Line Filter Protocol

- Measure time between rising edges of zero crossing detector (T_{zcd}) (frequency error)
- Measure time between rising edges of zero crossing detector and falling edge of reference square wave (T_{Pdif}) (phase error)
- Output a 50% duty cycle square wave whose output (Tree) is modified by a simple averaging algorithm

Averaging Algorithm

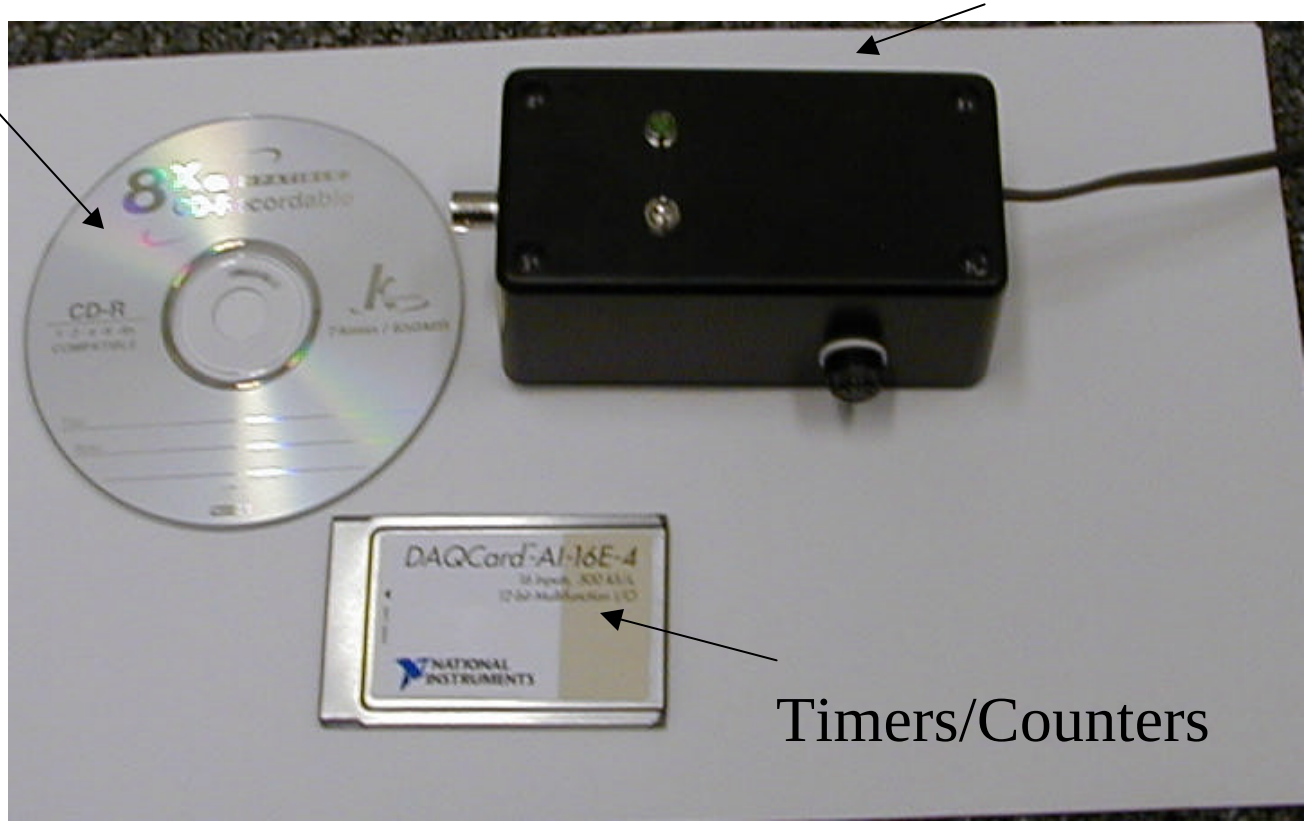
$$T_{ref}^{n} = \frac{1}{M} \sum_{j=n-M}^{n-1} T_{zcd}^{j} + \frac{1}{NZ} \sum_{j=n-M}^{n-1} T_{Pdif}^{j}$$

