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ON A THEORY OF CONTROL FOR LINEAR SYSTEMS OVER RINGS  
AN NONLINEAR/TIME-V (U) TEXAS TECH UNIV LUBBOCK DEPT  
OF ELECTRICAL ENGINEERING E EMRE SEP 85

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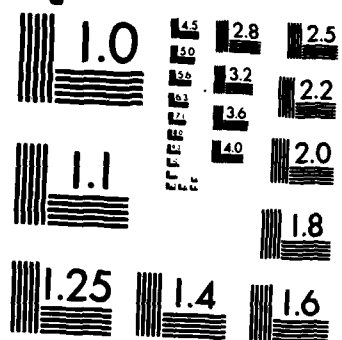
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Final Report on the AFOSR Grant 82-0282

"On a Theory of Control for Linear Systems  
Over Rings and Nonlinear/Time-varying Systems"

Duration: July 1982-June 1985

Principal Investigator: Dr. Erol Emre  
Dept. of Electrical Engineering  
Texas Tech University  
Lubbock, TX 79409

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## 1. RESEARCH DESCRIPTION (July 82-July 85)

We will describe our research on the AFOSR Grant 82-0282 referring to the attached list of publications. The results of publications [1-3] and [5-7] were obtained during 82-83 period.

[1-3] extends known results on regulation of linear systems over rings in several directions. [5] gives possibly the first results on decentralized control of linear systems over rings. [6] extends results on skew prime polynomial matrices to the case of arbitrary commutative rings. [7] studies the problem of resulting system order after dynamic feedback. These results were described in more detail in our proposals and reports to the AFOSR.

The results of [4], [8-11] were obtained during 82-85, and are described in detail in the progress report for 82-85. [4] solves the regulation problem for systems with fixed delays (for a large class of neutral systems) for the first time. [8-9] give new approaches and results on stabilization of linear time-varying systems and observers for nonlinear systems. [11] gives new results on minimum norm compensators for model matching.

Next we describe our research during 84-85 period. During this time, our research has concentrated on two main areas:

- i) Stabilization of Linear and Nonlinear Time-varying Systems, and
- ii) Computational aspects of delay differential systems, in particular, Tschebycheff Approximation.

i) We have considered the existence of continuous families of stabilizing compensators for continuous families of time-varying systems for the first time, and given a full solution to this problem. Then we combine these results with Tychonoff fixed point theorem, to obtain many local and global stabilization criteria for nonlinear systems of the type

$$\dot{x} = F(x,u,t)x + G(x,u,t)u.$$

This is a very large class and includes all bilinear and many types of polynomial nonlinear systems. Furthermore, our results yield stabilization by linear state-feedback. Furthermore, we have extended Kleinman's Newton type technique to approximate the steady state solution of the Riccati equation, to time-varying systems. We should note that this is very far from a direct application of Newton approximation theory. This provides

new stabilizing laws for linear time-varying systems which are sub-optimal, by linear techniques.

These results are in [12], [14], [16], and [18].

ii) We have developed new techniques for Tschebycheff approximation, for the purpose of computation of stabilizing compensators for delay-differential systems. These results are in [17].

In addition, in [16], we have a solution to globally stable adaptive pole-placement/stabilization with no external inputs and adaptive identification for classes of systems with unknown parameters subject to change. Our approach is algorithm-free, conceptually oriented and to some extent uses systems over rings results.

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## 2. LIST OF PUBLICATIONS (July 82-July 85).

### A) Journal Publications:

- 1) E. Emre, "Regulation of linear systems over rings by dynamic output feedback," Systems Control Letters, June 1983.
- 2) E. Emre and P. Khargonekar, "A note on regulation of linear systems over rings by dynamic output feedback," IEEE Trans. Autom. Contr., Jan. 1984.
- 3) E. Emre and P. Khargonekar, "Pole placement for linear systems over Bezout domains," IEEE Trans. Autom. Contr., Jan. 1984.
- 4) E. Emre and G. Knowles, "Control of linear systems with fixed noncommensurate point delays," IEEE Trans. Autom. Contr., Dec. 1984.

### B) Conference Proceeding Papers:

- 5) E. Emre, "On decentralized control of linear systems over rings," Proc. IEEE Intern. Symp. on Large Scale Systems, Oct. 1982.
- 6) E. Emre, "Further results on skew prime matrices," Proc. IEEE Conf. on Decis. and Contr., Dec. 1982.
- 7) E. Emre, "Pole-zero cancellation in linear feedback systems," Proc. IEEE CDC, Dec. 1982.
- 8) E. Emre, "Observers for nonlinear/time-varying systems," Proc. Allerton Conf., Oct. 1983.
- 9) E. Emre, "A polynomial fractional approach to linear time-varying systems," Proc. Allerton Conf., Oct. 1983.
- 10) E. Emre, "On regulation of linear systems by dynamic output feedback," Proc. IEEE CDC, Dec. 1983.
- 11) E. Emre, "On optimal model matching of linear systems," Proc. Midwest Symp. on Circuits and Systems, June 1984.
- 12) E. Emre and G. Knowles, "Stabilization of nonlinear time-varying systems; A systems over parameters approach," Proc. Allerton Conf., Oct. 1984.
- 13) E. Emre and G. Knowles, "Regulation of linear systems with fixed noncommensurate point delays," Proc. IEEE CDC, Dec. 1984.
- 14) E. Emre and G. Knowles, "A Newton algorithm for computation of the steady state solution of the Riccati equation," Proc. Mathematical Theory of Networks and Systems (MTNS), June 1984, Sweden.
- 15) E. Emre, "On globally stable adaptive control," MTNS 1984.
- 16) H.M. Tai, E. Emre and G. Knowles, "Stabilization of certain

nonlinear systems by linear feedback," Proc. IEEE CDC, 1985, to appear.

- 17) G. Knowles and E. Emre, "A Tschebycheff approximation approach to computation of stabilizing compensators for systems with delays," Proc. IEEE CDC, 1985, to appear.

C) Submitted Papers:

- 18) E. Emre and G. Knowles, "Continuous stabilization of time-varying systems: a systems over parameters approach," Submitted for publication. Aug. 1984.



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