

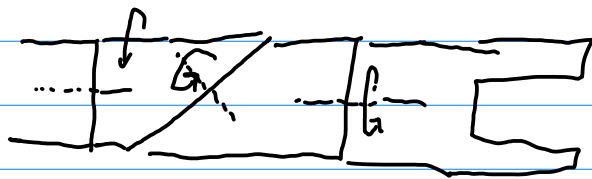
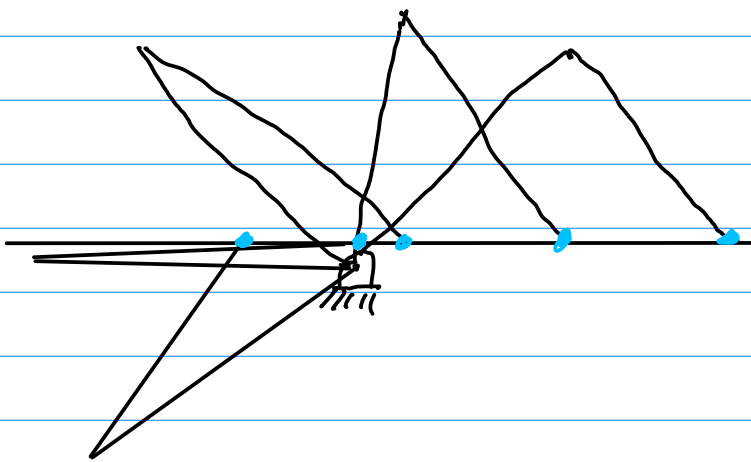
Singularities

At a singularity the manipulator loses one or more degrees of freedom - some direction it cannot move

Interior singularities

Boundary "

Joint rate $\rightarrow \infty$ at a singularity



Teach & playback

move to a position using a "teach pendant"

Record the joint angles

Play back through point

- No inverse kinematics required

Repeatability - how precisely can you return to a taught point

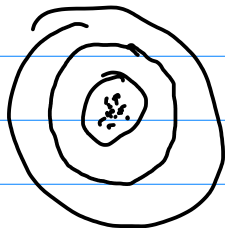
If you are moving to a computed point
eg. vision locates object

Inverse kinematics are involved

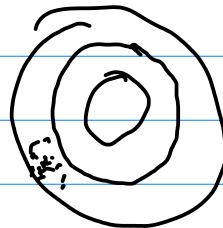
Accuracy = how precisely can you achieve a computed point

- depends on knowledge of joint parameters
- knowledge of joint angle is a big factor
- depends on accurate home

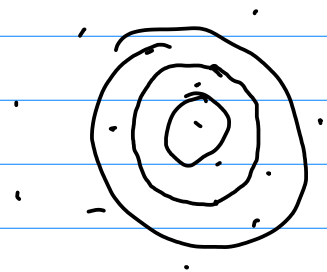
Repeatability is usually good
Accuracy is usually worse



