A Novel Design for Delay-Locked Loop Using Internal Model Control Approach

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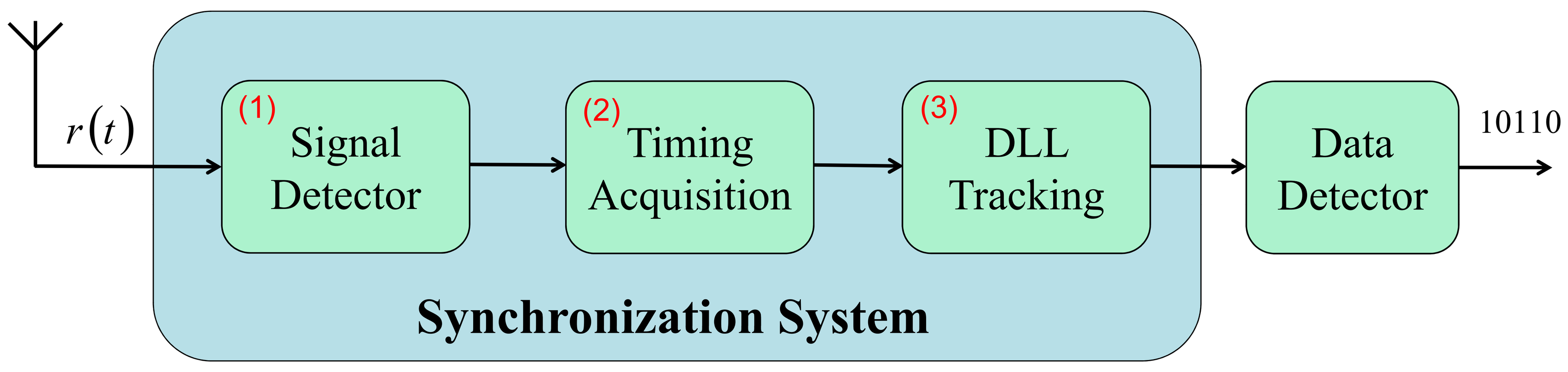
Context & Methodology

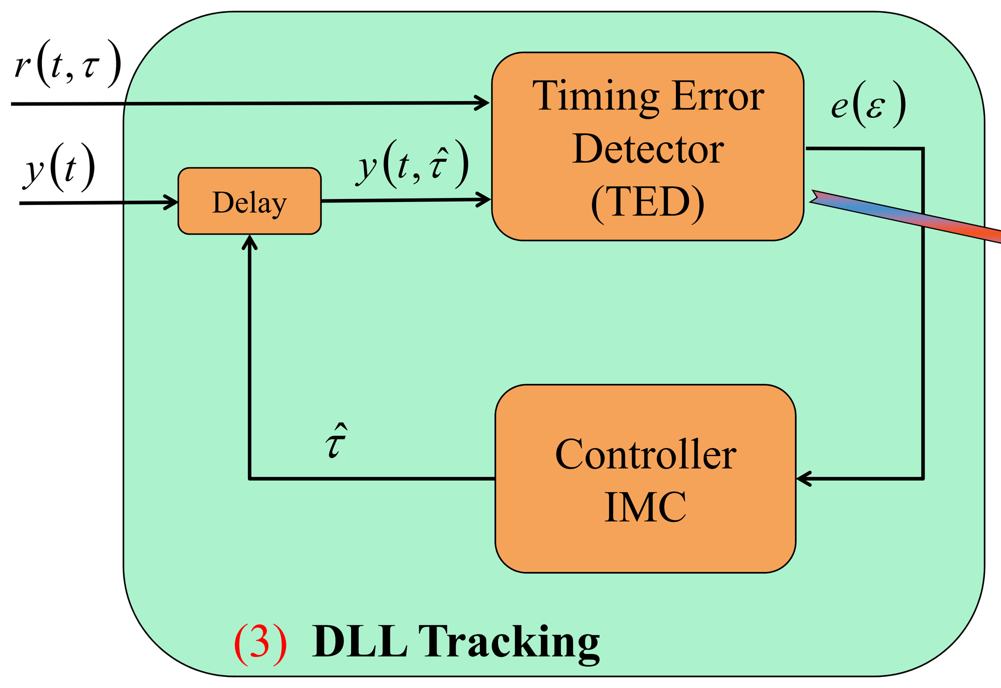
❖ Timing synchronization represents a major challenge in carrying out highly efficient wireless communications in the mobile sensor network applications

