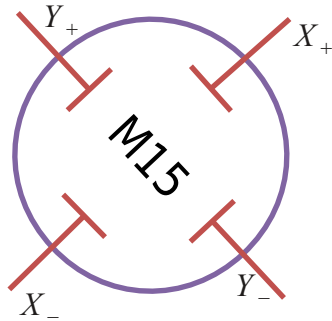


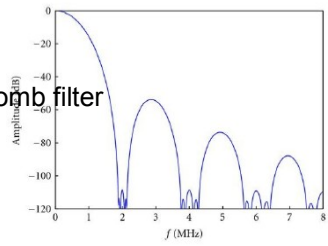
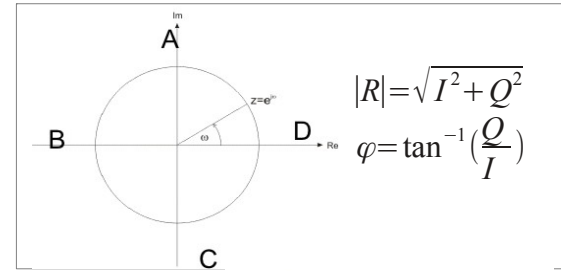
Rastered Beam Position Reconstruction

Pengjia Zhu 2/17/2012

Beam Position Monitor



$$X \propto \frac{X_+ - X_-}{X_+ + X_-}$$

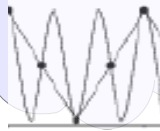


Cascaded integrator-comb filter

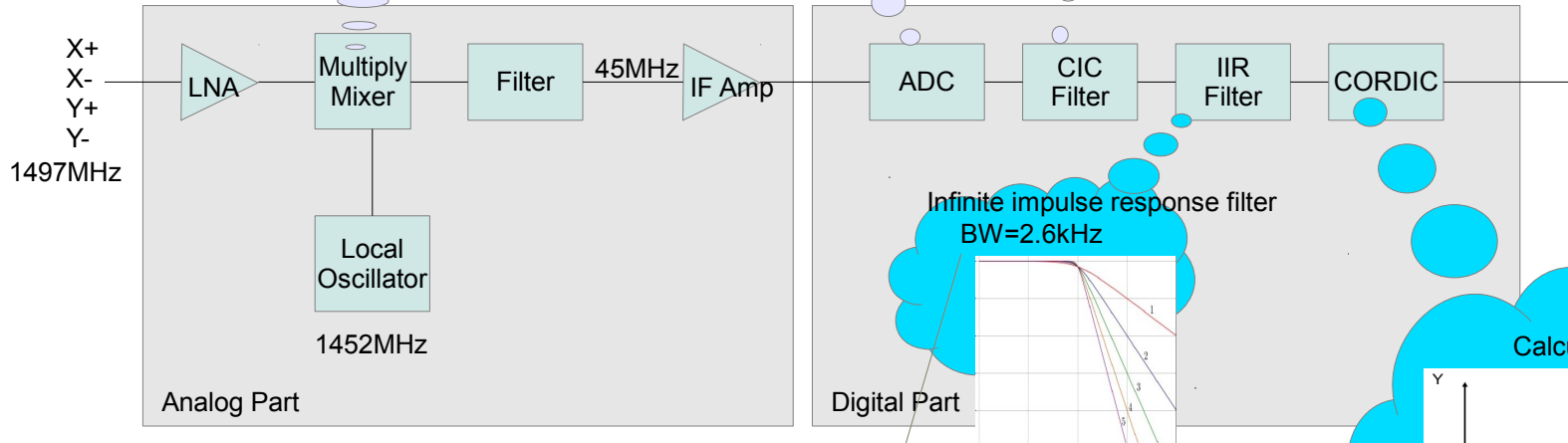
$$\int dt \quad \frac{d}{dt}$$

Noise limit
exclude out-of band signal

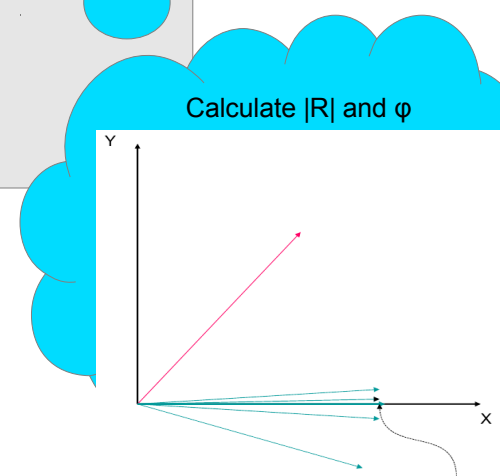
Harmonic sampling
Sample Rate: 36MSPS



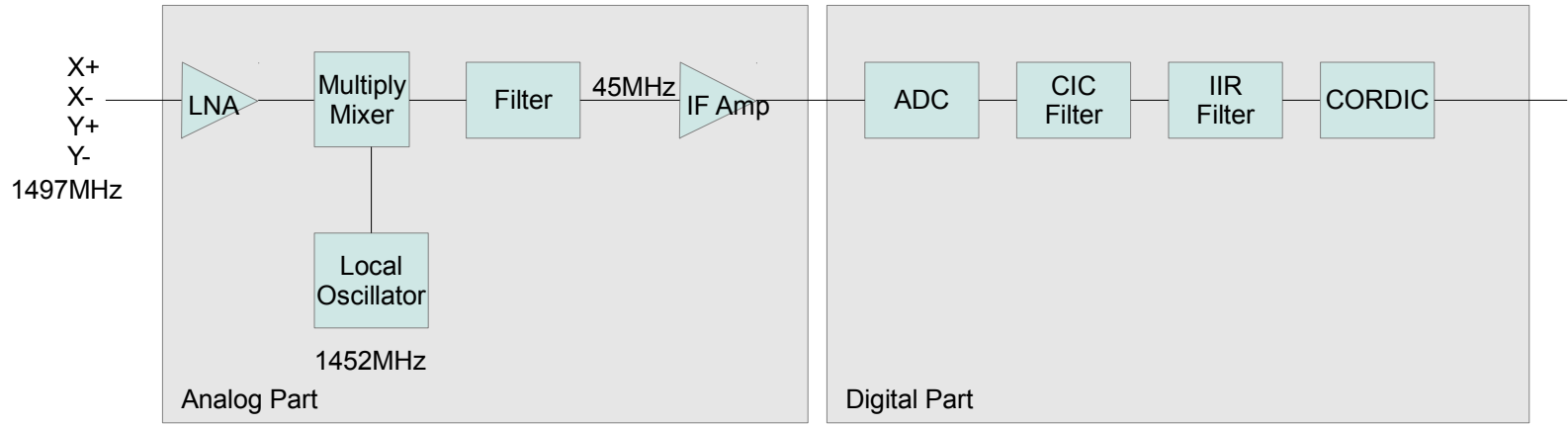
$$\sin \theta \sin \phi = \frac{1}{2} \cos(\theta - \phi) - \frac{1}{2} \cos(\theta + \phi)$$



We can not see fast raster signal



Signal Delay from BPM Receiver



Analog Delay < 1µs

$$Digital\ Delay(s) = \frac{1}{36 \times 10^6} + \frac{1}{1 \times 10^6} + \frac{1}{2.6 \times 10^3} + \frac{24}{36 \times 10^6} + \frac{1}{1 \times 10^6}$$

The equation is annotated with callouts explaining the terms:

- $\frac{1}{36 \times 10^6}$: From ADC Depends on Sample Rate
- $\frac{1}{1 \times 10^6}$: From Filter's Feedback
- $\frac{1}{2.6 \times 10^3}$: From Filter Depends on Bandwidth (This term is highlighted in orange in the original image)
- $\frac{24}{36 \times 10^6}$: From Cordic
- $\frac{1}{1 \times 10^6}$: From Cordic's Feedback

This Delay time is fixed

- To get this delay, there have 2 methods:
1. ask John Musson to give us this number
 2. reconstruct the phase

