Simulation of A TZFI Fed Induction Motor Drive Using Fuzzy Logic Control

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Abstract: This paper deals with modeling and simulation of FLC based TZSI fed induction motor drive. DC in stepped up using TZ network. The output of TZ network is applied to the three phase inverter. The inverter supplies AC power to the induction motor. Open loop system, closed loop system with PI and FL controllers are simulated and their results are compared. The TZSI fed drive system has advantages like reduced hardware size, reduced settling time and improved system response.

Keywords: TZ network, FLC, settling time, PI controller.

1. INTRODUCTION

Modern power electronic applications, especially those directly connected to the gird, usually require some voltage boosting. Traditional voltage-source inverters (VSIs) are therefore not satisfactory since the can only step down voltages. To add boost functionally, Dc – Dc boost converters can be placed before the FSIs[1]. Alternatively, single-stage buck-boost inverters can be used like the Cuk, SEPIC, and other similar Dc – Ac inverters[2]. These inverters however do not have intensive follow –up research. On the contrary, research in another buck-boost inverter, named as the Z-source inverter, has grown rapidly with its modulation, dynamics, control and sizing studied in its applications do motor drives, solar generation and electric vehicles [12]have also been attempted using the same basic Z-source impedance network found in figure 1.
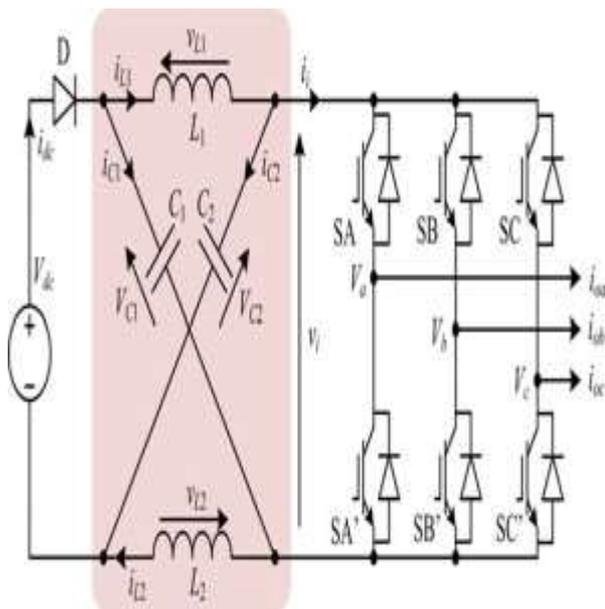
Figure 1. Traditional z-source inverter

Changes to the basic network only surface in, where their respective enhanced networks are name as improved, quasi, and embedded Z-source networks[3]. Although named differently, these networks are closely similar with explaining that they differ only in their source placements. The three networks can eventually be merged into a single generic network with no changes introduced to the number of LC components and input-to-output gain[11]. The latter is subsequently mentioned as a concern in, whose solutions are to add extra inductors, capacitors, and diodes for further raising gain[9]. The amount of components added is however not economically justifiable. The investigation then continues with using coupled inductors or transformers for gain boosting[14]. The circuits discussed in are particularly interesting since they use only one coupled transformer and one capacitor, which are significantly lesser than those found in. They are respectively, named as T-source inverters in trans-Z inverters in after identifying a few more variations[4].

Although the inverters presented in are attractive, their common turns ratio might become too high at high gain. This is certainly in line with classical transformer theories, but is not an exclusive requirement, as demonstrated by the proposed T-Z-source inverters[6]. The proposed inverters again use a transformer and a capacitor for voltage boosting. Their gain is however raised by lowering their transformer turns ratio, rather than increasing it. This is a feature, which so far, has not been matched by other Z-source circuits[5]. Performances of the proposed circuits have already been tested in experiments.

