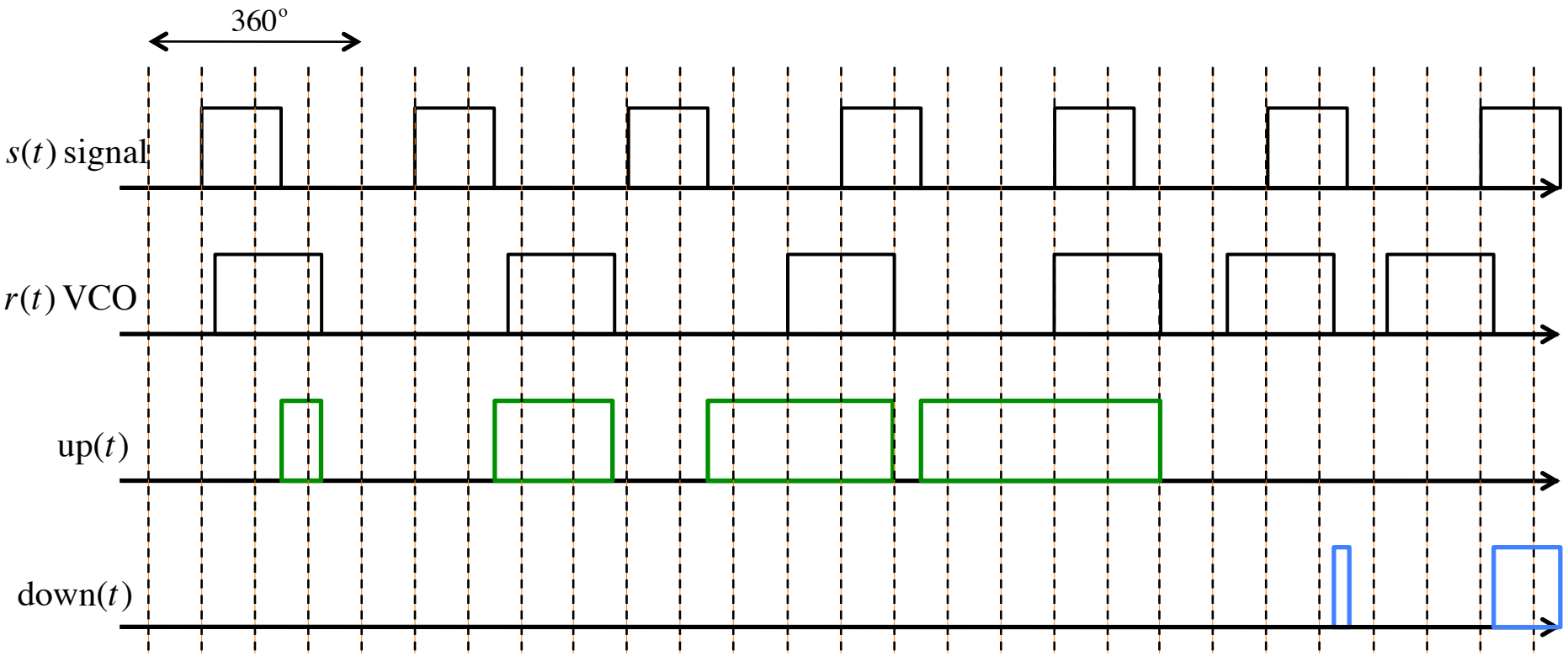
- Inputs `signal` and `vco` are hard limited.
- Transitions of FFs occur on falling clk edges.
- Output `up` is “1” to speed up vco, `down` is “1” to slow down vco.