M,N=number of cycles to average
Z=feedback divisor

Implementation

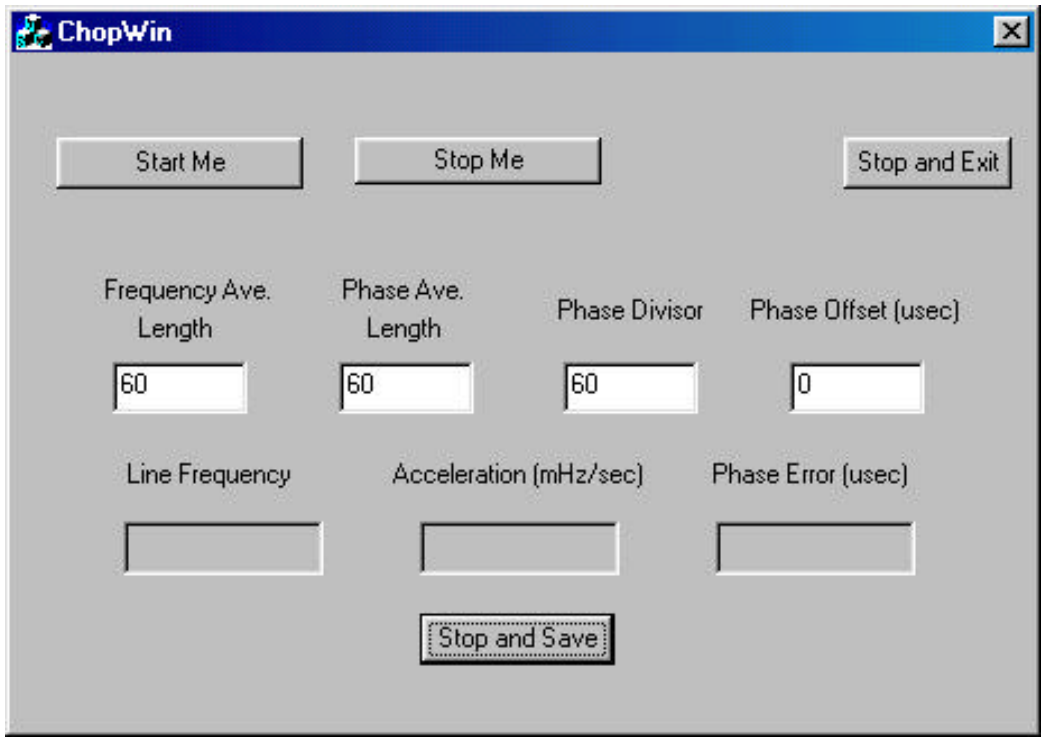
Software with custom driver

Zero Crossing Detector



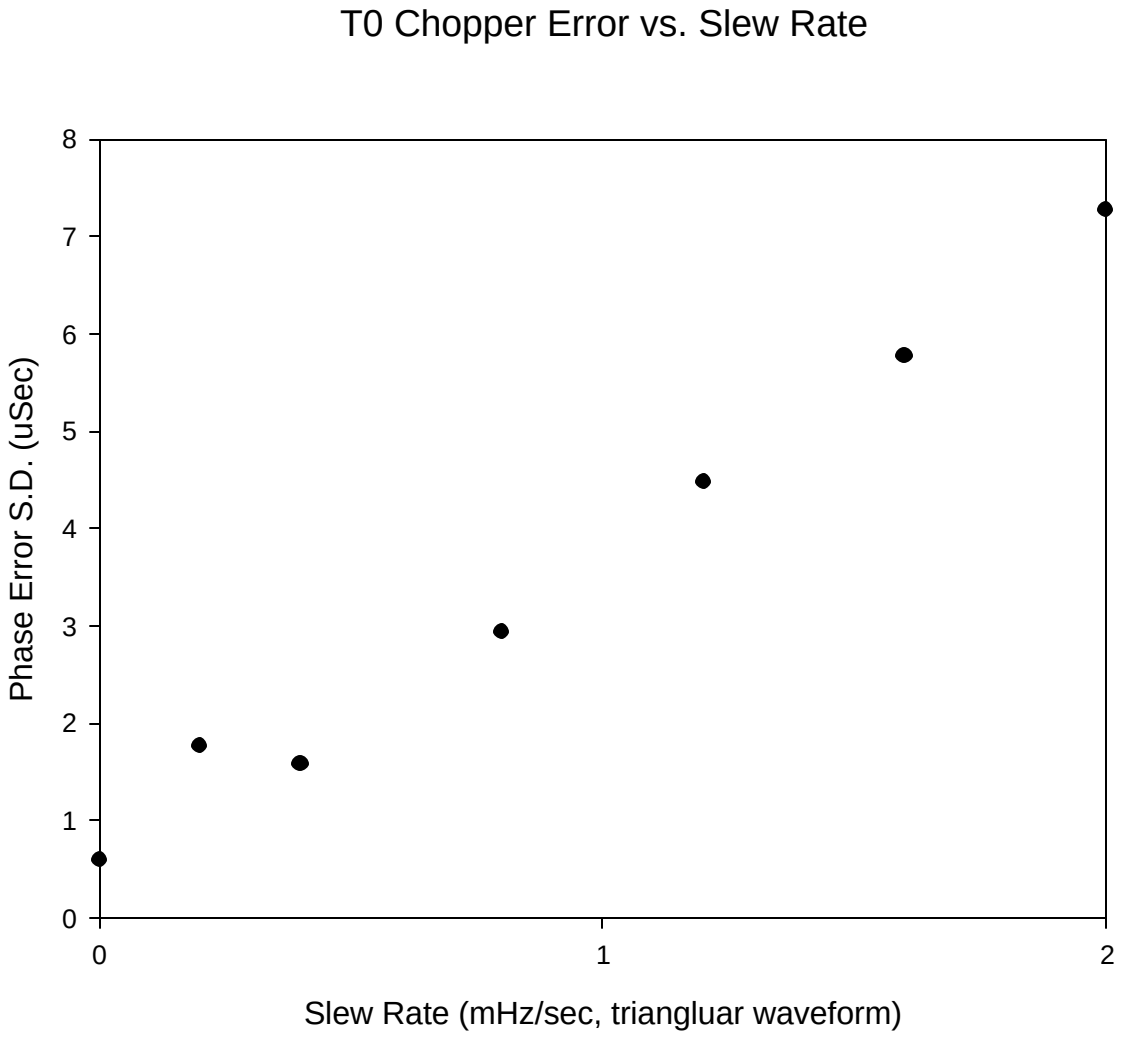
Timers/Counters

Program Interface

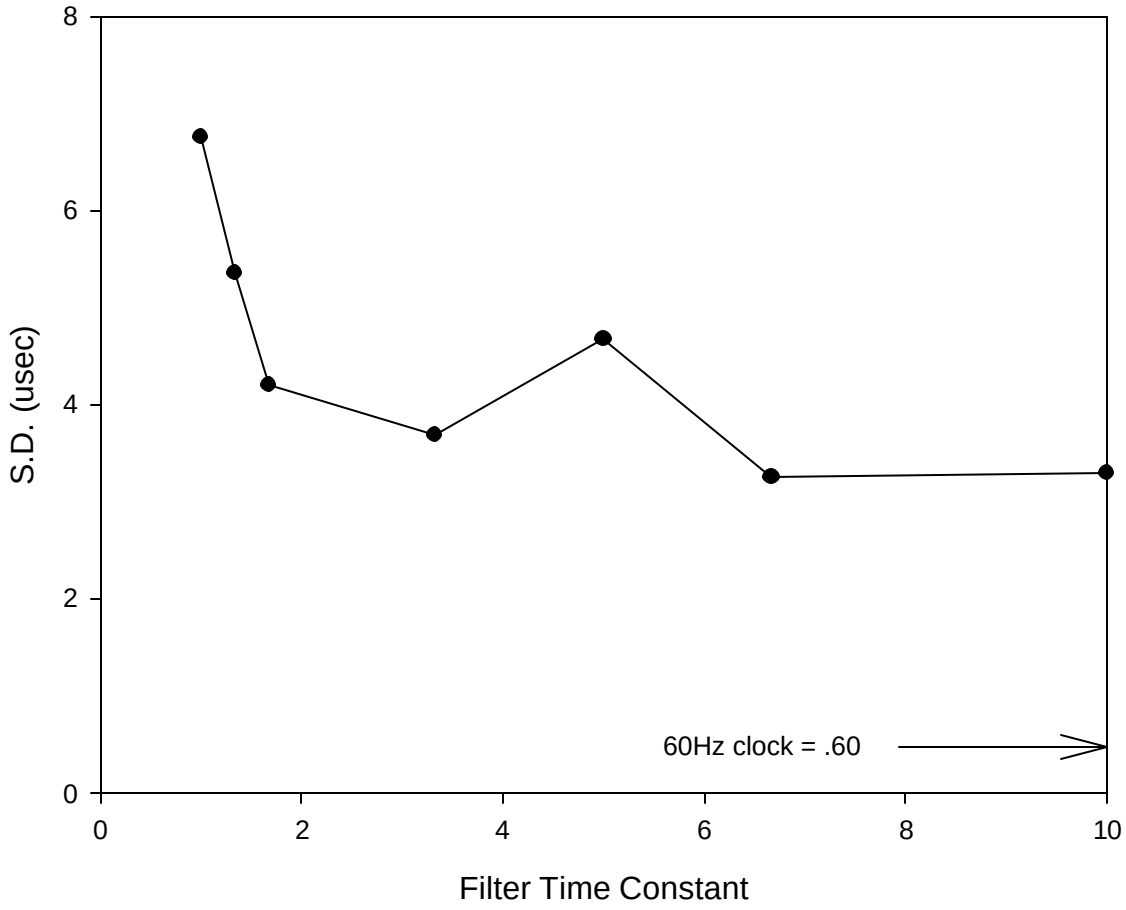


