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A Modified-Time-Sharing Switching Technique for Multiple-Input DC–DC Converters by using Fuzzy Logic Controller

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***Abstract*—In this paper, a switching strategy for multiple-input converters (MICs) is presented and analyzed. MICs have been identified to provide a cost-effective approach for energy harvesting in hybrid systems, and for power distribution in micro- and nanogrids. The basic principle of the proposed switching strategy is that the effective duty ratio of each switch is an integer multiple of a common duty ratio (CDR), the CDR being the duty ratio of a common switching function that is generated at a higher frequency by frequency division. The proposed strategy enables switching functions for MICs that have a greater number of input legs to be generated with relative ease. Another benefit of this scheme is that it allows an MIC's output voltage to be regulated by employing the CDR as the only control variable, irrespective of the number of input legs present. Essentially, the strategy transforms an MIC into an equivalent single-input single-output system for analysis, which simplifies controller design and implementation. Without loss of generality, this technique is demonstrated by analyzing a multiple-input buck–boost converter. A Fuzzy Logic controller is shown to regulate the MIC's operating point. The analysis is verified by simulations and experiments.**

***Index Terms*—Control systems, dc–dc power conversion, energy harvesting, hybrid systems, microgrids, multiple-input converter (MIC).**

I. INTRODUCTION

MULTIPLE-INPUT converters (MICs) transform the output of a variety of dc sources to power a common (or multiple) dc buses. These converters are receiving increased at-tention, with some researchers considering them to be an important element in many micro- and nanogrid applications. Essentially, MICs can effectively replace a relatively complex setup of several single-input converters by a simpler and more compact arrangement. In general, MICs may reduce complexity and cost.It improve dc power distribution efficiency, with-out compromising system availability. Additionally, MICs tend to simplify integration of renewable and alternative energy sources, such as photovoltaic sources,

because most of these sources have dc outputs. With proper design, MICs may improve availability when various renewable sources are used, by simplifying the realization of hybrid systems that employ diverse power sources.With conventional time-sharing switching, all switching functions have to share a fixed time interval (period sharing). As the number of input legs in an MIC increases, it becomes more difficult to practically generate switching functions that can share a fixed switching period.

In addition, using multiple switches to simultaneously stabilize an MIC's output voltage makes the closed-loop MIC a multiple-input single-output system. Consequently, controller analysis may require more sophisticated multiple-input multiple-output (MIMO) control design tools and added components in order to ensure robustness. This paper introduces a switching strategy that modifies the time-sharing concept, alleviates the difficulties associated with controlling multiple switching functions for conventional time-sharing MICs, and, thus, permits more input legs to be utilized.

The switching-function coupling in time-sharing MICs leads to a common assumption used in MIC analysis, which is that various input voltages unequal and the equal-input-voltage case usually renders the analysis invalid.The switching strategy presented here eliminates the aforementioned requirement, and thereby permits inclusion of the equal-input-voltage case in MIC analysis. This is an important advantage in energy harvesting applications in which multiple sources with equal output voltages can be expected.The scheme presented here uses toggle flip-flops and logic gates to eliminate any coupling that may exist among various switching functions in an MIC.

Rather, the switching functions now depend on a common switching function (CSF). Individual duty ratios of input-leg switches are integer multiples of the common duty ratio (CDR), which is the duty ratio of the CSF. The MIBB converter is chosen, because it is representative of many other MIC topologies. Simple control and the possibility of having sources with equal voltages are the main benefits of the switching strategy.Thus, the output voltage can be stabilized by employing the CDR as the only control parameter, making the closed-loop MIC a single-input single-output (SISO) system

II. SWITCHING STRATEGY

Frequency division is then performed on the CSF using logic gates and toggle flip-flops; the number of toggle flip-flops N_T is a binary logarithm of *N*. That is,

$$N = 2^{N\,T} \quad .(1)$$

Fig.2. illustrate this frequency division. Note that although there is no theoretical limit to the number of possible input legs, practical issues such as availability considerations may limit the number of input legs an MIC may have .Fig. 1 shows eight switching pulses that are recombined to yield three switching functions, for an equal number of corresponding MIC input legs.