❖ Therefore, the aim of my research is to show how we achieved better timing-sync with low-complexity and high performance

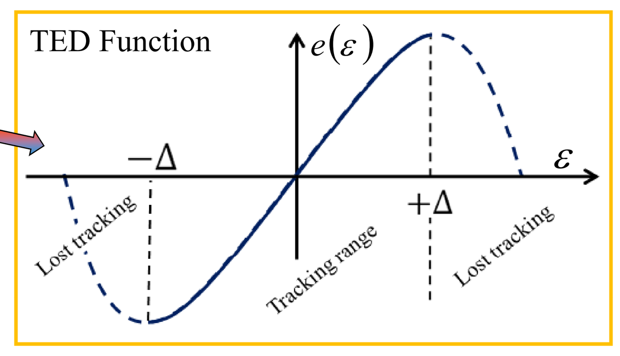
❖ My doctoral thesis studies the following three points :



Tracking Structure



❖ Reference Signal : $y(t)$
❖ Time Offset : $\varepsilon = \tau - \hat{\tau}$



$$e(\varepsilon) = \mathbb{S}(\varepsilon) + N_{eq}$$

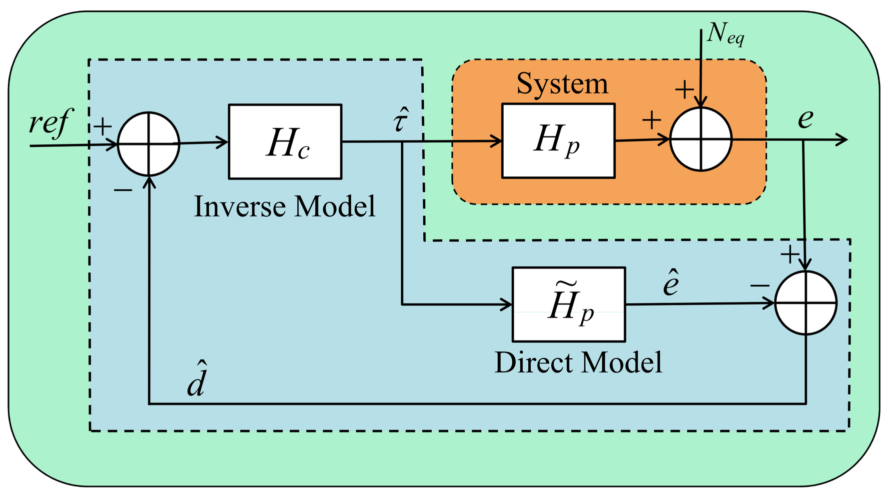
❖ $\mathbb{S}(\varepsilon)$: S-curve function
❖ N_{eq} : Equivalent tracking noise

