

# Experimental Determination of Uncertainty Models

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**Abstract:** This lecture derives an unstructured uncertainty model from a system's Bode plot data.

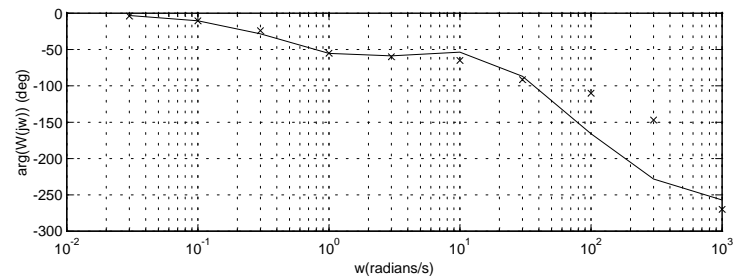
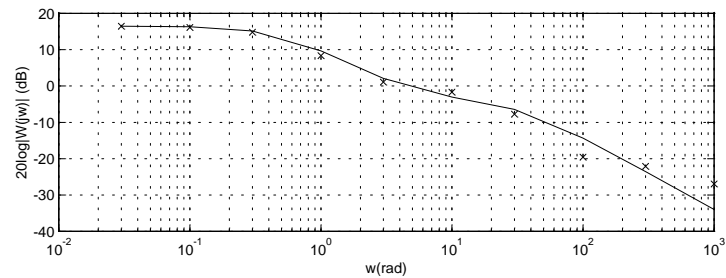
## Raw Data for System ID

- field-controlled DC motor with a flexible shaft coupling.
- Frequency domain measurements in the following table.

data(:,1)	data(:,2)-data(:,3)	data(:,4)-data(:,5)
$\omega(\text{rad/sec})$	Magnitude	Phase(deg)
$2\pi(.03)$	6.6-6.7	-3 to -5
$2\pi(.1)$	6.3-6.5	-10 to -11
$2\pi(.3)$	5.4-5.6	-23 to -25
$2\pi(1)$	2.6-2.65	-50 to -60
$2\pi(3)$	1.12-1.15	-50 to -70
$2\pi(10)$	.8-.85	-55 to -75
$2\pi(30)$	.32-.5	-70 to -113
$2\pi(100)$	.06- .15	-90 to -130
$2\pi(300)$	.037-.12	-89 to -214
$2\pi(1000)$	.01-.08	-214 to -326

# Nominal Plant

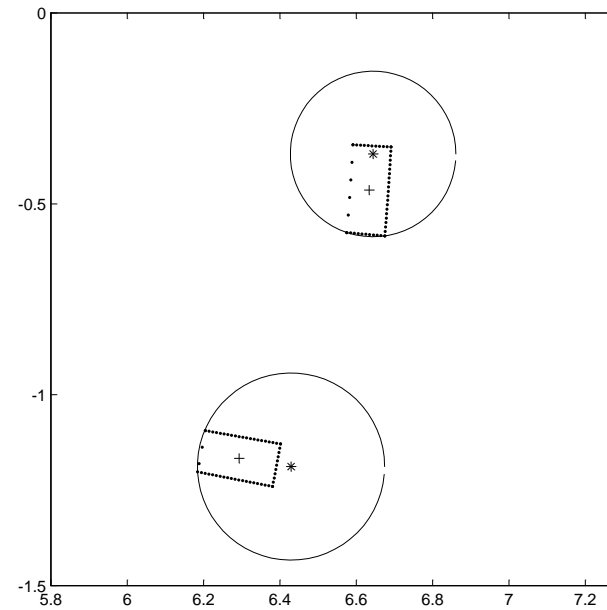
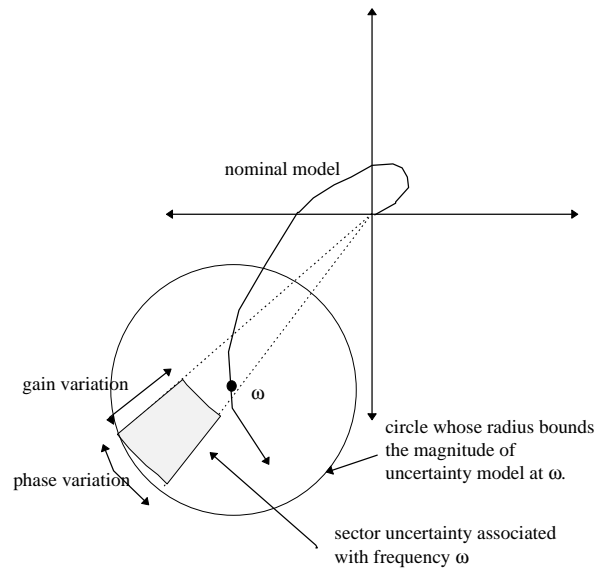
- Trial and error fit of the magnitude and phase data to obtain the **nominal plant**