That is, in Fig. 2,

$$j = N = 8, \quad i = M = 3$$

where *M* is the total number of *i* input legs, and *N* is the total number of *j*-switching pulses generated by frequency division.

From the Fig 2 , two flip-flops (U1 and U2) may be utilized; then N = 4, and switching pulses qU 2,T 1 through qU 2,T 4 are available for recombination. Similarly, if just one flip-flop (U1) is used, then N = 2, and switching pulses (qU 1,T 1 and qU 1,T 2) are available for recombination. It is assumed that each input leg has only one active switch, which is forward-conducting bidirectional-blocking (FCBB)., where qU 3,T 5 is not connected to the OR gate. As a result, seven CSF pulses are shared in the ratio 2:2:3 to produce q1 , q2 , and q3 respectively.

That is, two switching pulses are channeled to switch 1 and switch 2, respec-tively, while three switching pulses are channeled to switch 3.The technique permits only one control objective, because there is only one control parameter to be CDR. One design aspect to consider is that the number of input legs is lim-ited by the number of switching pulses generated. more switching pulses can be generated by adding more toggle flip-flops but as more toggle flip-flops are employed in the circuit in Fig. 2.

The interactions among gates become more complex. Variation of circuit components during circuit operation may result in noise generation. When multiple-level logical gating systems such as the circuit shown in Fig. 3 are utilized, this noise may result in unpredictable output states, caused by noise signals that “sneak in” between the trigger ($q_{C\ SF}$) output signals ($q_{U\ 3,T}$ s) to alter output.

When a noise signal sneaks in between the trigger and output signals, a hazard is said to occur. A hazard could be harmless, but if the hazard alters the output state, such a malfunction is referred to as a race condition . Race elimination schemes employed to prevent race conditions from occurring,.Yet adding these schemes will complicate the control circuitry.

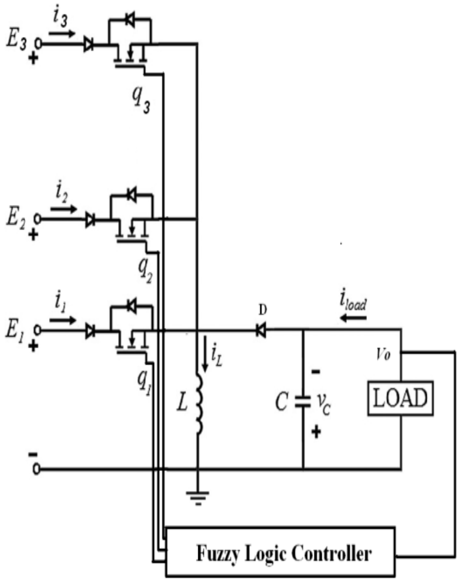

Fig. 1 Circuit schematic of the MIBB converter topology with Fuzzy Logic Controller

The Multiple input could be controlled by Fuzzy logic controller which is shown in the figure 1.An alternative option is to reduce the number of toggle flip-flops used. One additional advantage of the proposed switching strategy is that it can be implemented digitally, without involving signifi-cant modifications to its concept. A pure digital implementation may provide additional flexibility and eliminate concerns per-taining to the number of switching pulses and input legs by avoiding hardwired connections used in this manuscript and by changing the input power ratios online through adequate programmed software.

It would create virtual toggle flip-flops and interconnect them as necessary. Digital implementation of the controller may also facilitate improving its dynamic response.

However, digital implementation is not further detailed here be-cause of its implicit realization through the presented approach and because the discussed analog implementation.when compared with digital implementation, it will provide a clearer representation of the proposed control strategy.The maximum number of switch pulses generated by frequency division using *NT* number of JK flip-flops must be shared among *M* input legs. An increased number of switching pulses means that each effective duty cycle will comprise multiple switching pulses. Each switch may then undergo multiple turn-on and turn-off events in each switching period, which will increase the switching losses.