High accuracy
High repeatability



Low accuracy
High repeatability

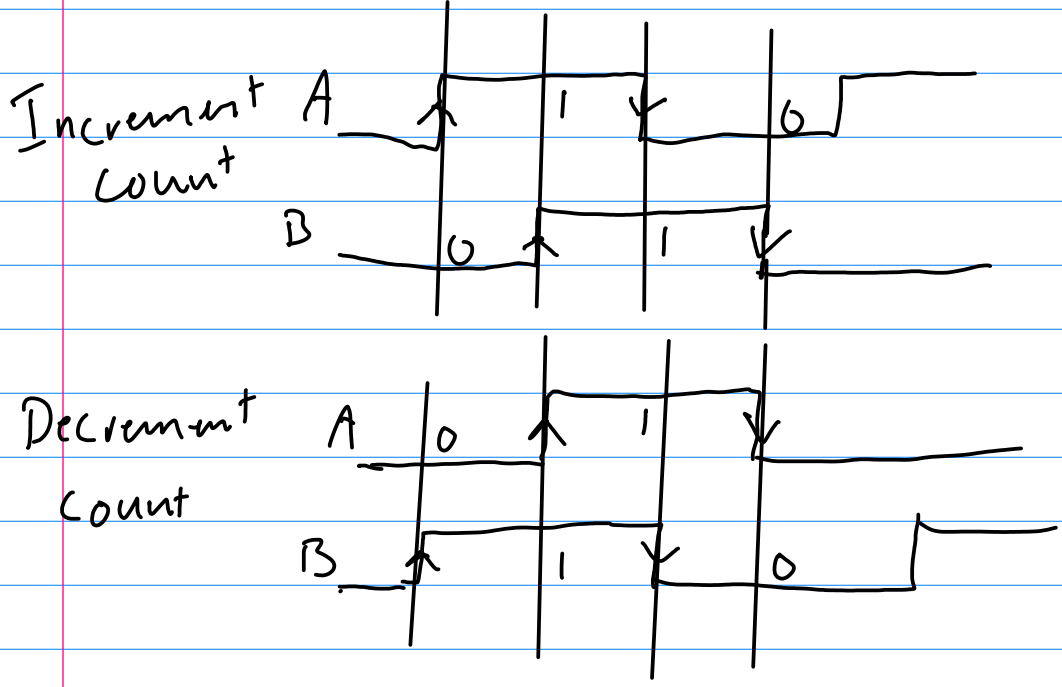
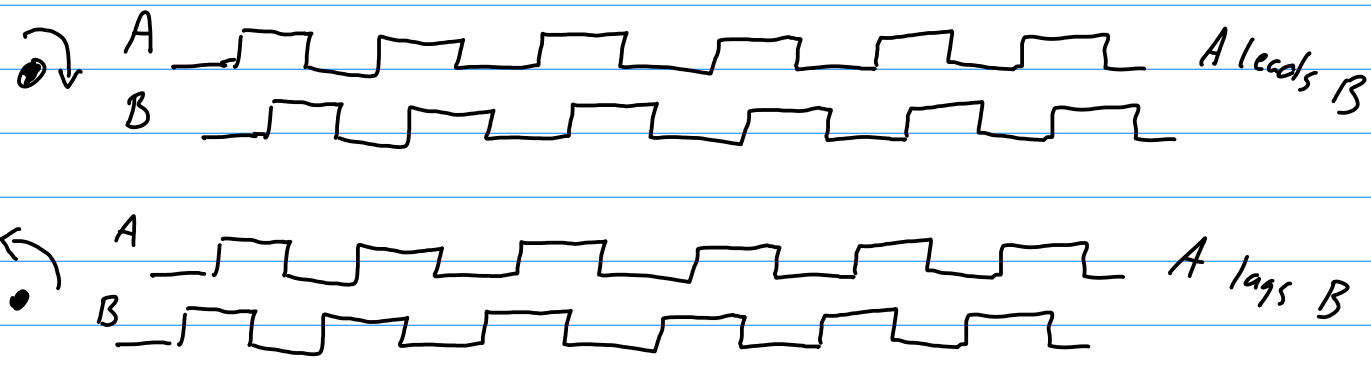


Low accuracy
Low repeatability

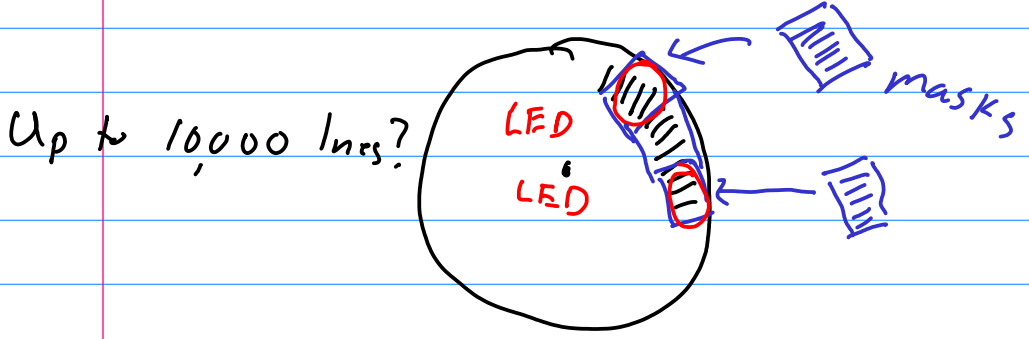
Joint position sensing

Two main kinds

① Incremental Rotary Optical Encoder aka Encoder
 Produces two square waves 90° out of phase

