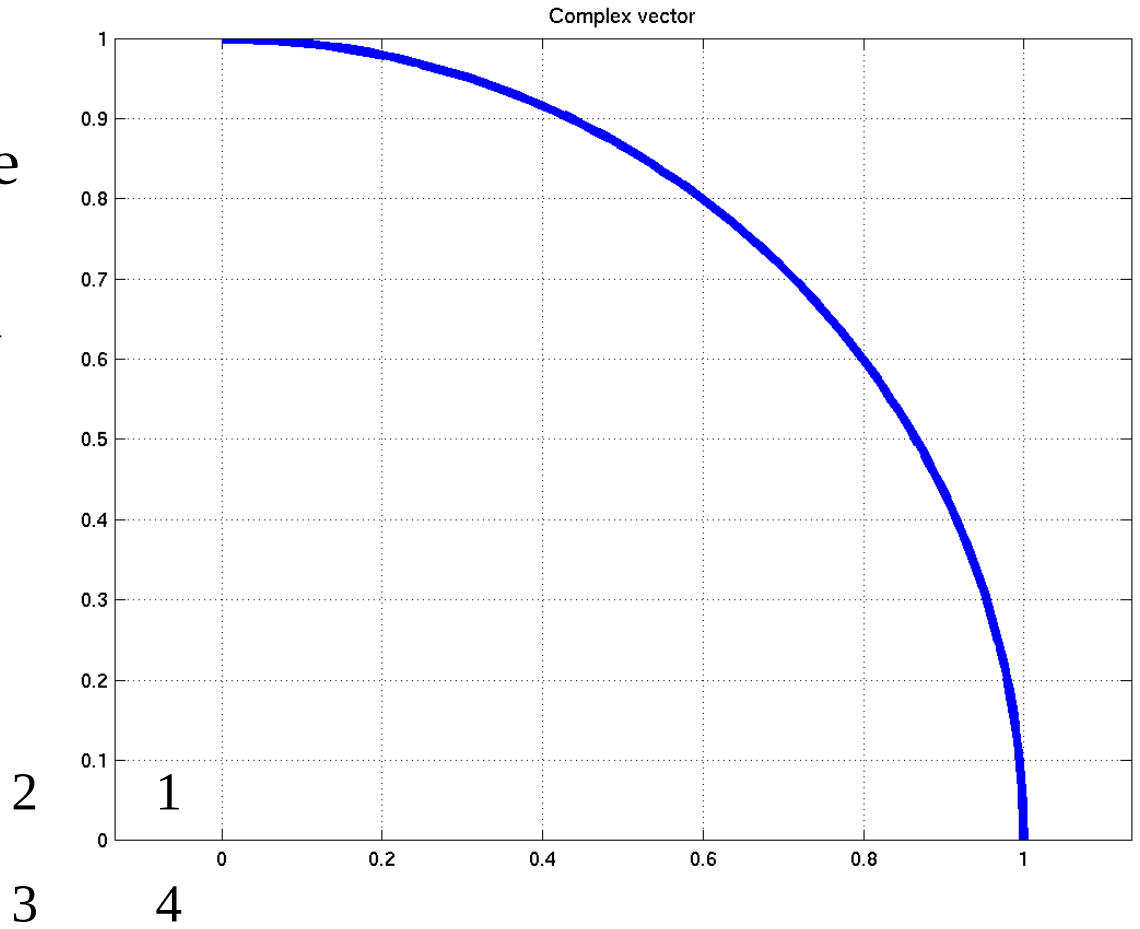
COMPLEX SIGNAL MAGNITUDE ESTIMATION

Amplitude Estimation for Complex Signals

1. Exact
   - sqrt($real^2 + imag^2$)
   - All four quadrants are supported
   - Hardware required
     - Two squares (one multiply equiv.)
     - Addition
     - Square root
       - Low-precision is easy with a lookup table
       - High-precision (wide output word) can be expensive especially is high speed is required