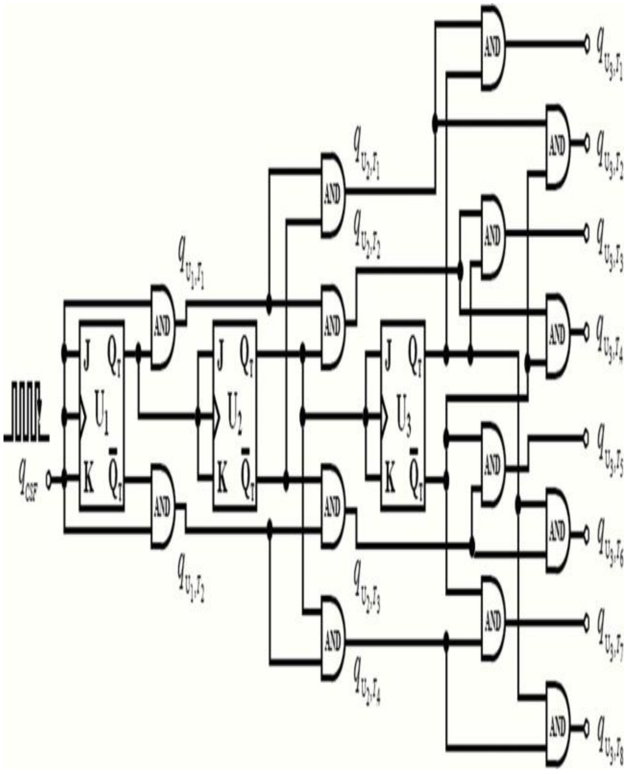

Fig. 2. Schematic showing frequency-division operation.

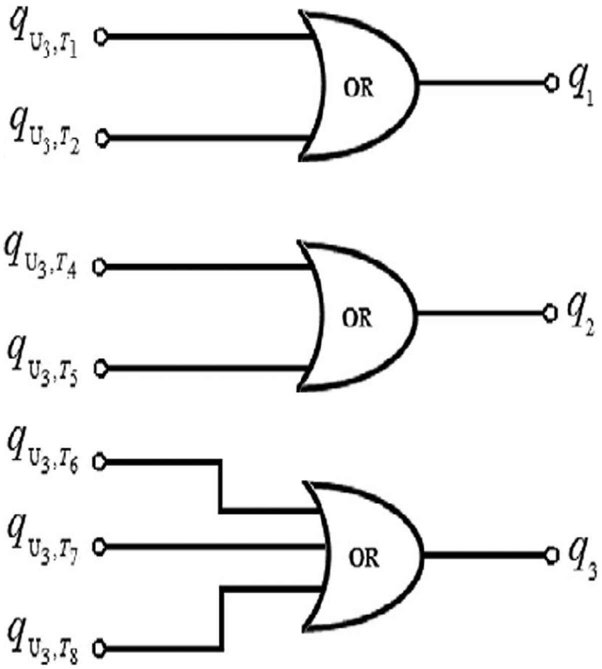

Fig 3. switch-function recombination using OR gates

Only one of the *N*-switching pulses is applied to each input leg, the result is a conventional MIBB converter with equal duty cycles to each input-leg switch; this leaves the switching losses and, thus, efficiencies comparable with the conventional MIBB case,

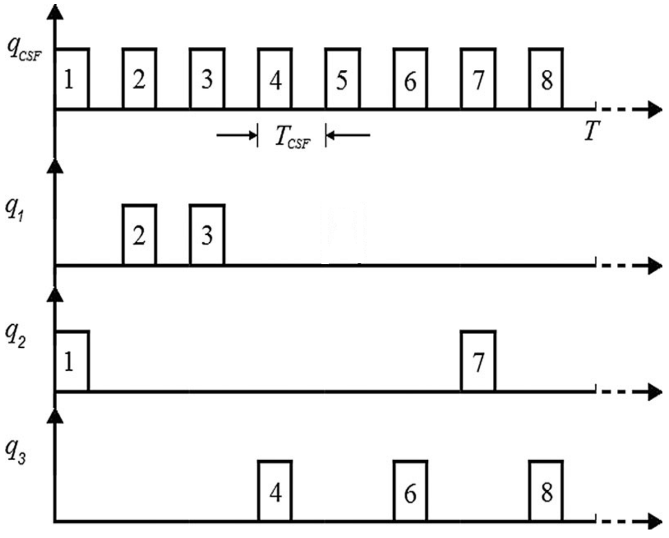

Fig. 4. Switching pulses recombined given to the swiches

The controller requires one circuit for all inputs, it is simpler and, thus, consumes somewhat less power than conventional MIC control circuits. The single controller used with in it and it is opposed to multiple controllers also reduces the power loss in controller stage, which tends to become more relevant at lower power level