Internal Model Control Approach

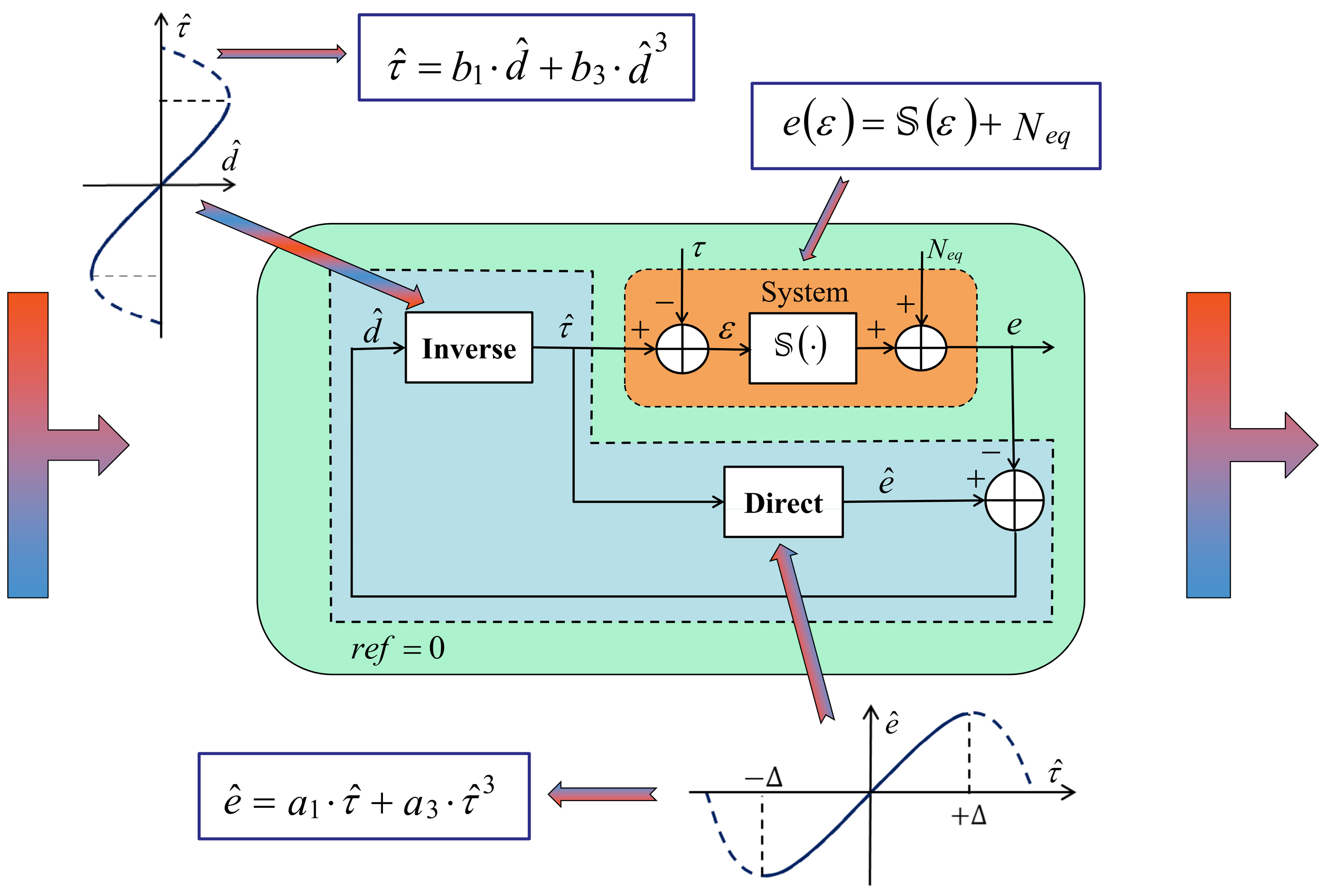
"It is a novel control strategy in the communication domain"

❖ Objective of IMC :

1. Make the output (e) track set-point (ref)
2. Reject the effect of disturbances (N_{eq})



❖ Hypotheses:
(1) $\tilde{H}_p(z) = H_p(z)$
(2) $H_c(z) = \tilde{H}_p(z)^{-1}$



Direct & Inverse model design steps

Generate input/output data set
$[\hat{\tau}_1, \hat{\tau}_2, \hat{\tau}_3, \cdots, \hat{\tau}_N]$
$[e_1, e_2, e_3, \cdots, e_N]$

↓

Select the model structure (order) for S-curve system and its inverse

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Compute the model coefficients
$\{a_1, a_3, b_1, b_3\}$
using Least-Squares solution