2. Z-SOURCE AND TRANS-Z-SOURCE INVERTERS

The first Z-source inverter proposed in is shown in where a unique X-shaped impedance network can clearly be seen. This added network allows switches from the same phase-leg, to be turned ON simultaneously without causing damages[7]. Instead, the scoot-through state created causes the inverter output to be boosted without distortion if it is used properly with the other eight nonschool-through active and null states. The resulting expressions for computing the network capacitor voltage Vc. Peak de-link voltage during the no shoot-through state, and peak ac output voltage – can subsequently be derived and written in the following equation.

(a)

(b)
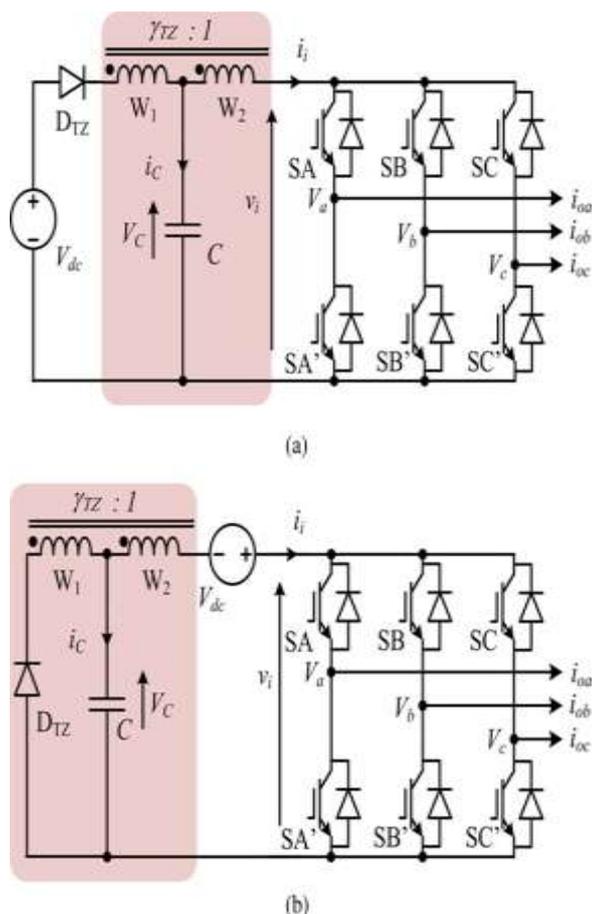
Figure 2. Trans Z-source inverter with source placed (a) diode or (b) VSI bridge

$$\text{Vc} = \frac{1 - dST}{1 - 2dST} VSei \quad 0_1 = \frac{1}{1 - 2dST} Vde \tag{1}$$

$$0_u = M \frac{0_1}{2} = \frac{1}{1 - 2dST}(0.5MV_{de} \tag{2}$$

Where V_{dc}, M and d_{ST} represent the input voltage, modulation ratio, and fractional shoot-through time, respectively.

The boost factor from hence expressed as B = $1/(1 - 2d_{ST})$. Setting its denominator to be greater than zero then results in the operating range of $0 \leq d_{ST} < 0.5$. Since the shoot-through state can only be placed within a null interval to avoid introducing volt-see error, relationship between M and d_{ST} can further be written as M $\leq$ 1.15 (1 - d_{ST}). To produce a high-voltage boost, M must hence be lowered. Lower M how ever leads to high-voltage stresses across the components and poor spectral performances. To avoid these constraints, T-source or trans-Z-source inverters are proposed. In common, the rans-Z-source inverters shown in use only one transformer with turns ratio Trz = W_1 / W_2 and one capacitor. They differ only in their source placements, whose effect is to vary Vc but not the other voltages. This can clearly be seen from where

expressions for computing Vc, 01, and 0 for the trans-Z-source inverters are presented.