III. SIMULATION DIAGRAM & RESULTS

In the MIBB, the parameters used are as follows : L =480 μH, C = 1.5mF, E_1 = 7.5V, E_2 = 10V,E_3 = 15V, *D*CSF = 0.65,F_{csf} = 100 kHz, *NT* = 2, *f* = 25 kHz, *R* = 10 Ω. the MIBB converter is operated with only three input legs, corresponding to three available sources: *E*1 = 5V, *E*2 = 10V, and *E*3 = 15V.

The Block Diagram of MIBB using fuzzy logic controller is shown in the figure 4.In the MIBB the Output voltage could be controlled in it by using Fuzzy logic controller.The output voltage would be controlled by giving control to the switching theswitch in it which is shown in the figure 5.The common switching frequency could be used in it for the purpose of providing the gate signal to each switch.It allows the switching of each switch in the appropriate time period with common node.

Figure 6 shows the Gating signal generator of the open loop structure.In this signal generating, switch 1 and 2 will have two switching CSF pulses and switch 3 will have three switching pulse which is shown in the figure.Thus the switching pulse could be adjusted with the comparing the values of error and change in error in it.Rules could be framed by using the Error and change of error. it could be adjusted in it to achieve reliability.

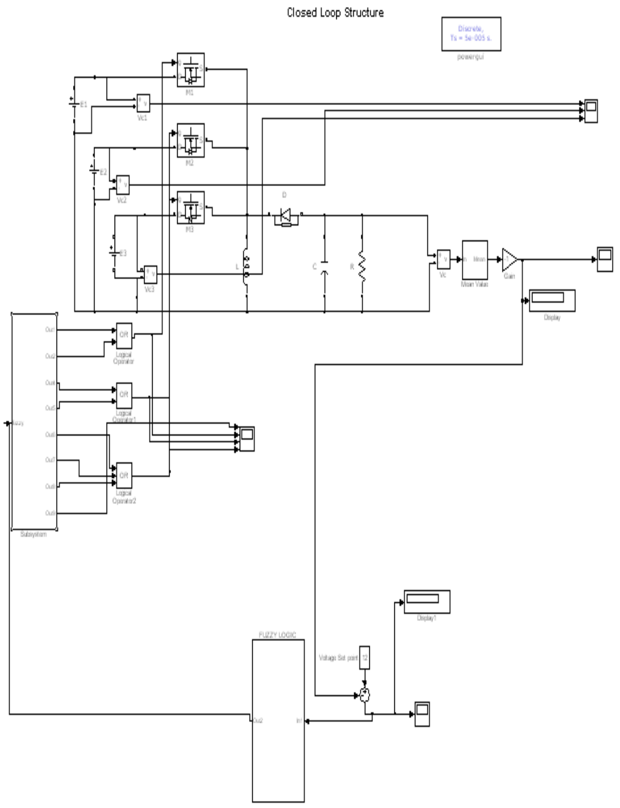

Fig 5 Block Diagram of FLC

Thus the Switching pulses given it to each switch could be adjusted in it.The common duty ratio could be implemented in it. Duty ratio is to be 65percent in this multiple input Buck-Boost Converter. Thus pulses are adjusted with the help of Fuzzy Logic controller. The Error could minimized in it by applying the rules.The thus the switching pulses is given it to the each switch for conduction. In the MIBB, Fuzzy logic controller is to be implemented in it.The converter will work under Buck-Boost operation in it.

