5. CONCLUSION

5.1 CONCLUSION AND FUTURE WORK

It can be now concluded on the basis of previous descriptions that the magnitude (peak) and nature (waves-shapes) of the switching transient current varies over large range depending upon the initial condition and the switching instant of the circuit. The switching transient current studies are generalize and simplified by introducing two factors $Y$ and $n$. Thus the switching current level (peak) of all types of the linear AC circuits, can be controlled in between its maximum and minimum values, simply by controlling the SI, at any initial condition. The graphs, showing the peak currents with respect to the whole range of SIs, are given for different types of the circuits at various initial conditions. Equations are also given to find out the correct SIs for minimum and maximum switching currents in the circuit. The minimum value of $I_p$ corresponds to the condition where the transient is either zero or minimum and the maximum value of $I_p$ gives the correct value of the maximum possible switching transient current that may flow into the circuit. The theory presented here are experimentally verified and can be extended easily to non-linear circuits and systems as it is applied here for induction motors and transformers.
Three ICS circuits are designed for controlling the transients in different load circuits. These circuits are found versatile in nature. The MCC is used for transient-free power control in resistive as well as in inductive loads (by combination of ICS and ICC techniques) in addition to its ability to work as controller for converters and choppers. MCC is successfully used as static relay to realize various characteristics of distance protection. Three phase reference sinewave is also generated by MCC that can be used for PWM.

A static relay is designed to distinguish fault current from the inrush current of transformer and it is successfully tested by ICS circuit under dynamic/actual conditions.

By ICS technique, for the first time, inrush current in 1-phase as well as 3-phase transformers are completely eliminated. Which will have enormous utility and applications in power systems. The importance of elimination of inrush current in 1-phase transformers (traction as well as used in converter plants with line filters in HVDC system) is discussed. Its utility in other field could also be sorted out e.g. transformer used in welding etc. [24]. Inrush current in 3-phase, 3-wire system was eliminated more efficiently than in 3-phase 4-wire system. In the former case the switching completes in lesser period (two steps and quarter cycle only). While in later case the switching completes in three steps and the switching currents, although very small, flow in the neutral wire till switching completes in 2/3 cycle. It is shown that the transformers can be switched even repeatedly, without the significant amount of transient current (inrush), by the proposed technique.
By ICS technique the switching current of induction motors (1-phase and 3-phase) also reduces significantly. Instead of simultaneous switching, the switching has to be done in steps as it was done for transformers. A suitable SI is also found for minimum switching current (peak) in case of simultaneous switching of a 1-phase induction motor. Thus the large switching current of saturated motors can be reduced more efficiently.

The speed of 1-phase as well as 3-phase induction motors are controlled by combination of ICS and ICC technique. A minimum OFF cycle (one or half) is proposed to avoid large pulsation. The speed variation is achieved over wide range without significant pulsation in torque and speed. Its utility for 1-phase induction motor (as prime mover of electric fans, coolers and compressors) is established. Thus large power wastage in the rheostatic regulators can be avoided easily by the proposed technique. Which will be certainly a boon to a country like India where the millions of 1-phase induction motors are in use and where power generation is far behind the power demand.

ICS technique can be extended easily for the determination of "decrement factor" of alternator for selection of circuit-breaker of proper MVA rating. Which is normally found by extensive random short-circuiting the alternator [4]. This test can be done in single attempt by ICS technique as it was done for determination of inrush current of transformer. Similarly maximum switching current of any machine can be found in single attempt.

In general ICS technique can be extended to all electrical circuits or systems which are subject to repeated switching and where transient condition has got some significance.