Phase / Freq. Detector Operation

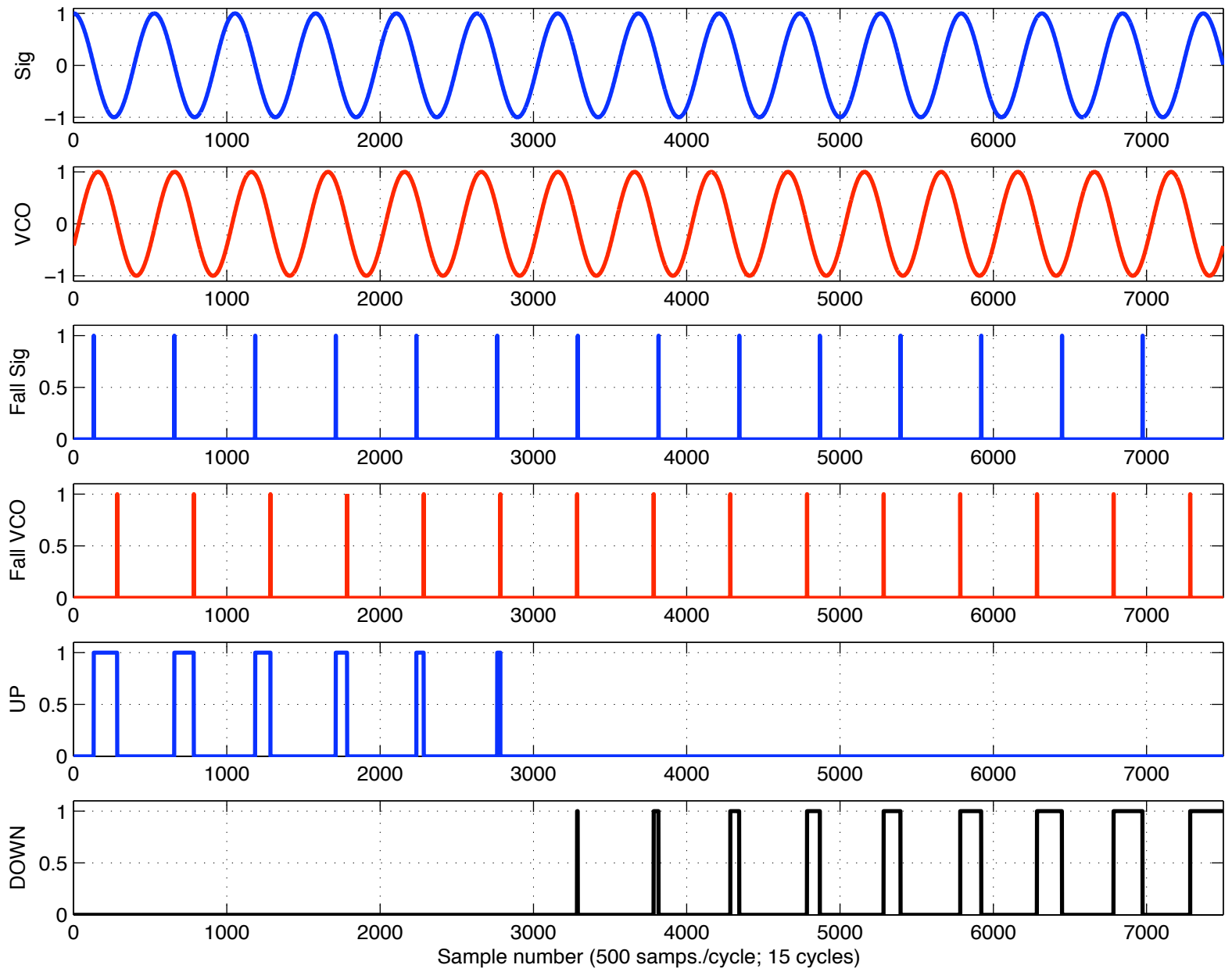


Phase / Freq. Detector Operation

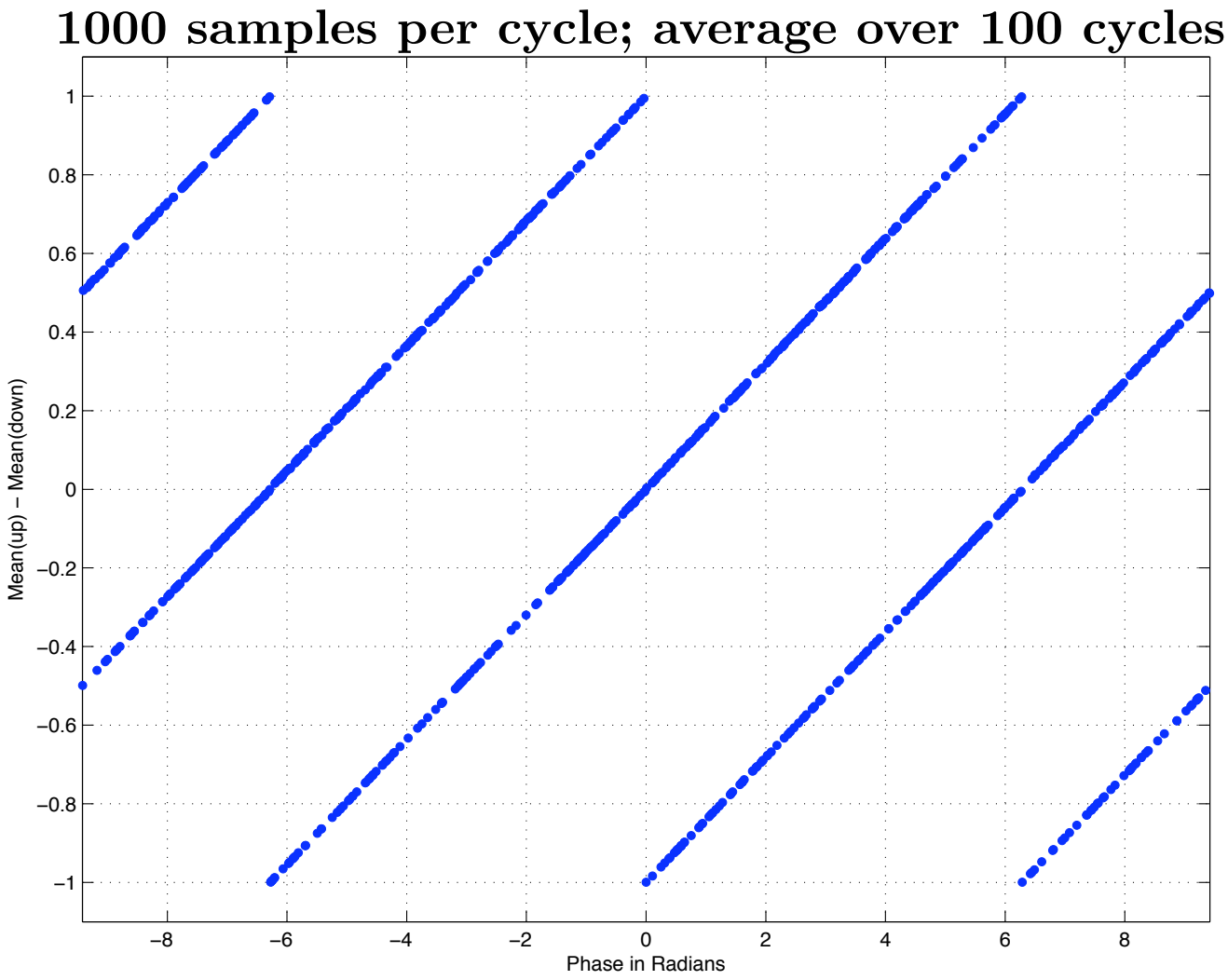


Matlab Code for Flip Flop PD/FD Experiments

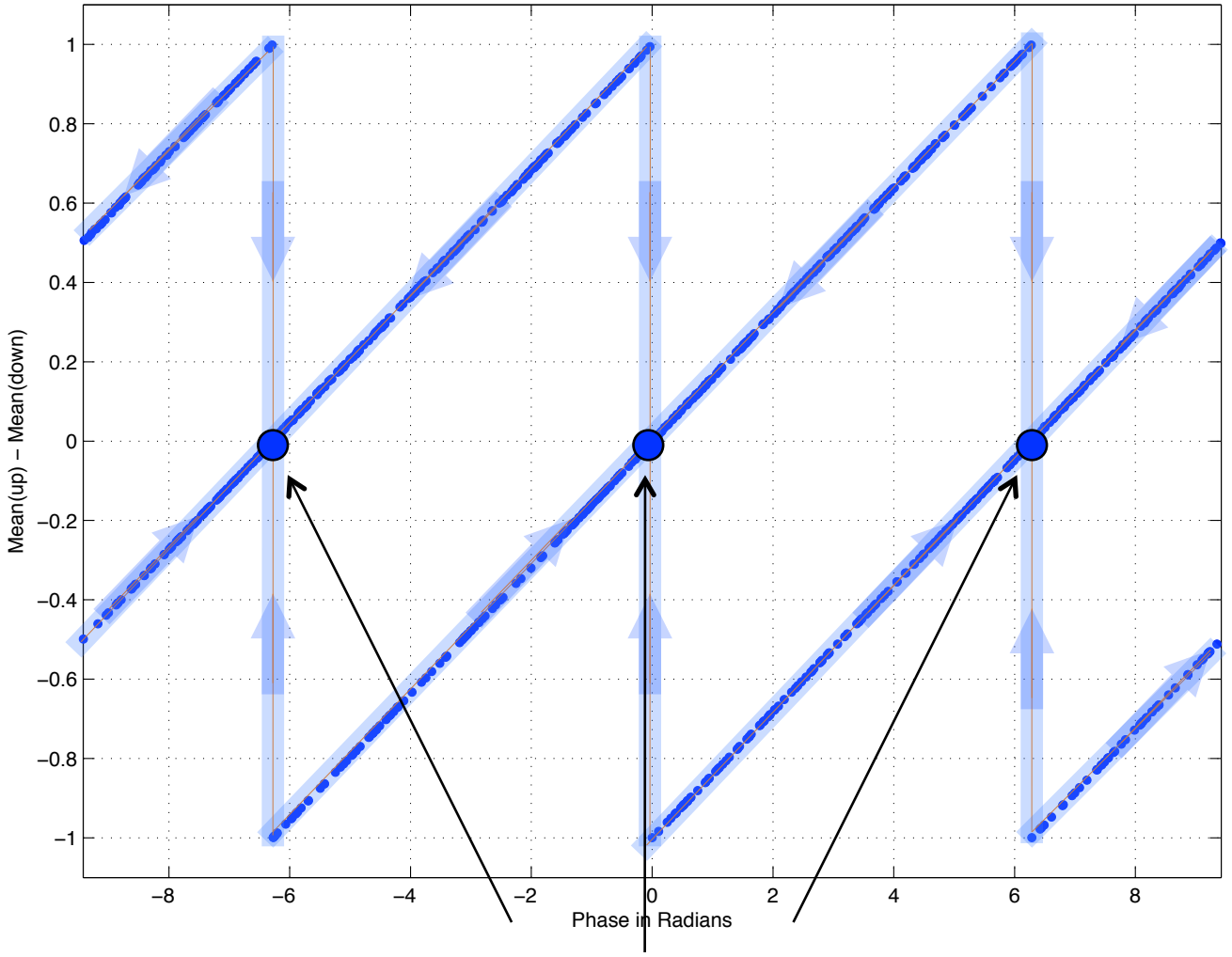
- Code used is:
  - `test_pd2.m`
    - A script for testing which generates random phase offsets for reproducing the phase detector characteristic.
    - Frequency offsets can be included.
    - Important parameters are the number of samples per cycle and the number of cycles over which average output is calculated. Effect of frequency offsets depends on length of interval over which average is computed.
  - `d_flipflop_pd.m`
    - Function computing output phase pulses. Inputs are hard limited inside the function.
  - `falling_edge.m`
    - Function for finding falling edges.


