Converter Design for Two-Phase IM or SM Load

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Abstract **The paper deals with two-phase power electronic system with variable orthogonal output for industrial- and transport drives applications. . Modelling and simulation of two-phase power electronic converters with both R-L and motor load is shown in the paper. The simulation models are created in program Matlab-Simulink and OrCAD. Results of simulation will be compared with experimental verification.**

Keywords **TPIM – two phase induction machine, two-stage system, two-phase orthogonal system, torque-speed characteristic.**

I. Introduction

In the very early days of commercial electric power, some installations used two-phase four-wire systems for motors [1]. Two-phase systems have been replaced with three-phase systems. Two-phase supply with 90 degrees between phases can be derived from a three-phase system using a Scott-connected transformer. Two-phase circuits typically use two separate pairs of current-carrying conductors, alternatively three wires may be used, but the common conductor carries the vector sum of the phase currents, which requires a larger conductor.

On the other side, it can be also easily created using power electronic converters e.g. from battery supply, with two-phase transfer of energy for zero distance DC/2AC, Figs. 1 and 2, and DC/HF_AC/2AC, Figs. 3a, b, converter system can generate two-phase orthogonal output with variable voltage and frequency [2] - [4]. This DC/HF_AC/2AC system usually consist of single-phase voltage inverter, AC interlink, HF transformer, 2-phase converter and 2-phase AC motor.

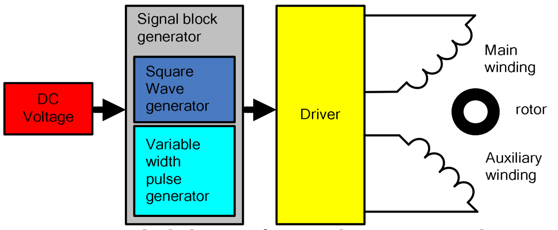

Fig. 1. Block diagram for two-phase motor supply

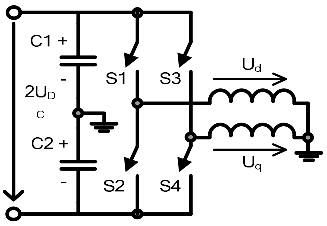

Fig. 2 Principle circuit diagrams of two-phase inverters [4]

Due to AC interlink direct converter (cyclo or matrix converter) is the best choice. System with matrix converter and high frequency AC interlink can generate two-phase orthogonal output with both variable voltage and frequency [4] - [6]. Switching frequency of the converter is rather high (~tens of kHz). Since the voltages of the matrix converter system should be orthogonal ones, the second phase converter is the same as the first one and its voltage is shifted by 90 degrees.

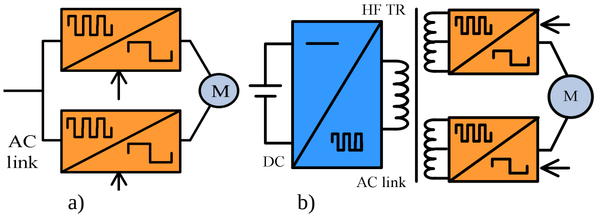

Fig. 3. a) principle diagram of full bridge converter with second phase shifted by 90 degrees, b) block diagram of half bridge converter with HF transformer and central points of the source

Inverter of first stage can be connected as:

1. Full or Half bridge converter,
2. Boost, PFC, or LLC converter.

Inverter of second stage can be connected as:

1. Full bridge converters connection, Fig. 3a,
2. Two half bridge ones with central point of the source using HF transformer, Fig. 3b or
3. Half-bridge ones with central points of the motor load.

II. Switching Strategy for Two-Stage and Two-Phase Converter System with AC Interlink

Equivalent circuit diagram of Half-bridge single phase converters for two-phase system is depicted in Fig. 4. The orthogonal voltages with bipolar PWM control are shown in Fig 5.

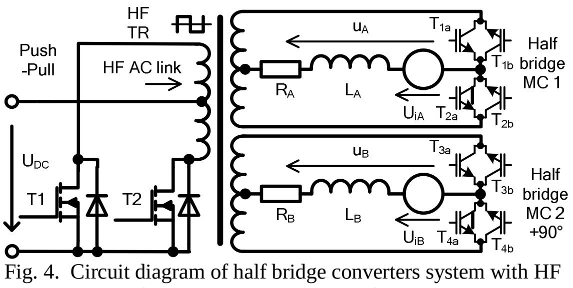

Fig. 4. Circuit diagram of half bridge converters system with HF transformer and central points of the source

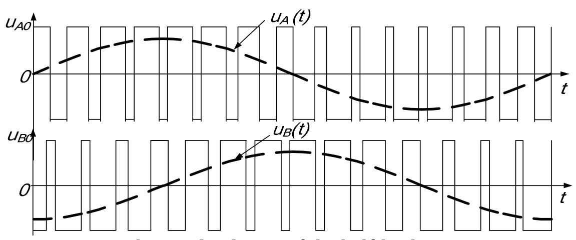

Fig. 5. Output orthogonal voltages of the half-bridge matrix converter system with bipolar PWM

Switching strategy of one half-bridge matrix converter, based on 'even' bipolar PWM, can be explained using Figs. 6, in greater details.