Other Points

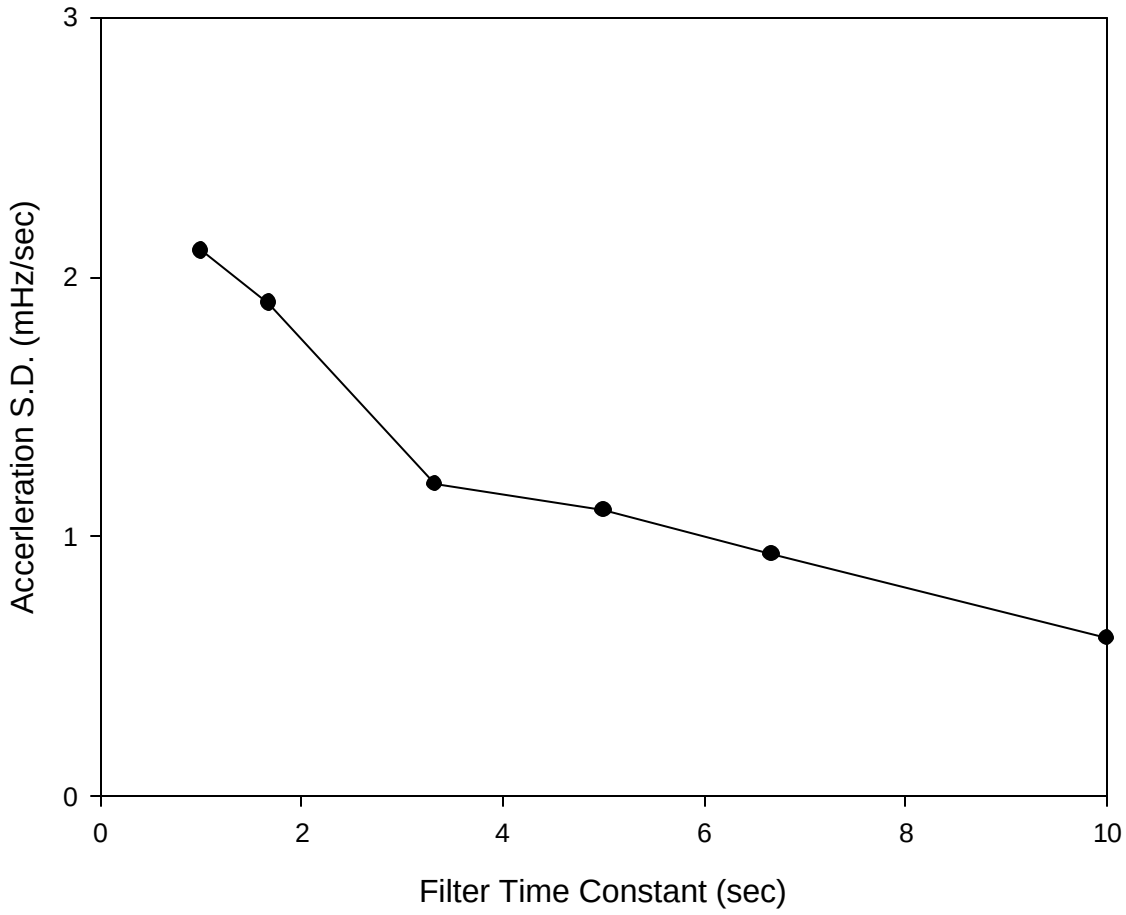
- Reply to comments from design review committee.
- SEW and Chopper control must act like an electronics chopper (I.e. slew rate limited)
- Document from SNS accelerator group stating line following requirements.