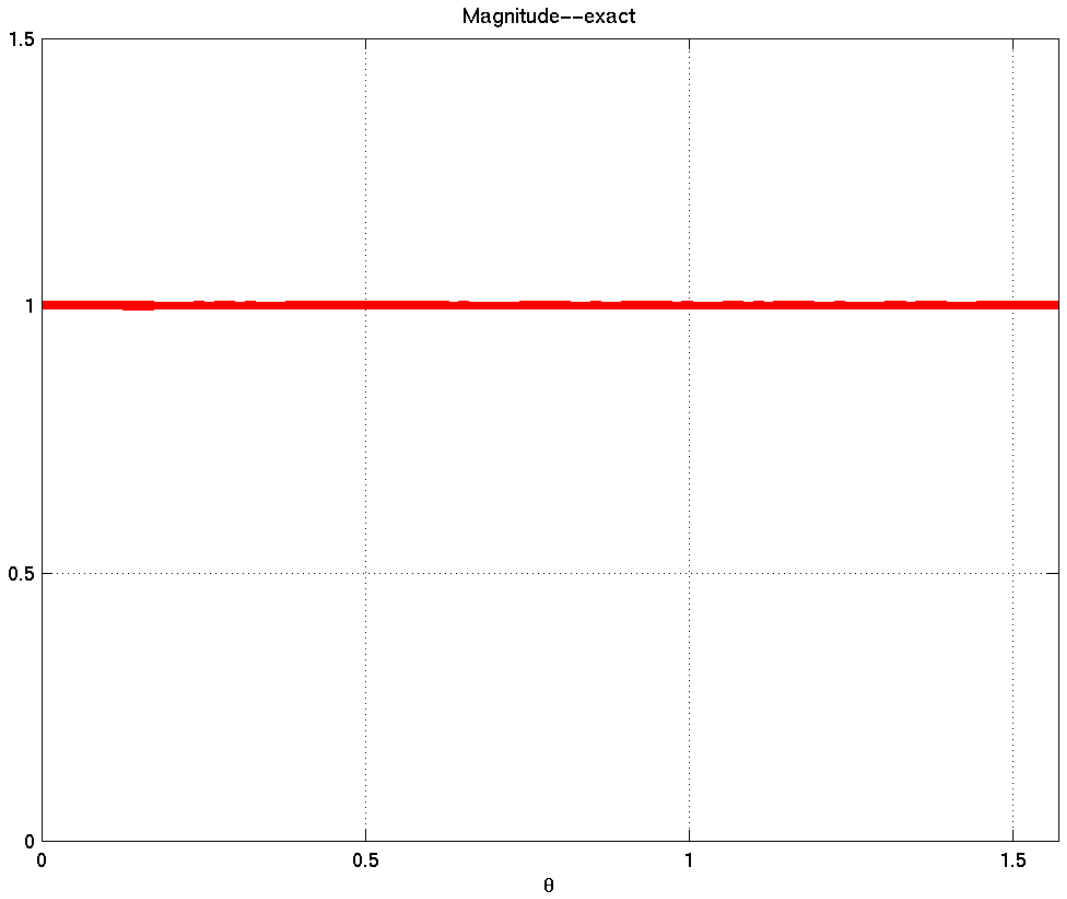
0 - π/2 Input Vector

- First quadrant example
- Note that some techniques do not work in all quadrants
- Magnitude = 1



