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HF ELECTROMAGNETIC INTERFERENCES IN SUPPLY VOLTAGE OF FREQUENCY CONVERTERS WITH DC LINK

The paper concerns a MATLAB-model which considers parasitic parameters of voltage source converter, asynchronous motor and supply network. The offered model allows to determine common and differential electromagnetic interferences(EMI) during the EMI filter designing.

1 INTRODUCTION

Voltage distortion in supply network of asynchronous variable speed drives (VSD) with frequency converters (FC), is caused by the functioning of two key schemes amounting to mentioned converter: diode rectifier (DR) and voltage source converter with PWM modulation. Harmonic distortion of FC supply voltage, according the power quality standards (ГОСТ 13109 – 97, EN50160), are generally determined by low frequency (LF) harmonics (up to 40 inclusively), which are conditioned by the DR functioning.

IGBT commutation with high PWM carrier frequency 10…20 kHz is resulting in high frequency (HF) electromagnetic interferences (EMI) in radiofrequency range (units of kHz…dozens of MHz), generated by FC in to supply network.

HF EMI are spreading through the wires, “turn-to-turn” capacitances of transformers, parasitic capacitances "phase-to-phase" and "phase-to-ground" of electrical equipment and cable routing. Conducted EMI levels for VSD are regulated by the international standard EN55014.

The questions of HF EMI reduction are most actual for electric power systems (EPS) of remote controlled submersible vehicles (RCSV), which are equipped with FC. Captive RCSV are equipped with own propulsion units, video control, instruments and devices for underseas jobs. RCSV are receiving control signals and voltage supply by the cable-rope (CR) from EPS of carrier vessel.

Together with other important factors normal functioning and liveness of such expensive and complicated objects as RCSV is affected by electromagnetic compatibility (EMC) of their elements [1]. General practice of marine movable objects exploitation displays, that conducted EMI causes disturbances in their information, navigation, automatic control and electromotion systems [1]. Emergency operation of RCSV caused by such disturbances are prohibitive, because resulting in essential financial losses and RCSV fails.

All said confirms importance of EMC problem no only for RCSV electrical equipment but for connected with carrier vessel EPS which is connected with vehicle.

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Power quality (PQ) is a component of EMC which characterize electromagnetic environment, in our case – EPS of RCSV. PQ is determined by chain of factors [2], with the main – total harmonic distortion of current and voltage.

The questions of EMI lowering in carrier vessel's EPS are deeply [3]. At the same time, the actual problem of EMI illuminating in EPS with RCSV having own electrical drives with FC, is learned insufficiently.

The solving of mentioned problem is complicated with difficulty of physical realization of EMI filters on the board of RCSV, by presence of essential parasitic parameters of cable-ropes and high conductivity of sea water beside the frames of electrical equipment. Last two factors assisting to appearance of new ways for HF EMI (generated by FC of RCSV) propagation in range – units of kHz…dozens of MHz.

The object of the paper is MatLab-model designing for RCSV EPS with asynchronous VSD, which conceders parasitic parameters of not only VSC but also asynchronous motor and CR. The model investigation gives opportunity of common and differential mode EMI determination during the effective harmonic filter development.

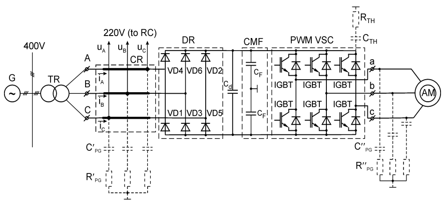

Fig.1.

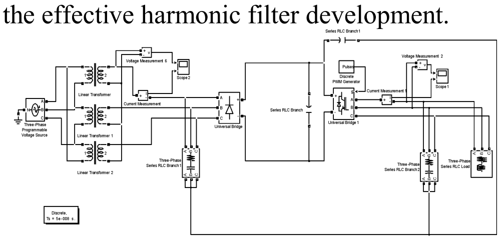

Fig.2.

The scheme RCSV EPS is shown in the Fig.1. Main elements of the scheme are: generator (G), transformer (TR), CR, DR, smoothing filter (C_d), IGBT VSC, asynchronous motor (AM). The next parasitic parameters are accepted in the: C'_{PG}, R'_{PH} – capacitance and resistance phase-to-ground of CR, C''_{PG}, R''_{PH} – equivalent capacitance and resistance phase-to-ground of AM and collector-to-heat sink for emitter group of valves, C_{TH}, R_{TH} – collector-to-heat sink capacitance and resistance for collector group of valves.

The model of the system without of harmonic filters is shown in the Fig.2. The model have next parameters: $S_{TR} = 180\ VÀ$; $u_{S.C.} = 5\,\%$; $C_d = 220\ mF$; $C'_{PH} = 33\ nF$; $R'_{PH} = 1\ Îhm$; $C''_{PH} = C_{TH} = 3{,}3\ nF$; $R''_{PH} = R_{TH} = 1\ Ohm$; $S_{AM} = 180\ VA$; $U_{AM} = 220\ V$; $cos\varphi_{AM} = 0{,}8$; frequency on input and output of the FC are 50 and 400 Hz accordingly; frequency of PWM $f_{î} = 10\ kHz$; modulation index $m = 0{,}4$ rise and drop time for VSC output PWM impulses are 200 and 100 ns accordingly.