T0 Chopper Error vs. Slew Rate
Phase Error S.D. (uSec)
0
1
2
3
4
5
6
7
8
0
1
2
Slew Rate (mHz/sec, triangluar waveform)

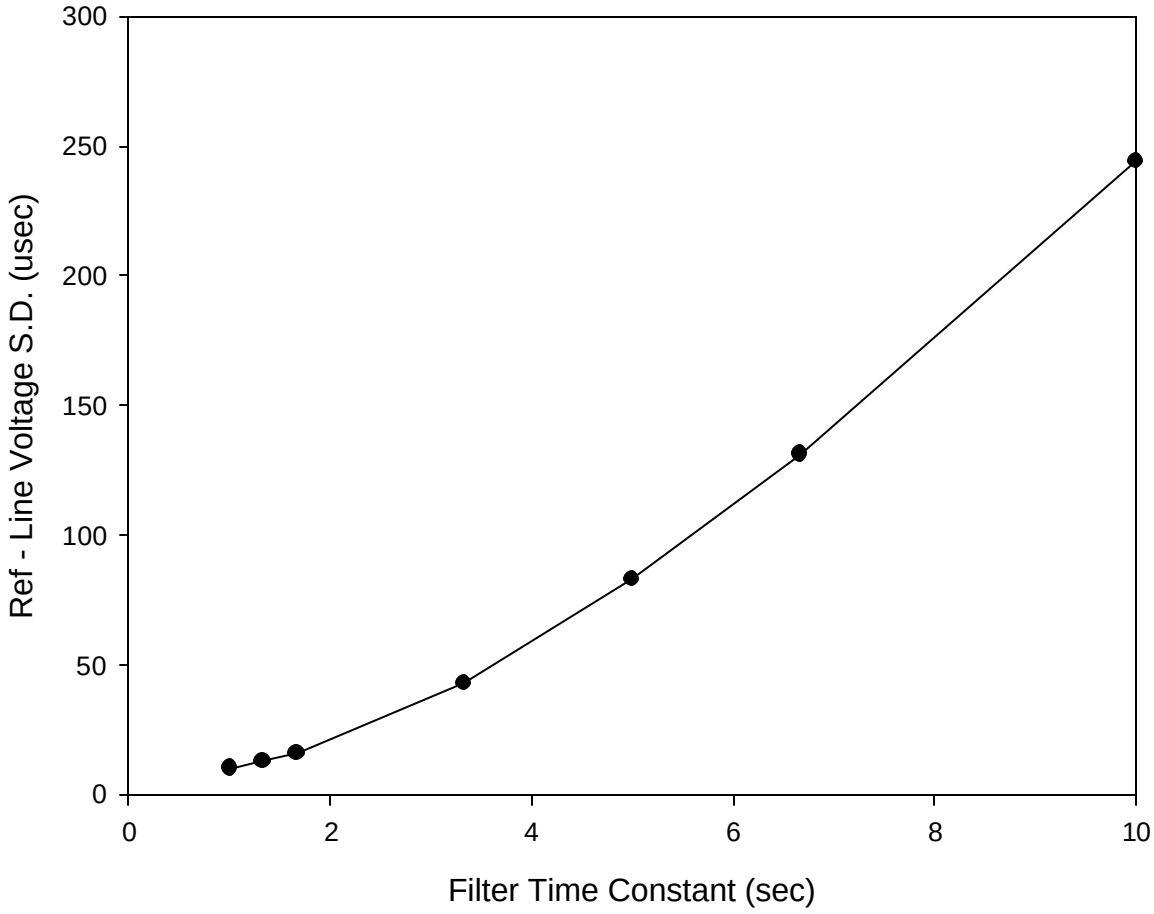
Nelco T0 chopper Data
S.D. (Ref-TDC) vs. Filter Time Constant



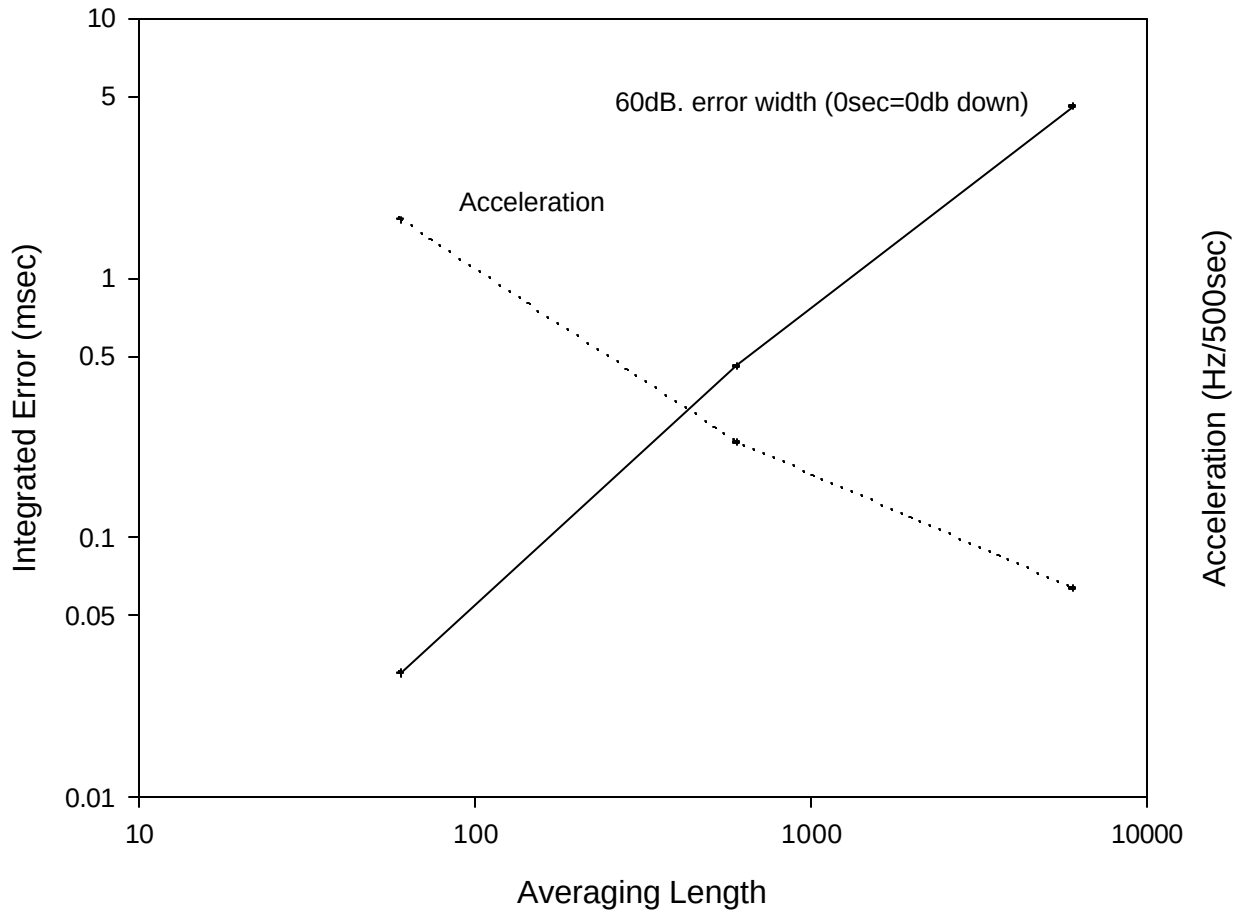
Reference Signal Acceleration vs. Filter Time Constant