(a)

(b)
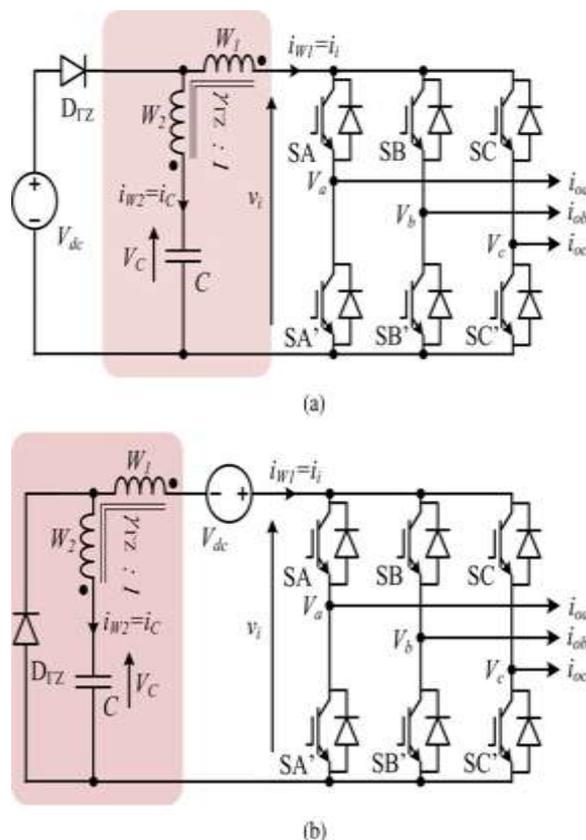
Figure 3. TZ source inverter with source placed in series with (a) diode or (b) VSI bridge

$$\text{V}_c = \frac{1 - d_{ST}}{1 - (rrz + 1)d_{ST}} Vde \tag{3}$$

$$\text{Vc} = \frac{rrxd_{ST}}{1 - (rrx + 1)d_{ST}} V_{sc} \tag{4}$$

$$0_1 = \frac{1}{1 - (rrz + 1)d_{ST}} V_{sc} \tag{5}$$

$$0_{sc} = \frac{1}{(rrz + 1)d_{ST}}(0.5MV_{dc}). \tag{6}$$

Comparing the denominators fo it is clear that the trans-Z-source gain can be raised above the traditional Z-source gain if Trz is set greater than one (rrz $\geq$1). From the new limits for d_{ST} can also be determined as $0 \geq d_{ST} < 1/(rrz + 1)$. After setting the denominator of to be greater than zero. Clearly, the upper limit of d_{ST} can be reduced by using a higher rrz for gain boosting. The lower d_{ST} then leads to a higher modulation ratio since M $\leq$ 1.15 (1 - d_{ST}).