Sig
VCO
Fall Sig
Fall VCO
UP
DOWN
1
0
−1
0.5
0
1000
2000
3000
4000
5000
6000
7000
Sample number (500 samps./cycle; 15 cycles)

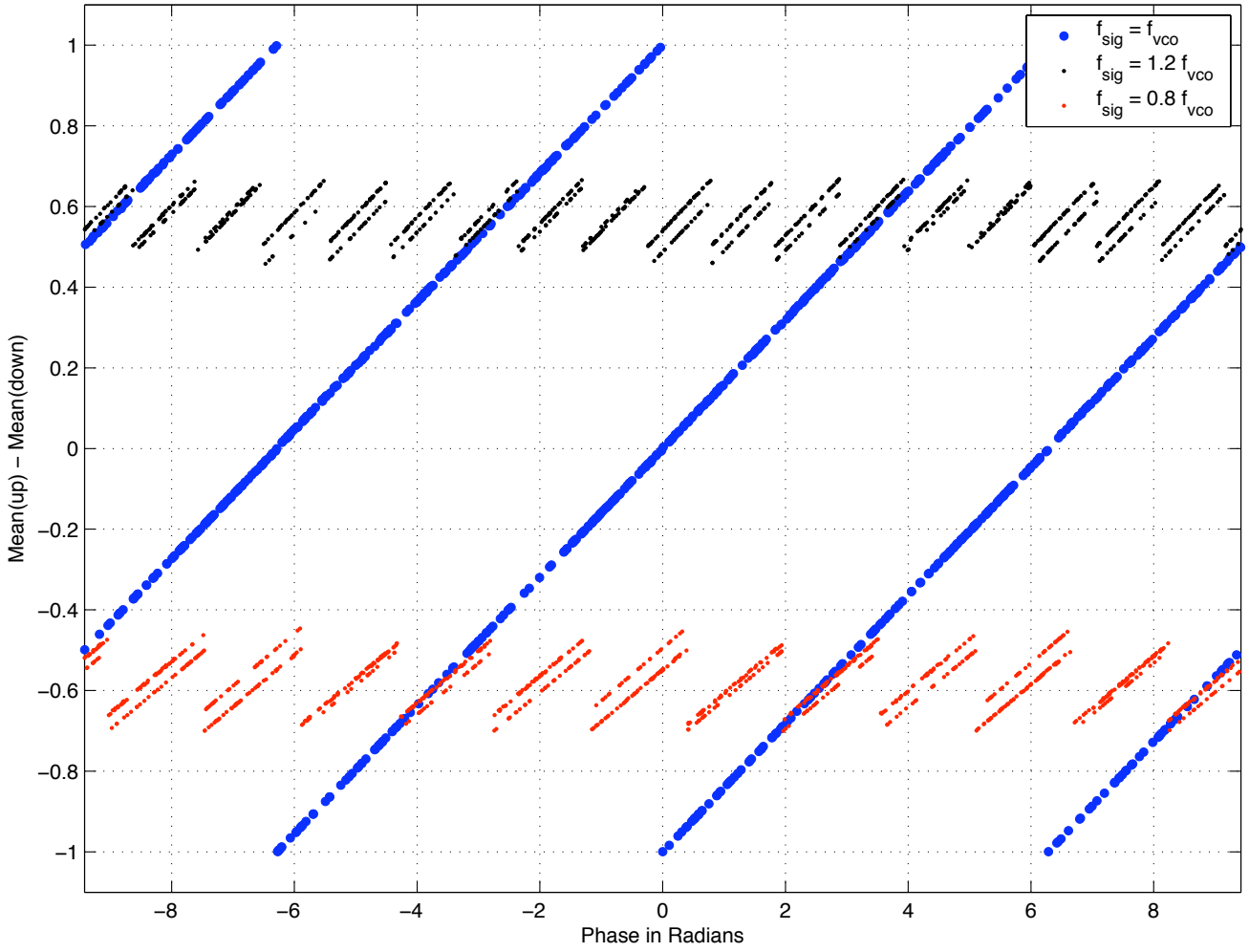
Phase Error Characteristic Showing Hysteresis



Phase Error Characteristic Showing Hysteresis



Effect of Frequency Offset



PD/FD Output versus Offset (Averaged over Phase)