The switching pattern used in Fig. 4 indicates that the input leg switches operate at different frequencies; q1 switches at $f_{CSF}/2$, q2 and q3 switch at $f_{CSF}/4$. There is some freedom associated with selecting switching patterns. the MIBB converter is operated with only three input legs, corresponding to three available sources: E1 = 5V, E2 = 10V, and E3 = 15V which is shown in the figure 7.

The output voltage is regulated to 12V which is shown in the figure 8. The desired output voltage regulation is still achieved by the Fuzzy Logic controller. Being able to control MICs with the equal-input-voltage case is also essential in order to realize active power distribution nodes for microgrids. . Thus the Output voltage could be stabilized in it and settling time is 4.15µs which is shown in the figure 8. Thus the equal input voltage applied to the each switch which is shown in the figure 9.The output voltage could be adjusted by using Fuzzy Logic controller.Thus the output voltage could be obtained as near as the set voltage which is given in it. The rules has to be framed with the help of checking error and change of error in it.Thus the rules framed and reduce the error with comparing set voltage and output voltage in it. Thus the output voltage would be obtained as the In the figure 9, Input Voltage is applied as same for the three input in the MIBB converter.Thus the each switch could be switched on and off with the common switching frequency

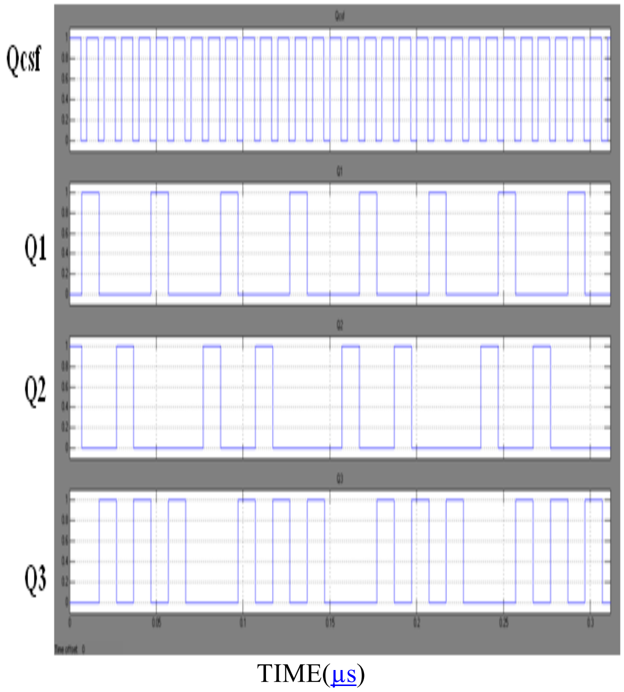

Fig 6 Gating Signal Generator-FLC

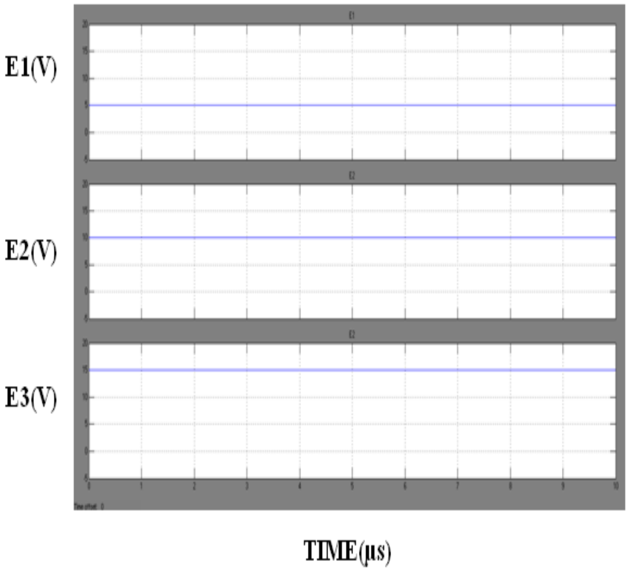