Complex Signal Magnitude Estimation

- Exact calculation



Amplitude Estimation for Complex Signals

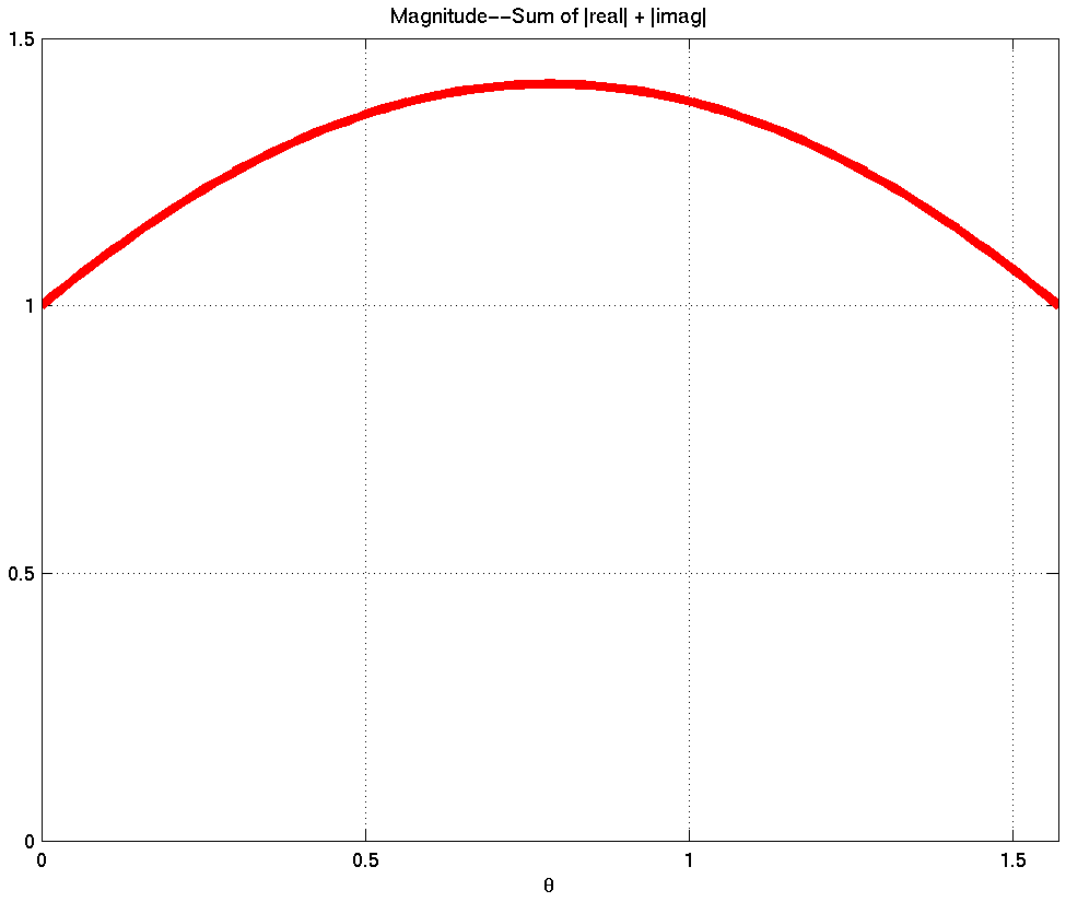
- For the remaining three methods, we can extend from the 1st quadrant to all 4 quadrants by first taking the absolute value of *real* and *imag* and then calculating the magnitude

2. Sum of magnitudes
   - $real + imag$ First quadrant
   - $|real| + |imag|$ All quadrants
   - Not very accurate
   - Three adders (or one adder for first quadrant version)

[Yee and Brodersen, Jan 2000]

