CHAPTER 6 : SUMMARY AND RECOMMENDATIONS

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The work carried out in previous chapters pertains to the problems of most economic and useful application of MHD generator for the interconnection with electrical supply utility for bulk power transmission. The force commutated inverter link is used in this study because of major advantages already mentioned in section 1.2. The MHD generator inverter link is treated as a single machine connected to infinite bus with simplifying assumptions and approximations.

The findings described in this thesis can be summarized in the following main points:

1. The feasibility of using a simple square wave inverter has been illustrated for the conversion and control of MHD duct feeding into a power system. The salient features of the feasibility study are:

(a) A computer programme has been prepared which simulates the connection of either a square wave or PWM inverter to the MHD duct.

(b) A modified computer programme has been prepared for the satisfactory harmonic reduction by using 5th and 7th
harmonic filters.

(c) Quasi static changes in fluid dynamic conditions have been allowed for, by considering variations in MHD duct voltage and internal resistance.

(d) It has been investigated that power transfer from MHD duct is maximum for a system reactance \( (X_s) \) of 0.45 P.U. and phase difference between inverter and infinite bus voltage as 60 degrees. The reactive power flow to infinite bus for this condition is zero and therefore power factor is unity.

(e) A simple and single controller has been used for power control compared to complex control arrangements described earlier [39,42].

(f) Maximum power has been transferred from MHD inverter link to infinite bus at any desired power factor without any power factor correction needed.

2. A simple scheme has been presented for the simulation of MHD inverter link in the laboratory. The results of the digital simulation are verified with the experimental setup.

3. The detailed design of the force commutated inverter is presented for the interconnection of the 2 MW MHD test facility. Special attention has been paid for the design of
commutating components. The minimization of commutation losses, skin effect and size of the component is considered. The different designs of inductor is presented for this purpose.

4. Safe inverter operation is investigated under various operating conditions.

5. A simple rewirable fuse wire is suggested for the protection of semiconductor devices. An experiment has been conducted to suggest an approximate length of the fuse wire for the protection of a semiconductor device of known $I^2t$ rating. The graphs are plotted for different lengths of the fuse wire versus $I^2t$ rating. These graphs can be used to predict the approximate length of the fuse wire for the protection of any power electronic device of known $I^2t$ rating.

6. A feedback controller has been designed for the automatic control of power from MHD duct to infinite bus. A good steady state and dynamic response is demonstrated by the controller in open loop and closed loop system.

7. Time dependent computer model of the generator has been used for the determination of V-I characteristics of a 2 MW, 20 electrode pair MHD generator in Faraday and diagonal mode. These curves then are utilized for power control to infinite bus.
8. The transient studies are carried out on the above model with a voltage source inverter (VSI) interface. Sudden load changes has been considered from operating point. The time variations of voltage and current for different electrode pairs have been plotted. The variation of temperature, pressure and Mach No. along the duct is also plotted. The important conclusions have been drawn as discussed in Chapter 5. These conclusions will form the basis of further transient stability studies of the MHD-inverter link. Results were also obtained with different values of filter capacitor. An optimum size of 0.1 μF/VA is suggested for fast control action and better system stability.

6.2 Recommended further studies

Because of the simplifying assumptions adopted in some of the investigations described in this thesis, some of the results obtained can be regarded as first order approximations. Therefore, as a possible improvement on the present study more realistic approach can be made on the following points:

1. The representation of the generator model should be more accurate and resistance should be added for the MHD-generator inverter link analysis as discussed in section 2.3.

2. The present study assumes velocity \( \mathbf{V} \), magnetic field \( \mathbf{B} \) and electric field \( \mathbf{E} \) in one direction only. Also
temperature, pressure, mass density and conductivity are taken constant over Y-Z plane. In practice these quantities vary significantly in the channel. The calculations with variations in these quantities will lead to more accurate results of the proposed inverter link.

3. The work should be extended to commercial size MHD generator connected to a multimachine power system rather than single machine connected to infinite bus bars.

4. Two independent 3 phase square wave inverters combined via a single transformer should be analysed with the variation of phase relative to a.c. bus.

5. So far time dependent quasi one dimensional equations are considered for the solution of MHD flow in the duct as discussed in section 5.3. The present analysis should be extended with accurate time dependent two and three dimensional equations. These approaches in numerical analysis can be made so that a comparison on the results is obtained. These calculations should include effect of varying magnetic field, dynamic coupling of electrodes, end effects and electrode effects as mentioned in section 2.2.1.

6. Analogue models of the MHD generator are very useful [31] for many types of study which cannot be conveniently carried out with digital technique. Therefore the MHD
simulation in the laboratory shall be replaced by analogue model for better results.

7. The study presented is related with a single electrode pair analysis. Therefore more inverters will be needed for the power transfer to infinite bus. For the reduction of inverters the voltage consolidation circuits be included for the analysis.

The above recommended work would significantly increase the understanding of the operational characteristics and stability of large MHD-inverter utility interactive power system. These proposed investigations are only a few of the many possible direct extension of the study presented in this thesis. Since the integration of an MHD generator into a conventional a.c. network is a very new and challenging engineering problem, the number of areas that still require much study are innumerable.