3. SIMULATION RESULTS

The Matlab/Simulink model of PI controlled closed loop system is shown in fig.4. the actual speed is measured and it is compared with a set speed. The error controls the pulse width to regulate the speed. Output voltage of TZ-Source inverter is shown in Fig.5. The speed response is shown in Fig.6. And torque response is shown in Fig.7.Macintosh, use the font named Times. Right margins should be justified, not ragged.
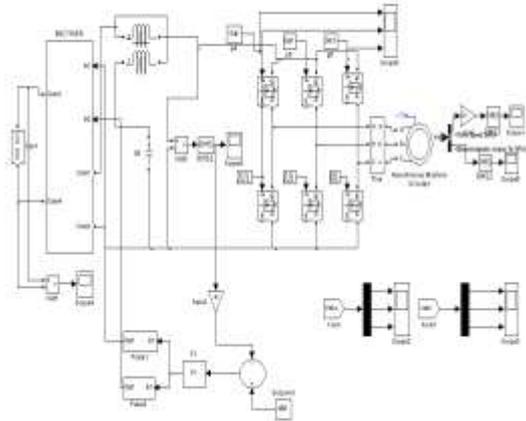
Figure 4. PI controlled closed loop induction motor drive
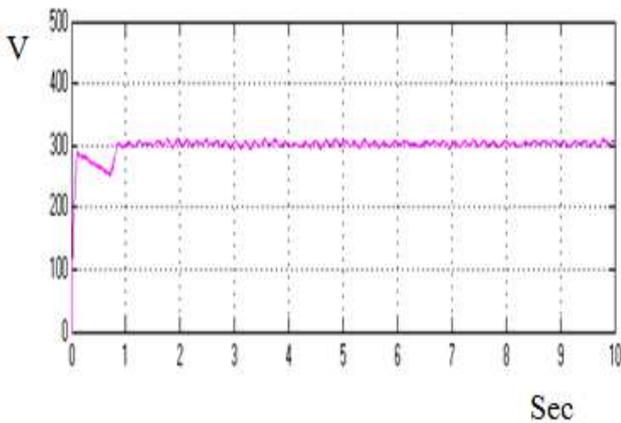
Figure 5. Closed loop PI fed TZ-source output voltage
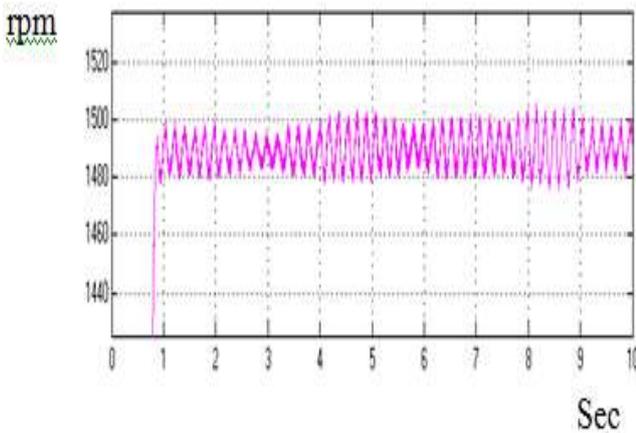
Figure 6. Closed loop PI fed induction motor speed curve
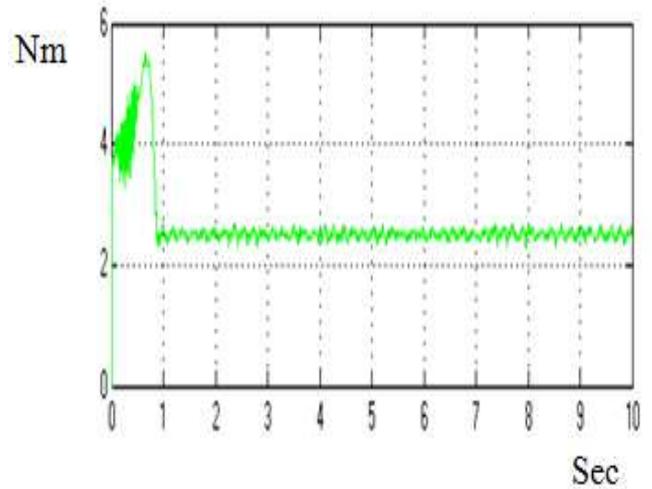
Figure 7. Closed loop PI fed induction motor torque curve