Complex Signal Magnitude Estimation

- Sum of magnitudes of real and imag parts
- Max error = 41.4%



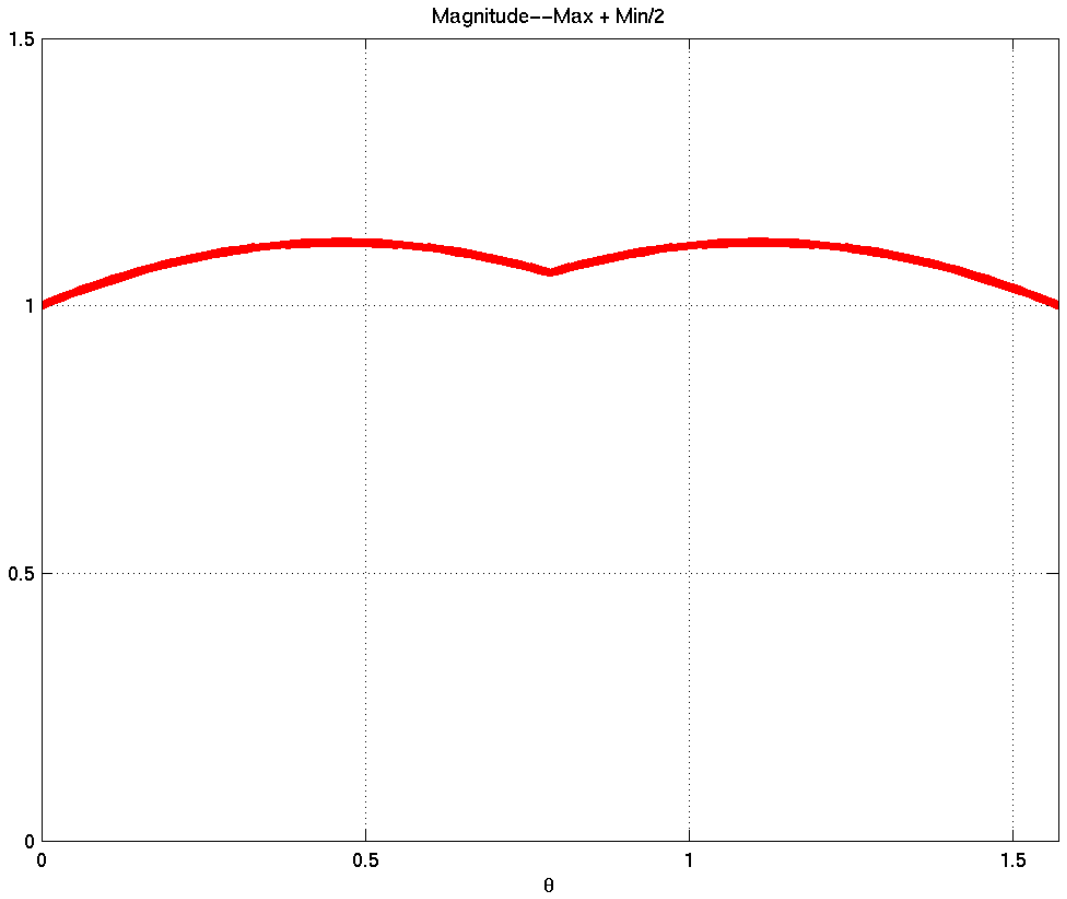
Amplitude Estimation for Complex Signals

3. Max + Min/2
   - max(*real*, *imag*) + ½ min(*real*, *imag*)
   - First quadrant
   - A possible hardware implementation
     - One subtractor (comparison of *real* and *imag* by subtracting, then muxing based on the sign of the difference)
     - Two muxes for max and min selection
     - Divide-by-2 shifter for min is free
     - One adder

[Yee and Brodersen, Jan 2000]

Complex Signal Magnitude Estimation

- Max
  + ½ Min
- Max error = 11.8%



Amplitude Estimation for Complex Signals

- Notice positive bias and see if we can do better…

4. Max + Min/2 - Max/16
   - max(*real*, *imag*) + ½ min(*real*, *imag*) – 1/16 max(*real*, *imag*)
   - A possible hardware implementation
     - One subtractor (comparison of *real* and *imag*)
     - Two muxes for max and min selection
     - Shifters are free
     - One three-input adder (similar in hardware to two CPA adders; similar in delay to 1+ CPA adder)

Complex Signal Magnitude Estimation

- Max
  + Min/2
  - Max/16
- Max error = 6.25%
- Many opportunities for algorithm design!