Fig 7 Different Input Voltage-FLC

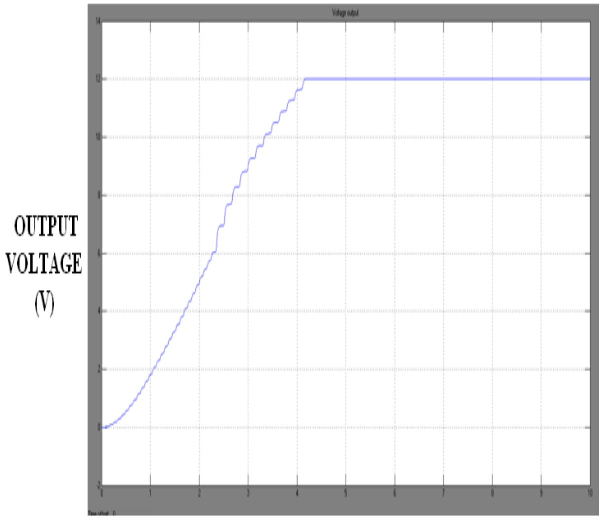

Fig 8. Output Voltage- FLC

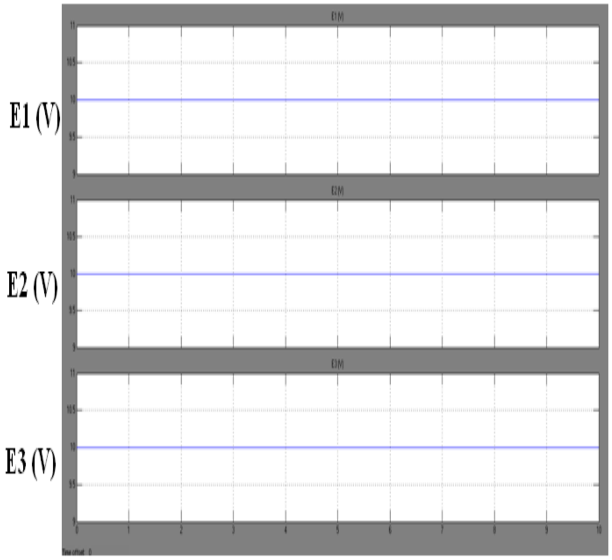

Fig 9. Equal Input Voltage-FLC

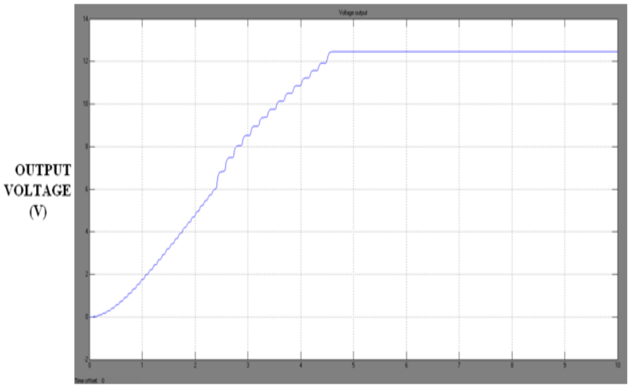

Fig 10.Output Voltage For Equal Input-FLC

The The output voltage could be controlled in it by using FLC. From the figure 10,The output voltage of MIBB by using FLC is obtained as 12.45V in it. The Settling Time will be 4.55µsin it. Thus the output voltage will be stabilized in it and it could be controlled to the set voltage with the help of fuzzy logic controller used in it.

IV.CONCLUSION

A new switching strategy is presented for Multiple Input Converters. With this technique, all switching functions depend on a Common Switching Frequency; the effective duty ratio of the respective switching functions is integer multiples of the Common Duty Ratio, which is the duty ratio of the Common Switching Frequency. The Multiple Input Converter can be reduced to an equivalent single-input converter for analysis, so that its output voltage can be regulated by a Fuzzy logic controller, with the Common Duty Ratio being the only control parameter. The proposed switching strategy is shown to be very simple; it achieves stabilization by implementing only one control circuit for all input legs. Moreover, the proposed switching strategy can be extended into digital implementation in a direct manner. Multiple Input Buck-Boost converter could be used with fuzzy logic Logic controller implemented in it to stabilize the output voltage.

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