Identification Example

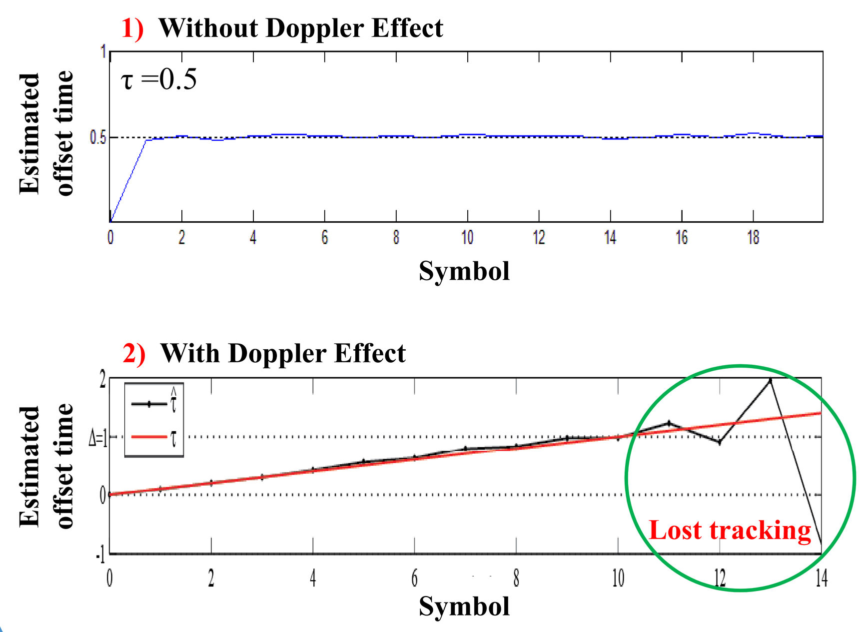
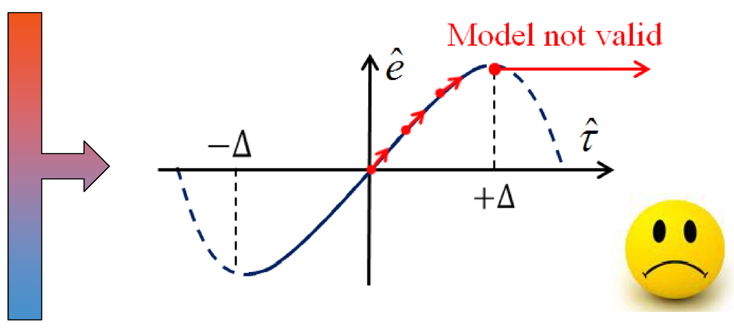


Table 1: The system parameters & The tracking performance

SNR	Model	R^2	Equation
20db	Direct	≈ 1	$\hat{e} = 0.98286 \cdot \hat{\tau} - 0.27497 \cdot \hat{\tau}^3$
	Inverse	0.999	$\hat{\tau} = 0.90639 \cdot \hat{d} + 0.9005 \cdot \hat{d}^3$

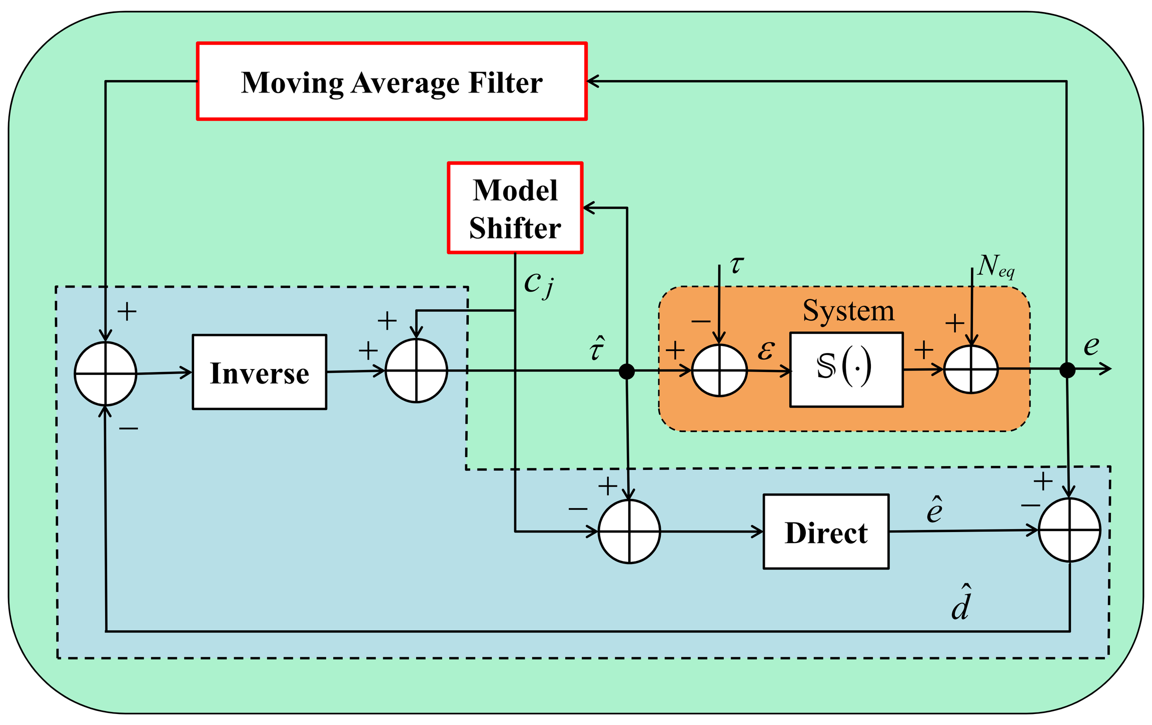
$R^2 > 0.9$ R^2 : determination coefficient