The Matlab/Simulink model of closed loop system with FLC is shown in Fig.8. The PI controller is replaced by FLC. The output voltage waveforms are shown in Fig.9. The speed and torque response are shown in Fig.10 and Fig.11 respectively.
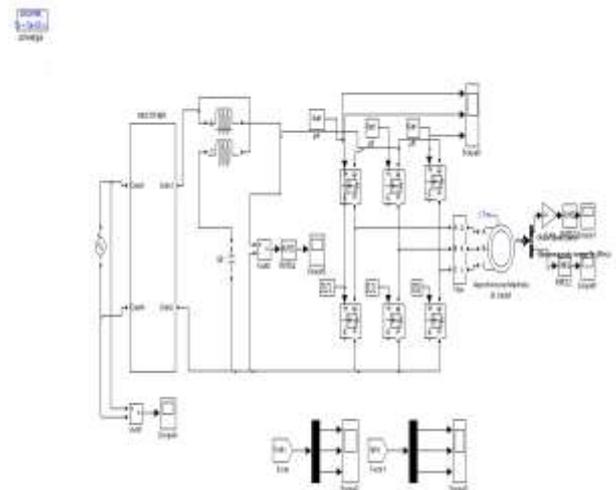
Figure 8. FLC controlled induction motor drive
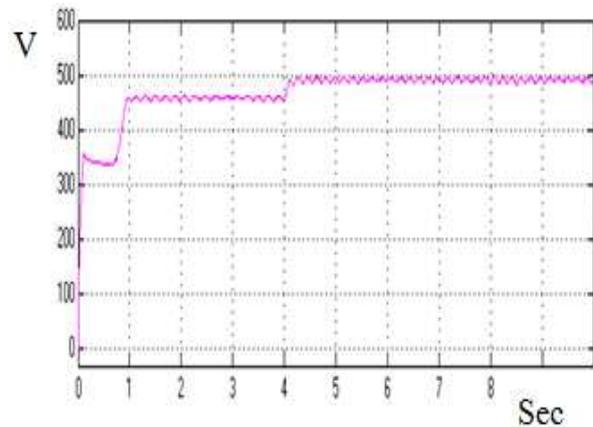
Figure 9. Closed loop FLC fed TZ-source output voltage
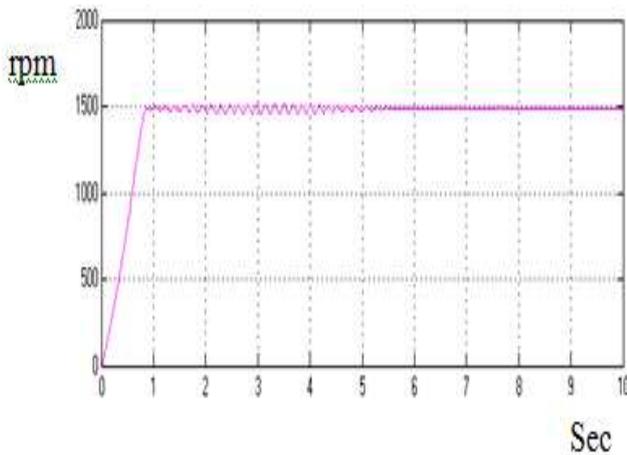
Figure 10. Closed loop FLC fed induction motor speed curve
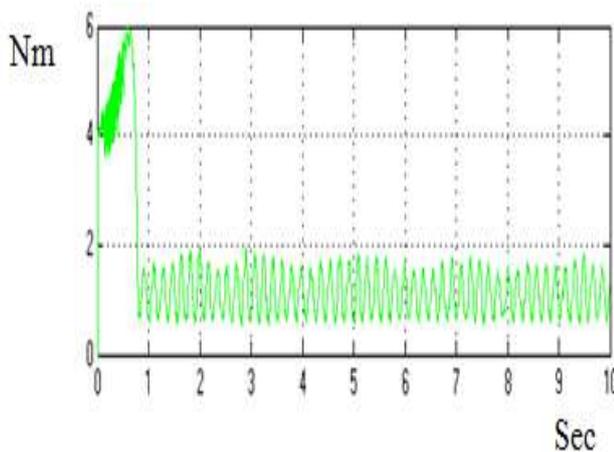
Figure 11. Closed loop FLC fed induction motor torque curve

4. COMPARISON TABLE

Table .1 Comparisons between PI and FLC controller

Controllers	Rise time (sec)	Settling time (sec)	Steady state error (rpm)
PI Controller	0.3	0.35	30
Fuzzy Logic Controller	0.25	0.26	0.5

5. CONCLUSION

FLC based TZSI fed induction motor drive is successfully modeled and simulated using Matlab/Simulink software. The comparison of PI & FLC controlled TZSI fed drives indicate that FLC has better response since the settling time and steady state error are reduced.   This drive has advantages like minimum hardware size   and steady state error.   The disadvantage of TZSI is that it needs a coupled coil. The present work deals with comparison between PI and FLC

based systems. The comparison between PI & ANN systems will be done in future.

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