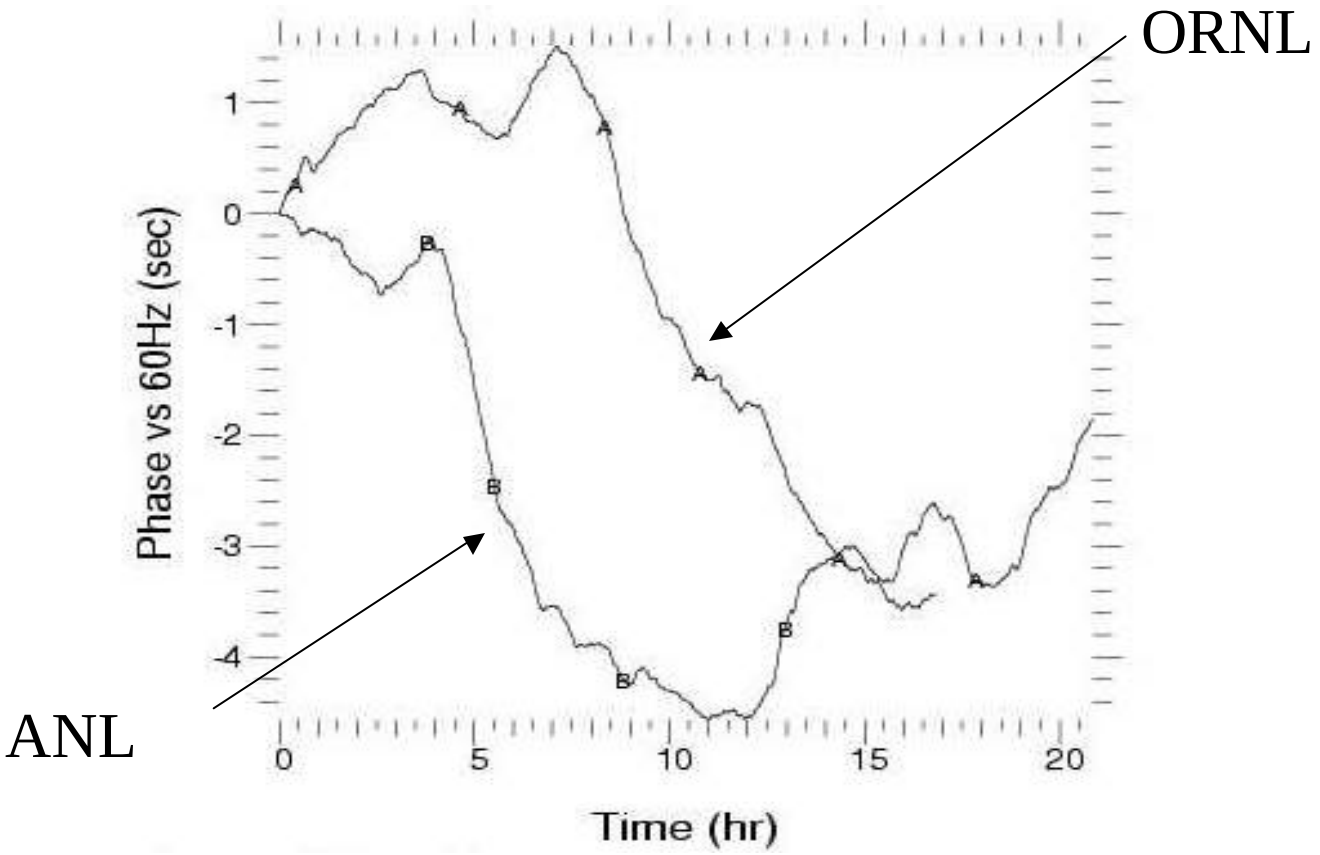
S.D. of Phase Difference between reference signal and zero crossing vs. Filter time constant