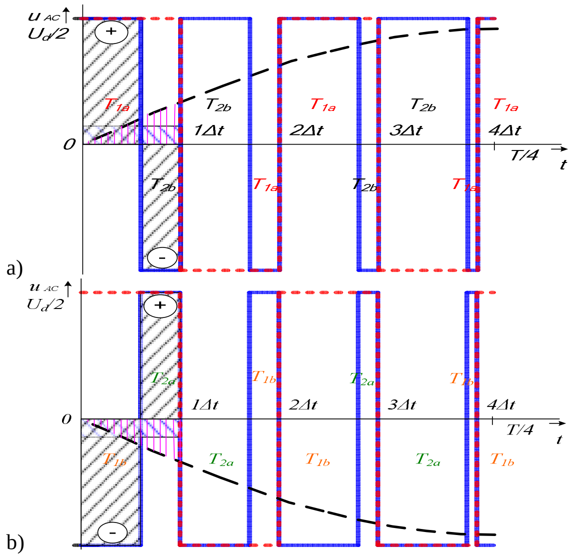

Fig. 6. Switching strategy of half bridge converter for a) positive and b) negative half period of operation

III. Simulation of Proposed System

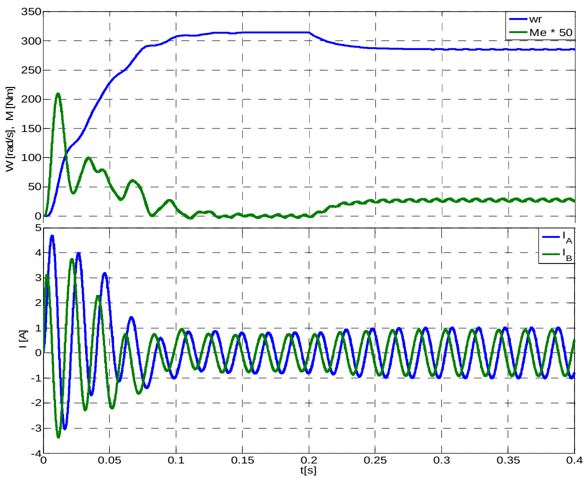

Fig. 7. Simulated waveforms speed, torque and currents of TPIM during start-up (*PWM-* U_{DC} *= 350 V,* f_{sw} *= 50 kHz,* U_{outAC} *= 230 V,* f_{out} *= 50 Hz,* P_N *= 150W,* V_N *= 230V,* n_N *= 3000rpm,* I_N *= 1A,* T_N *= 0.55Nm, and [7])*

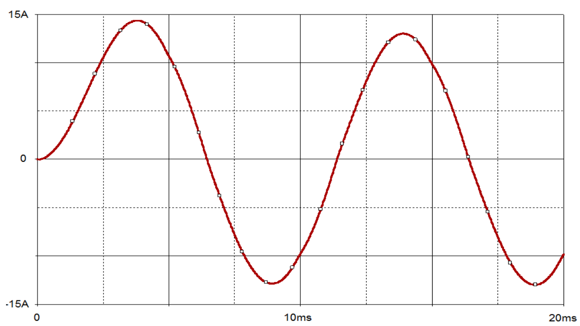

Fig. 8. Simulated waveform of output current of the two-stage single-phase converter under R-L load (U_{inDC} *= 325V,* $U_{iSQUARE}$ *= 325V,* f_{in1} *= 50kHz,* U_{AC} *= 300V,* f_{SW} *= 100kHz,* f_{OUT} *= 100Hz, R = 12Ω, L = 30mH)*

Simulated waveforms during start-up of the two-phase induction machine (TPIM) supplied by two-phase switched voltage shifted by 90 degree (MatLab) are depicted in Fig. 7. Simulation result of two-stage converter with using single-phase half-bridge matrix converter with R-L load (OrCAD) is shown in Fig. 8.

IV. Conclusion

Article shows a new concept of electric propulsion system for electric vehicle and industrial application. It consists of two-stage converter created by single-phase converter and two single-phase matrix converters commutated by HF-AC input voltage, and two-phase induction TPIM or synchronous motors with PM. The simulated results will be compared with real measurement. With using of two-stage converter, overall system losses can be reduced [7], [8]. Using chosen half-bridge connection for both inverter and matrix converters with bipolar PWM the number of power switching elements of the two-stage converter can be reduced and smaller then those of classical three-phase voltage inverter. Using higher switching frequency, it is possible to achieve not only higher efficiency, but also smaller harmonic distortion (THD) of output current.

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