INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

DC-DC buck converters belong to the class of complex and time varying variable structure systems. These are primarily employed to obtain an uninterrupted lower level of DC voltage at the output end from a DC input voltage source. However, the output voltage tracking in these converters is significantly sensitive to unanticipated load disturbances, parametric uncertainties and input voltage fluctuations. In this thesis, a few backstepping based adaptive control methodologies have been proposed for the robust output voltage control in DC-DC buck converters with immunity to external disturbances, matched and mismatched uncertainties. The effect of an uncertain load on the converter has been compensated by incorporating online parameter adaptation, which estimates the load disturbance. The proposed adaptive law ensures overall closed loop stability of the DC-DC buck converter satisfying Lyapunov stability criterion. Performance of the proposed controller is evaluated over a wide range of operating points. Further, the designed adaptive backstepping control (ABSC) methodology is extended and validated on a DC-DC buck converter driven permanent magnet DC (PMDC)-motor system, wherein the problem of angular velocity tracking is addressed under a wide range of load torque disturbances. In order to improve the transient performance of output tracking with backstepping control method, a neural network based learning scheme is developed for a faster and more accurate estimation of the uncertain load. A single layer Chebyshev neural network (CNN) based adaptive backstepping control technique is proposed for output regulation in DC-DC buck converters. Such a methodology circumvents the drawbacks faced by the ABSC in its application to DC-DC buck converters. Further, the proposed CNN based ABSC offers decreased computational complexity and fast learning. The proposed approach is improved by using a Hermite neural network (HNN) in the backstepping framework for quicker and closer estimation of unknown load parameters. This HNN based ABSC results in a faster rejection of load perturbations, thereby delivering a superior control mechanism. Although the proposed neuro-adaptive schemes yield a bound and asymptotic load estimation, yet guaranteeing the exactness of estimation is analytically difficult. Therefore, a disturbance observer based backstepping control scheme is proposed for output voltage tracking in DC-DC buck converters. The disturbance observers exactly estimate the uncertainties encountered during the converter operation in finite time. In addition to rapidity and exactness, such a time bounded estimation based control scheme enhances the output transient and steady state performances over a wide operating range. Finally, a current sensorless adaptive control approach is proposed to overcome challenges faced in measuring current in practical applications. The adaptive control schemes proposed in this thesis have been validated through extensive simulation and experimentation in laboratory. The experimental results support the theoretical propositions.