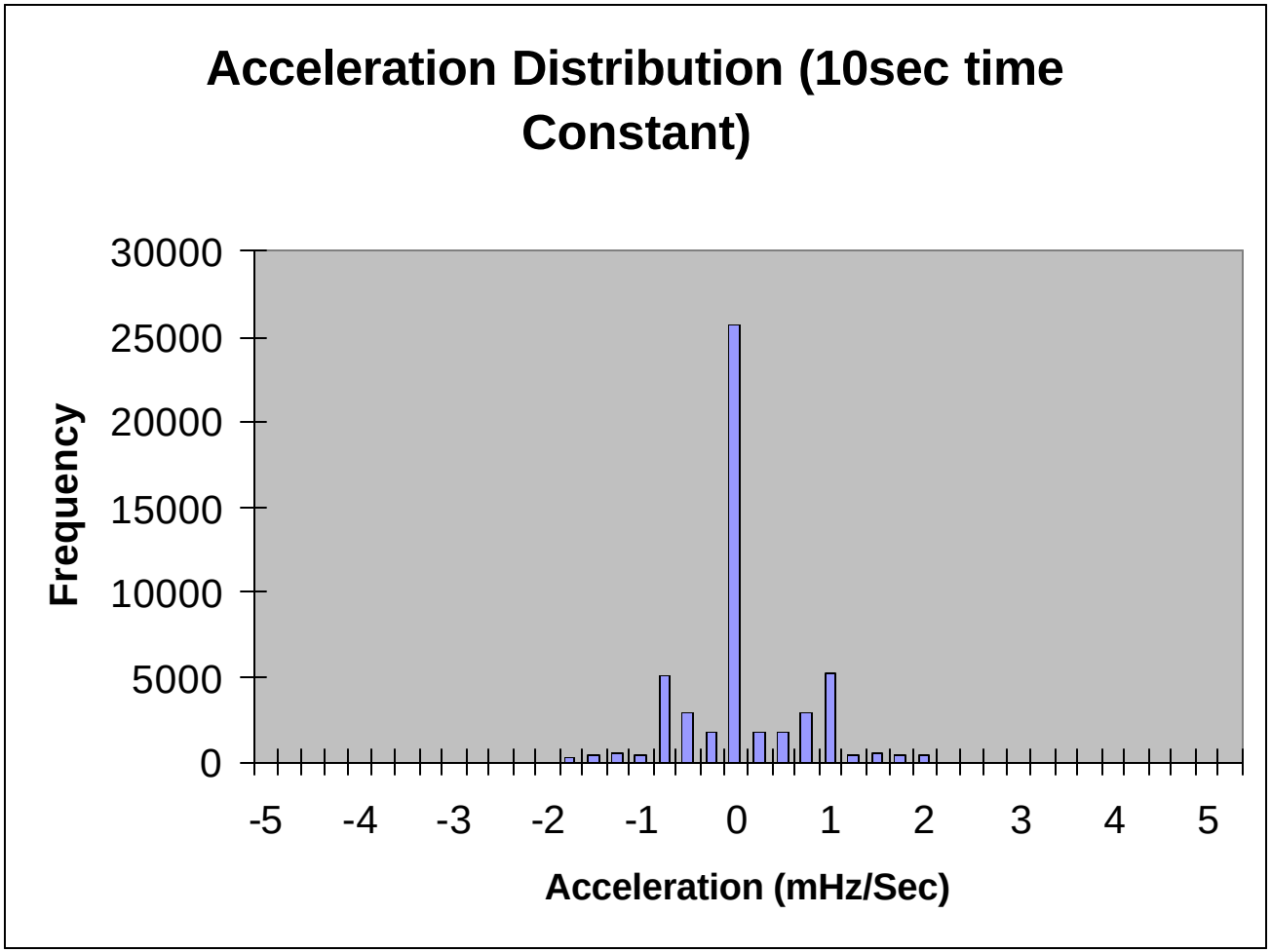


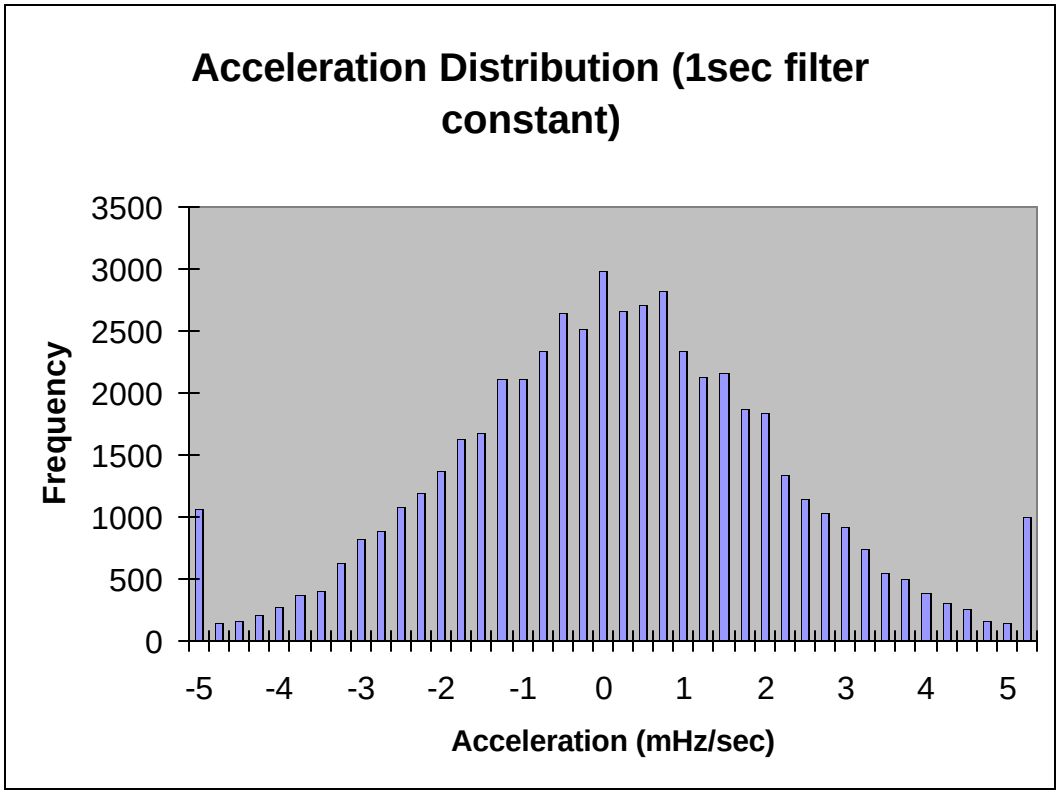
ORNL Line Voltage Characteristics

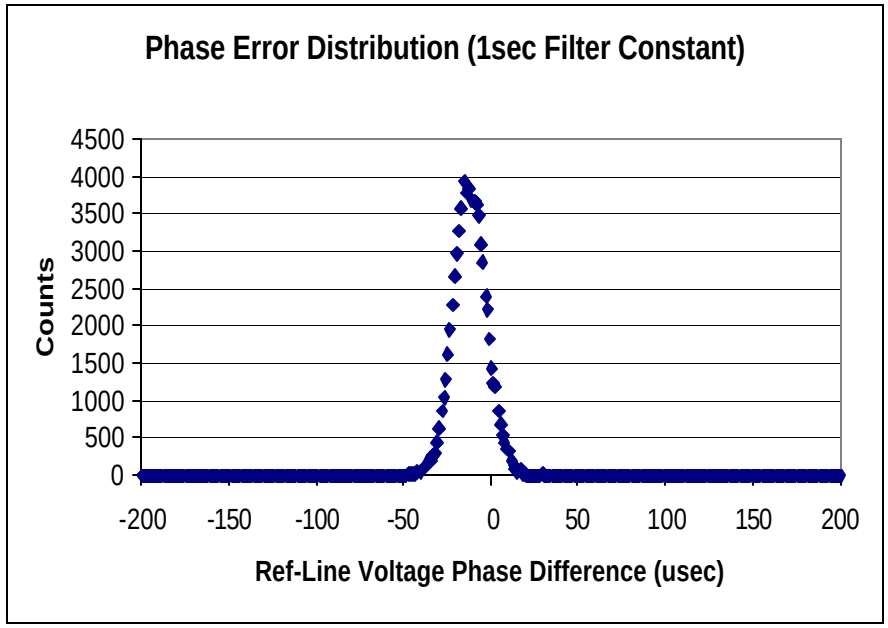


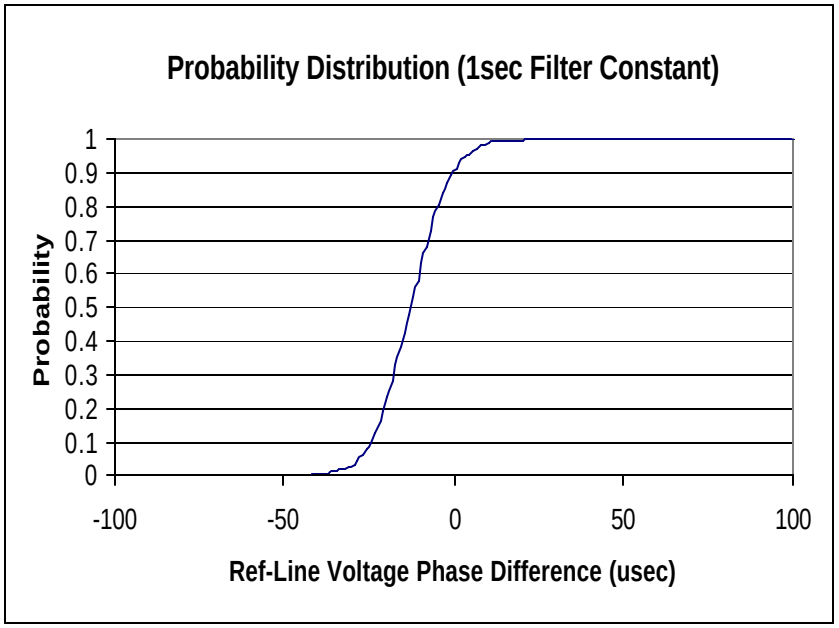
Line Voltage Zero Crossings

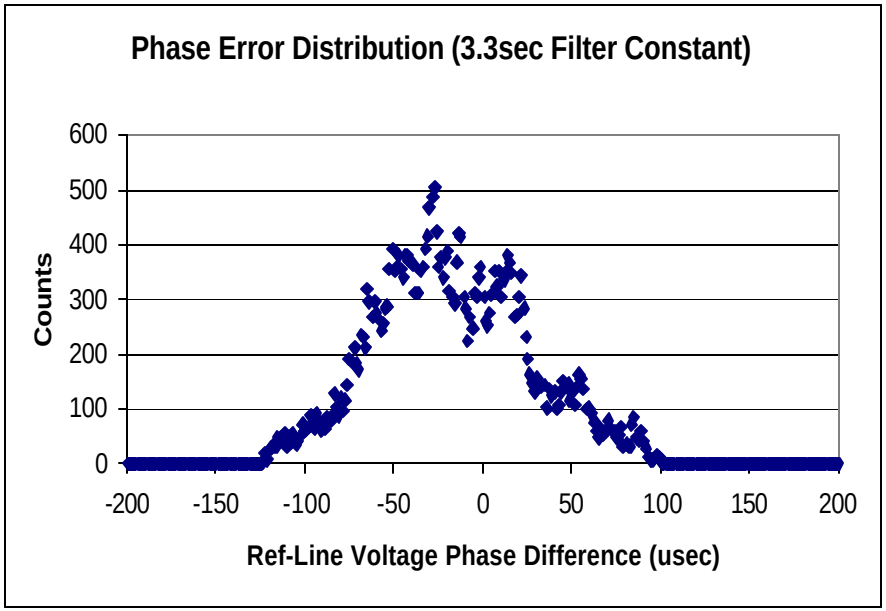


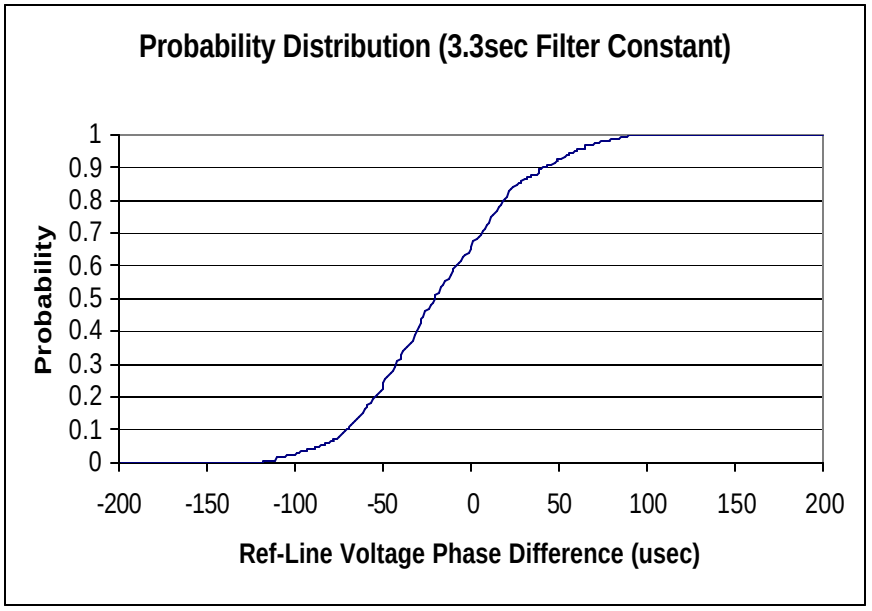

Acceleration Distribution (10sec time Constant)
Frequency
30000
25000
20000
15000
10000
5000
0
-5
-4
-3
-2
-1
0
1
2
3
4
5
Acceleration (mHz/Sec)

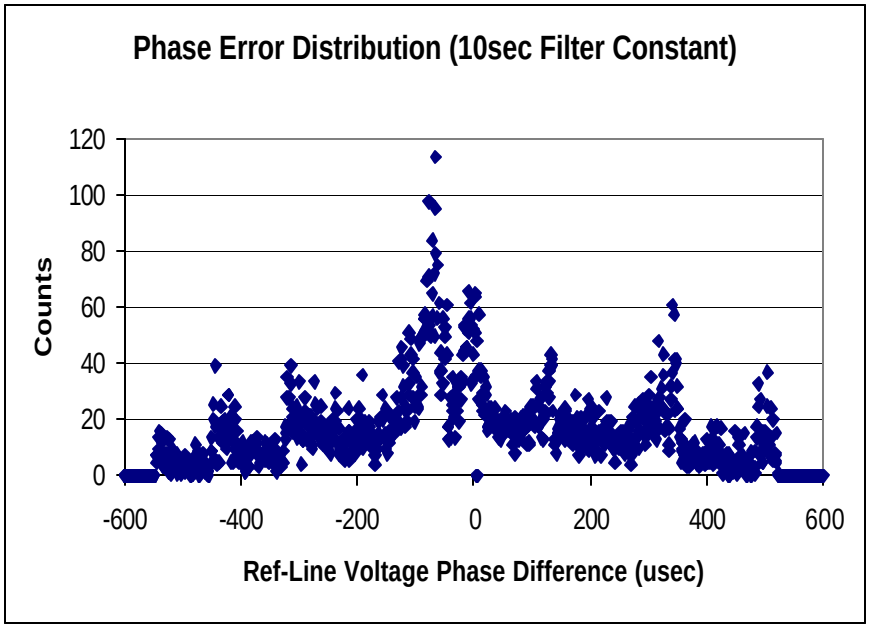

Acceleration Distribution (1sec filter constant)
Frequency
3500
3000
2500
