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# DESIGN OF REDUCED-ORDER SCALAR FUNCTIONAL OBSERVERS

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Abstract. *In the existing literature, the existence conditions and design procedures for scalar functional observers are available for the cases where the observers' order p is either p=1 or p=(v-1), where v is the observability index of the matrix pair* $(C, A)$. *Therefore, if an observer with an order p=1 does not exist, the other available option is to use a higher order observer with p=(v-1). This paper shows that there exists another option that can be used to design scalar linear functional observers of the order lower than the well-known upper bound (v-1). The paper provides the existence conditions and a design procedure for scalar functional observers of order 0≤ p ≤2, and demonstrates the presented results with a numerical example.*
**Keywords:** Estimation, Linear functional observers, Stability, State observers

1. **Introduction.** This paper revisits the problem of designing a reduced-order observer to reconstruct a scalar linear function of the state vector for multivariable systems. To be precise, consider a linear time-invariant multivariable system described by

$$\begin{aligned} \dot{x}(t) &= Ax(t) + Bu(t) \\ y(t) &= Cx(t) \\ z(t) &= Fx(t), \end{aligned} \tag{1}$$

where $x(t) \in R^n$, $u(t) \in R^m$ and $y(t) \in R^r$ are the state, input and the output vectors, respectively. $z(t) \in R^1$ is a scalar linear functional state vector to be estimated. The triplet $(C, A, B)$ is observable and controllable, matrices $A$, $B$, $C$ and $F$ are known constant of appropriate dimensions. Without loss of generality, it is assumed that matrix $C$ takes the canonical form

$$C = \begin{bmatrix} I_r & 0 \end{bmatrix} \tag{2}$$

(if this is not the case, then system (1) can always be transformed by an orthogonal similarity transformation).