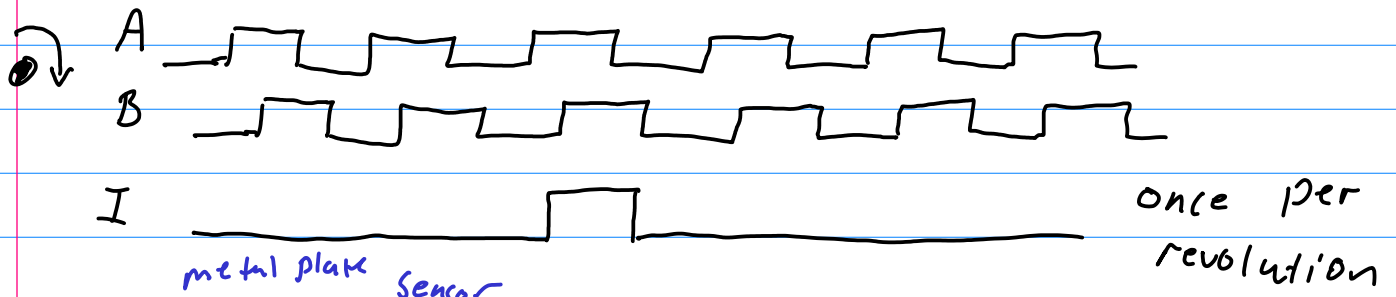


Many cycles / revolution

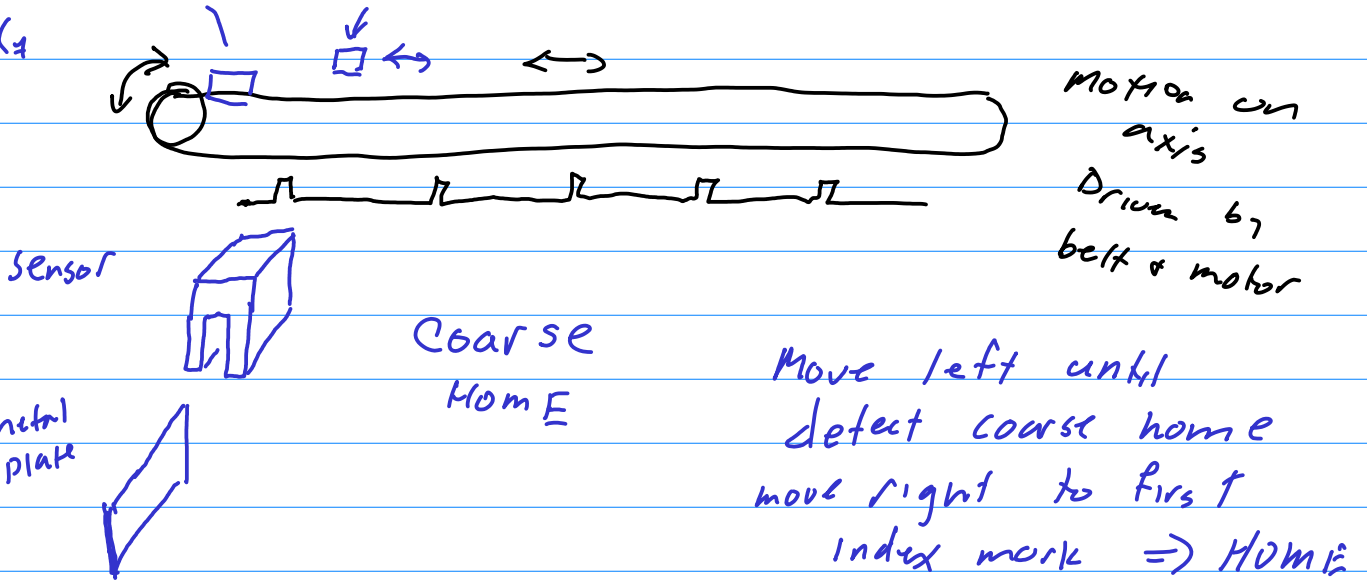


Up to 10,000 lines?

we used 1200 or 1250 lines → 4800 - 5000 Counts Per rev



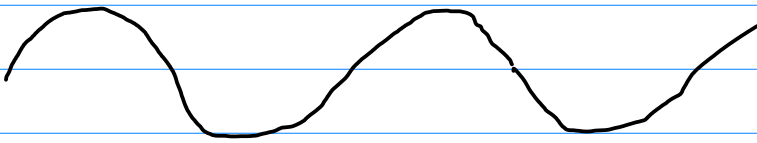
Homing



Resolver \checkmark Very robust

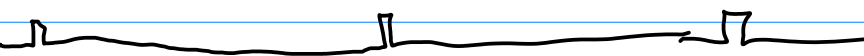
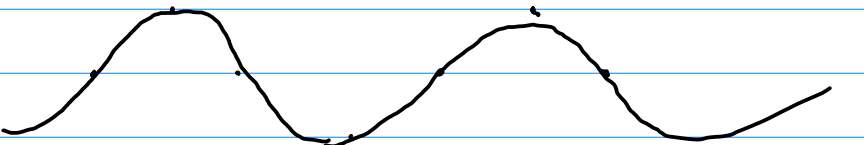
2 sine waves 90° out of phase

$$x = \cos \theta$$



One cycle per revolution

$$y = \sin \theta$$



$$\theta = \text{atan}^2(y, x)$$

\nwarrow can have index pulse

Gear to improve precision.