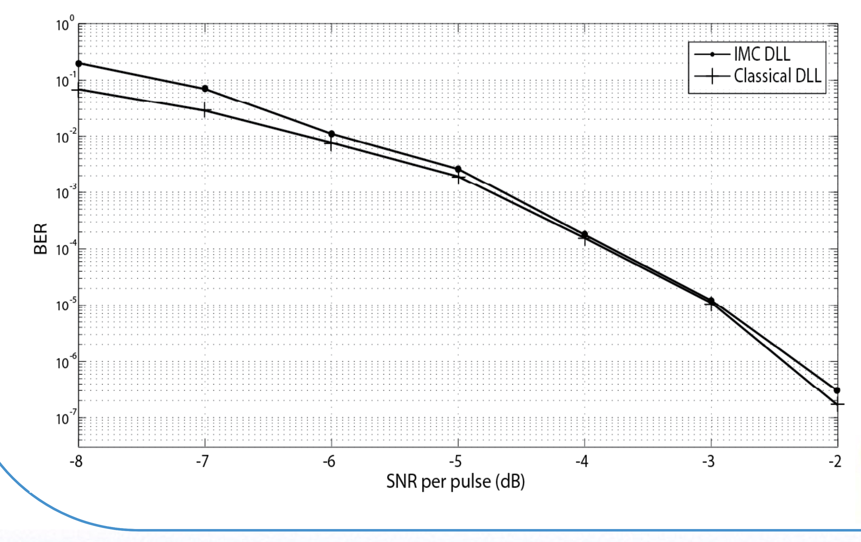


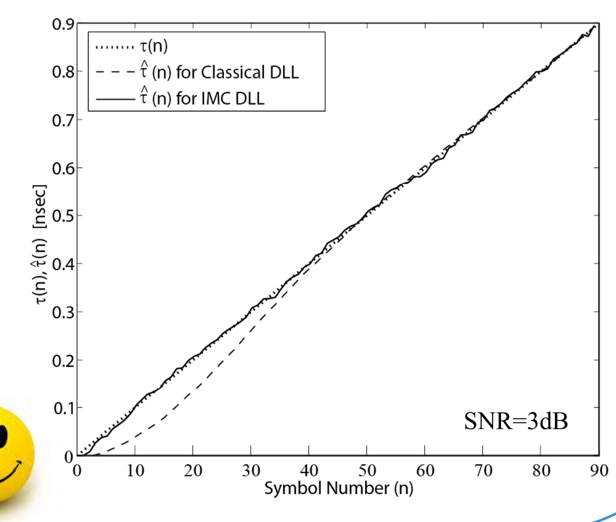
Enhanced IMC

❖ To solve Doppler problem, IMC structure is modified by adding the following two blocks :

1. Model Shifter
2. Moving Average Filter







Summary & Perspective

❖ Summary :

- Presented my thesis methodology for improving the synchronization system
- Designed the controller unit in the tracking level using Internal Model Control strategy
- Developed the IMC structure in the presence of Doppler Effect, by adding average-filter and model-shifter blocks

❖ Perspective :

- Evaluate and validate DLL tracking based on IMC method utilizing an experimental circuit

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