CONCLUSIONS

Dynamic braking is one of the most effective discrete supplementary controls recommended for transient stability improvement of power systems subjected to severe disturbances such as a close-in line fault on a generating station with maloperation of the circuit breaker. However, the conventional dynamic brakes so far studied or placed in service suffer from the disadvantage that the switch in and switch off instants of the dynamic brake have to be predetermined and optimised for better performance, with the result all these dynamic brakes tended to be specific i.e. useful only for the system for which they are designed and lacked universal applicability. Moreover, there is no control over the braking power developed by such devices.

The thyristor controlled dynamic brake introduced and investigated by the author in the present work is free from all these disadvantages. The switch in and switch off of the thyristor controlled dynamic brake is smooth and automatic. As such there are no switching transients associated with its functioning. No on-line or off-line computations are needed. The control scheme is simple and based on sensing the variation corresponding to synchronous
machine rotor speed deviations only. The braking power developed by the thyristor controlled dynamic brake is proportional to the synchronous generator rotor racing. The only disadvantage of the thyristor controlled dynamic brake is not technical but economical. Due to presence of power thyristors in the regulating schemes it is more expensive than the conventional dynamic brakes.

To investigate the effectiveness of a thyristor controlled dynamic brake in improving the transient stability of a power system the author has developed a mathematical model of thyristor controlled dynamic brake suitable for digital simulation [52,53]. Transient stability computations with respect to a two machine representation system showed that thyristor controlled dynamic brake is very effective in improving the transient stability. Of the two possible modes of regulation of thyristor controlled dynamic brake, control of thyristor controlled dynamic brake as a function of rotor relative angular velocity is found to be better than the control with respect to rotor acceleration [53,60].

The performance comparison of a thyristor controlled dynamic brake with an optimally switched dynamic brake has established beyond doubt the better damping abilities of a thyristor controlled dynamic brake[59].
Investigations regarding selection of suitable synchronous machine model in transient stability studies with thyristor controlled dynamic brake showed that the electromechanical transient phenomena are qualitatively accurate even with simpler models based on \( E' \) constant or \( E' \) varying and that the computational time is prohibitive if a large number of calculations of exploratory nature have to be carried out with Park's model.

Transient stability investigations carried out with respect to two different multimachine system configurations showed that under similar operating conditions, the performance of a thyristor controlled dynamic brake is far superior to an optimally switched dynamic brake in damping out transient swings. The investigations have further showed that for long distance bulk power transmission schemes provision of usual stability improvement measures such as high ceiling rapid response excitation systems is alone not sufficient to retain the system stability especially during severely faulted conditions. In such cases, thyristor controlled dynamic brake when used alone, or in conjunction with high ceiling rapid response excitation system succeeded in damping out the transient swings and has been found to be effective in maintaining system stability.
A full wave thyristor controlled dynamic brake injects harmonics in line currents of the generator due to its nature of operation. Harmonic analysis of the line current waveform indicated that the fifth harmonic magnitude is maximum and has a value of 22.7% of the fundamental component. However as the duration for which the thyristor controlled dynamic brake is switched in is short, it may be inferred that the presence of such harmonics is not going to affect adversely the system performance [59,64].

The expensive component of a thyristor controlled dynamic brake is the power thyristor. In order to make the thyristor controlled dynamic brake more economical, an alternate scheme of thyristor controlled dynamic brake using three thyristors connected as a half bridge circuit has been proposed by the author. A mathematical model to represent the half wave version of thyristor controlled dynamic brake in transient stability investigations has been developed. It is found from the G(\alpha) characteristic that the braking power developed in case of half wave thyristor controlled dynamic brake is one-fourth that of the power developed by the full wave thyristor controlled dynamic brake, for the same value of the braking resistance. Performance comparison of a half wave thyristor controlled dynamic brake made with a full wave thyristor controlled
dynamic brake and an optimally switched dynamic brake showed that both the types of thyristor controlled dynamic brake i.e. full wave and half wave, have better damping abilities compared to an optimally switched dynamic brake. The half wave thyristor controlled dynamic brake is found to produce damping of transient swings to the same degree as is possible with a full wave thyristor controlled dynamic brake for a value of braking resistance which is one-fourth that used with the full wave thyristor controlled dynamic brake. The harmonic content of generator line currents due to the presence of half wave thyristor controlled dynamic brake is more than that of the full full wave version, the second harmonic being the largest (58% of the fundamental). However as the duration for which a thyristor controlled dynamic brake acts is short this may be permitted.

Certain operating features peculiar to a thyristor controlled dynamic brake have been observed in case of transient stability investigations of a two-machine power system with thyristor controlled dynamic brake, when the magnitude of braking resistance of thyristor controlled dynamic brake is small. For low values of braking resistance \( R \) of thyristor controlled dynamic brake i.e. for very large values of braking power, it is found that the thyristor controlled dynamic brake damps out the first few swings successfully but tends to slow down the progress of the system.
in reaching the final steady state operating point. Such behaviour has been explained by the equal area criterion\cite{59}. Whenever very large values of braking power are employed, this situation may be avoided by introducing a dead zone in the law of regulation of the thyristor controlled dynamic brake such that the thyristor controlled dynamic brake does not come into action in latter part of the transient process when the system is approaching post-fault steady state operation. The introduction of the dead zone removes the restriction on the magnitude of braking power to be developed by the brake. The necessity of a dead zone near the cut off point of a thyristor controlled dynamic brake arises from the dynamic stability considerations also \cite{43}. However introduction of a dead zone does not underrate thyristor controlled dynamic brakes performance as their main objective of providing effective supplementary control immediately after occurrence of a severe fault is always realised. The dead zone comes into play only when the transient stability is restored and it is time for the primary controls to take over and damp out fewer oscillations of smaller amplitude.

Thus it may be concluded that a thyristor controlled dynamic brake (both full wave and half wave) though expensive may be preferred as a discrete supplementary control to the conventional dynamic braking schemes due to its vast technical
superiority. From the cost considerations a half wave thyristor controlled dynamic brake is an attractive alternative to the full wave version. Optimisation of the law of regulation and testing of a prototype version in field are some more interesting aspects yet to be studied for a thyristor controlled dynamic brake.