2000
1500
1000
500
0
-5
-4
-3
-2
-1
0
1
2
3
4
5
Acceleration (mHz/sec)

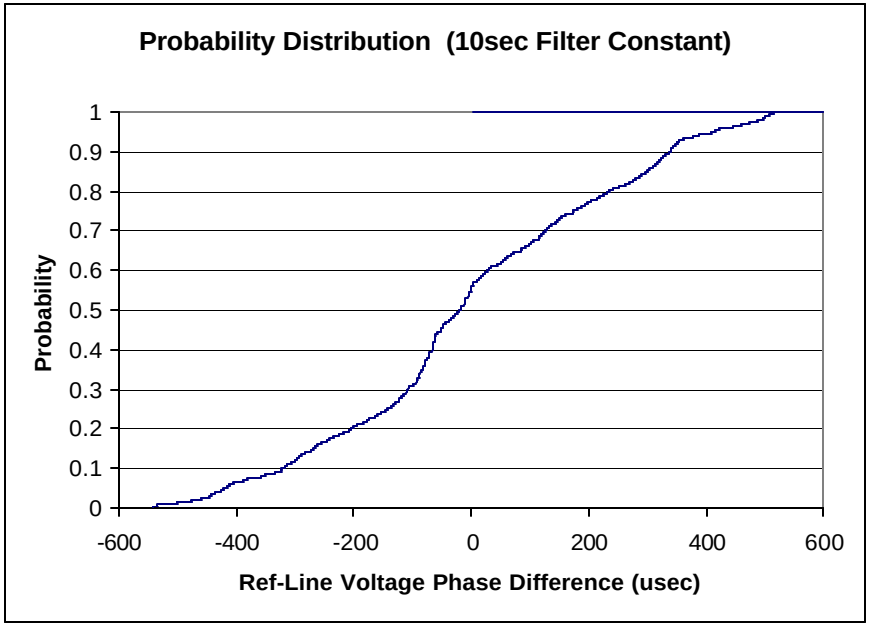

Phase Error Distribution (1sec Filter Constant)
Counts
4500
4000
3500
3000
2500
2000
1500
1000
500
0
-200
-150
-100
-50
0
50
100
150
200
Ref-Line Voltage Phase Difference (usec)


Probability Distribution (1sec Filter Constant)
Probability
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-100
-50
0
50
100
Ref-Line Voltage Phase Difference (usec)


Phase Error Distribution (3.3sec Filter Constant)
Counts
600
500
400
300
200
100
0
-200
-150
-100
-50
0
50
100
150
200
Ref-Line Voltage Phase Difference (usec)


Probability Distribution (3.3sec Filter Constant)
Probability
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-200
-150
-100
-50
0
50
100
150
200
Ref-Line Voltage Phase Difference (usec)


Phase Error Distribution (10sec Filter Constant)
Counts
120
100
80
60
40
20
0
-600
-400
-200
0
200
400
600
Ref-Line Voltage Phase Difference (usec)


Probability Distribution (10sec Filter Constant)
Probability
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-600
-400
-200
0
200
400
600
Ref-Line Voltage Phase Difference (usec)