DR input voltage and current diagrams, achieved during the modeling are shown in the Fig.3,a,b accordingly.

Spectrogram shows, that HF EMI maximums are corresponding to the ranges bordering to frequencies, which are divisible by modulation frequency.

The modeling results displays, that HF EMI levels are far away from standard rates in dozen hundred times. Such EMI in general are conditioned by common mode (CM) EMI components.

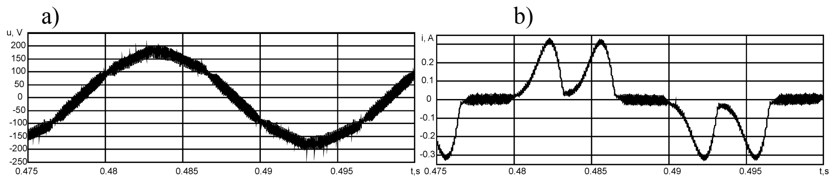

Fig.3.

The specter of the EMI in voltage of scheme without of harmonic filter (Fig.2) are presented in the Fig.4.

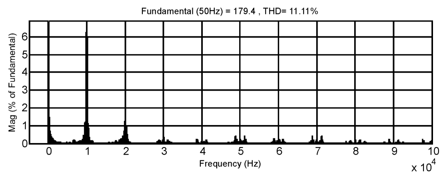

Fig.4.

CM component of input current

(1) $$i^{in}_{cm} = (i_A + i_B + i_C)/3$$

For differential mode (DM) components of phase currents we can get

(2) $$i^{in}_{dm} = i_m - i^{in}_{cm}, \; m = A, B, C$$

For the phase A equation (2) can be transformed

(3) $$i^{in}_{dmA} = (2i_A - i_B - i_C)/3$$

Important to note, that appearance of CM components in the input currents and voltages is conditioned by the capacitive currents in parasitic circuits. For the HF EMI elimination in the currents and voltages of FC it is necessary to use special common mode filters (CMF). The simplest of them – capacitive filter, consists from two capacitors C_F (Fig.1). The model of system with CMF ($C_F = 1$ mF) is shown in the Fig.5.

The oscillograms of the phase voltages and currents are given in the Fig.6,a,b. Phase voltage specter is presented in the Fig.7.

The model experiment displays, that CMF using allows to make maximum EMI lower in thirty times. The results of full-scale experiment confirms effectiveness of CMF in respect of complete elimination of conducted EMI influence on responsible consumers of RCSV "Agent – 1".

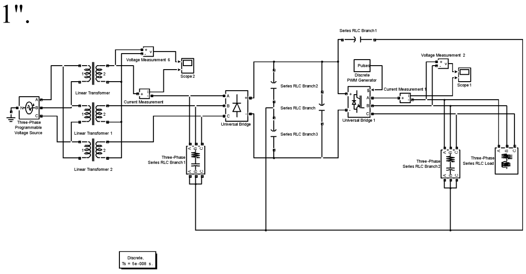

Fig.5.

Hence, proposed MatLab-model of RCSV "Agent – 1" EPS, which considers parasitic parameters of the system (first of all CR), allows to estimate the HF EMI levels in supply voltage and current at the stage of RCSV designing. Utilization of CMF is proposed for HF elimination. The effectiveness of CMF was confirmed experimentally.

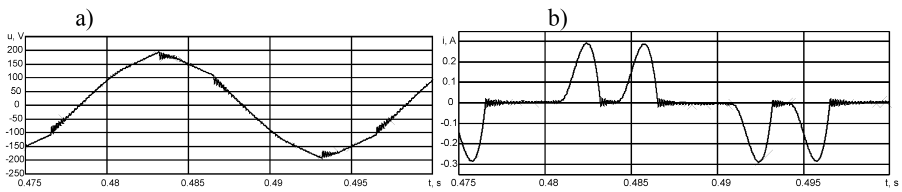

Fig.6.

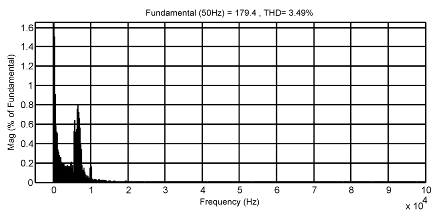

Fig.7.

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HF ELEKTROMAGNETYCZNA INTERFERENCJA W UKŁADACH ZASILANIA PRZEKSZTALTNIKÓW CZESTOTLIWOŚCI Z OGNIWEM DC

Referat dotyczy modelu MATLABa uwzględniającego parametry źródła zasilania, asynchronicznych maszyn i sieci elektrycznej. Zaproponowany model pozwala określić ogólne i specjalne elektromagnetyczne oddziaływanie podczas projektowania filtrów.