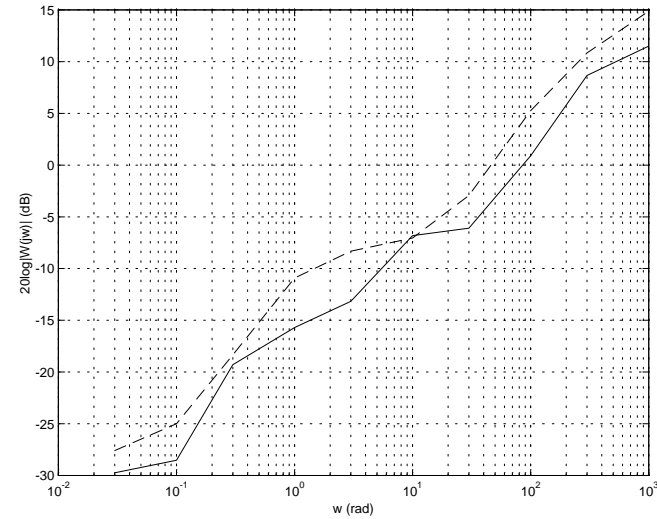
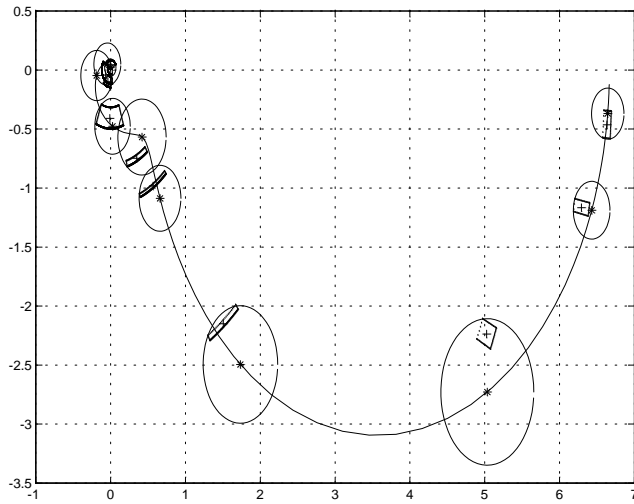
$$\mathbf{G}_0(s) = \frac{\frac{20}{3} \left( \frac{s}{5} + 1 \right) (-s + 100)}{\left( \frac{s}{5} + 1 \right) \left( \frac{s}{30} + 1 \right) (s + 100)}$$

# Uncertainty Circles

- Uncertainty circles
- Nyquist plot of nominal model and uncertainty circles



# Uncertainty Model



$$\mathbf{W}(s) = \frac{0.04 \left(\frac{s}{.1} + 1\right) \left(\frac{s}{20} + 1\right) \left(\frac{s}{1000} + 1\right)}{(s + 1) \left(\frac{s}{2000} + 1\right)}$$