Nonlinearity and x,y couple

Some nonlinearity need to be checked in event-by-event position reconstruction:

1. from raster magnet itself
2. from quadruple magnet

Beam Position Reconstruction

$$X = \langle X \rangle + X(I_{sr}) + X(I_{fr})$$

$\langle X \rangle$ is average beam position in 1000~2000 events gotten from BPM

$X(I_{sr}), X(I_{fr})$ is the position offset calculated by 2 rasters' current

If ignore linearity, $X(I_{sr}) = m_{sr} \cdot (I_{sr} - \langle I_{sr} \rangle)$, $X(I_{fr}) = m_{fr} \cdot (I_{fr} - \langle I_{fr} \rangle)$

To get $X(I_{sr})$ and $X(I_{fr})$, we need to do raster calibration

Slow Raster Calibration Procedure:

1. Change X shape to $\sin(\omega t)$, close Y
2. Take data, Get relationship between BPM readout and slow raster current readout, BPM information need to take phase reconstruction
3. do the same thing as Y

Phase Reconstruction:

$$\begin{aligned} \text{Raster Current:} & \quad R_{im} = R_a \cdot \cos(\omega t_i) \\ \text{BPM value:} & \quad B_{im} = B_a \cdot \cos(\omega t_i - \phi) + B_{off} \\ \text{True Position:} & \quad B_{true} = B_a \cdot \cos(\omega t_i) + B_{off} \end{aligned}$$

$$|\phi| = 2 \arctan \sqrt{\frac{\sum_{i=1}^N \left[\frac{R_{im}}{R_a} - \frac{B_{im} - B_{off}}{B_a} \right]}{\sum_{i=1}^N \left[\frac{R_{im}}{R_a} + \frac{B_{im} - B_{off}}{B_a} \right]}}$$
$$\omega t_i = \arccos\left(\frac{R_{im}}{R_a}\right)$$

Phase Reconstruction at BPM