THE ANALYSIS OF THE THREE PHASE RECTIFIER WITH SEVERAL PULSES

Dănilă Cerbulescu, University of Craiova
e-mail:dcerbule@electronics.ucv.ro
Craiova.Ro-1100,Romania

Abstract-This paper describes o complete analysis of a thre-phase bridge rectifier with resistive load, using Matlab/Simulink enviroments.
The work present the analysis of the wave forms of the three-phase controlled rectifier in normal function regime.

Key words: rectifier, bridge, SCR, diode, LIGB1.

1. INTRODUCTION

The rectifier depicted in fig. 1 is formed by 6 thyristors and 2 diodes with a three phase power source, in witch we have 4 branches, 3 of them only with diodes and one branch with diodes. The branch on witch the diodes are connected is connected to the power source null.

2. FUNCTION

The regulation of the load tension is made by modifying the driving angle of the thyristors.

Depending on the driving angle of the thyristors we have 3 functioning domains:

<u>Domain I</u> of functioning, in witch the driving angle ∝ < α < 30. In this domain we have a conduction state only for thyristors. The rectifier is a three phase in bridge, full driven, RTP6, in witch we have 6 pulses on a period.

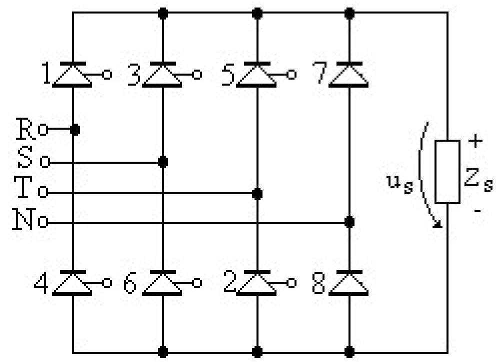

Fig.1. Three-phase bridge rectifier.

The medium value of the rectified tension is given by:

$$U_{o\alpha} = U_o \cos\alpha \, . \qquad (1)$$

$$U_o = \sqrt{2} U_2 \frac{\sin \frac{\pi m}{m}}{\frac{\pi}{m}} . \qquad (2).$$

witch U_2 is the tension of phase.

The rectified tension pulses are given by fragments of the line tension. That's because only the devices that have the greater line tension are commuting.

If we note with 1 logic the conduction state and with 0 logic the blocking state, the conducting and commuting sequence is given by the step matrix:

Devices →	1	2	3	4	5	6	7	8
Tact 1↓	1	1	0	0	0	0	0	0
2	0	1	1	0	0	0	0	0
3	0	0	1	1	0	0	0	0
4	0	0	0	1	1	0	0	0
5	0	0	0	0	1	1	0	0
6	1	0	0	0	0	1	0	0

The rectified tension contains only n=km order components (multiple of m phases),

witch

$$u_d = U_{do}\{1 + \sum_{k=1}^{\infty} \cos k\pi \left[\frac{\cos[km\omega t - (km+1)\alpha]}{km+1} - + \frac{\cos[km\omega t - (km-1)\alpha]}{km-1} \right]\}$$

Domain II. If we angle the driving, 30<∝<90 we have time intervals in witch alternatively conducts 2 thyristors and one thyristor and a diode.

The waveform of the load tension is given by fragments of the line tension (when thyristors are conducting) alternating with fragments of the phase tension (when a thyristor and a diode are conducting).

In the same way as in the domain I, we can write the step matrix, witch is:

Devices →	1	2	3	4	5	6	7	8
Tact 1↓	1	1	0	0	0	0	0	0
2	1	0	0	0	0	0	0	1
3	0	1	1	0	0	0	0	0
4	0	1	0	0	0	0	1	0
5	0	0	1	1	0	0	0	0
6	0	0	1	0	0	0	0	1
7	0	0	0	1	1	0	0	0
8	0	0	0	1	0	0	1	0
9	0	0	0	0	1	1	0	0
10	0	0	0	0	1	0	0	1
11	1	0	0	0	0	1	0	0
12	0	0	0	0	0	1	0	1

The rectified tension has different values, depending of the way the rectified tension is obtained from the line tension or fragments of the phase tension.

$$u_d = \frac{3.\sqrt{3}}{\pi}.\sqrt{2}.U_L\{\cos\alpha + \sum_{n=1}^{\infty}\left[\frac{1}{(6n-1)^2} + \frac{1}{(6n+1)^2} - \frac{2\cos 2\alpha}{(6n+1)(6n-1)}\right]^{1/2}. \sin(6n\omega t + v_{6n}\}.$$

witch

$$v_{6n} = -\frac{n\pi}{6} + tg^{-1}.\frac{\frac{\cos(6n+1)\alpha}{6n+1} - \frac{\cos(6n-1)\alpha}{6n-1}}{\frac{\sin(6n+1)\alpha}{6n+1} - \frac{\sin(6n-1)\alpha}{6n-1}}.$$

Domain III. If we angle the driving, 90^o<∝<150^o .

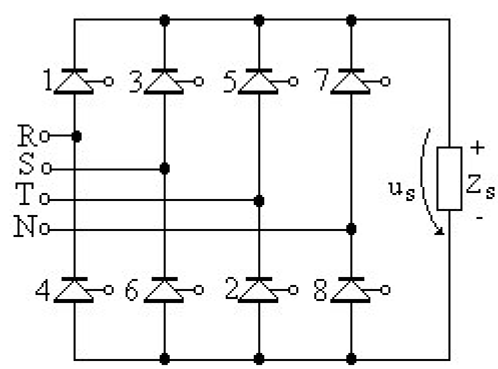

Fig.2. The rectifier full controler.

If we can say that the circuit in fig 2 is full rectifier, then the circuit in fig 1 is a half rectifier.

As for the AC converters, presented in fig 3, related to the devices type we can have AC converters full driven or half driven. Depending on the type of the devices we have 3 functioning domains.

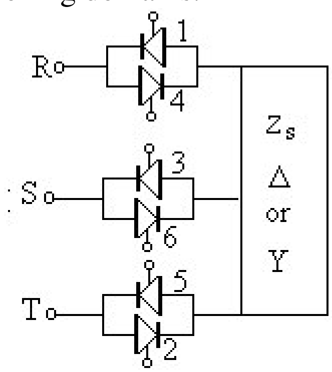

Fig.3. AC converter.

At a rectifier, for driving a DC electric motor, we have to follow:

- the regulation of the medium value of the rectified tension, in order to ensure the couple of the running machine;

- the harmonics content, in order to analyze the way in witch the electrical network is loaded with harmonics from the rectifier functioning and how the electrical DC engine is loaded with harmonics witch drive to the overheating and functioning limitation.

If we compare the two step matrix given by the relations 1 and 2, we can deduce:

- for the domain I each device drives a time interval equal with $2\pi/m = 120°$ (m= number of phases) and for the domain II we have a driving angle equal with $\pi/m = 60°$. The conduction interval is equal with a step of the step matrix.

The steps have equal length. From the Fourier series developing results that the first non-zero harmonic, for domain I is f_1=pf = 300Hz and for the domain II, the frequency of the first harmonics depends of the fragments of the line or phase tension witch approximates the load tension

- f_1 = 300Hz – when the thyristors are conducting (we have RTP6)
- f_1 = 300Hz or f_1 = 150Hz when a thyristor and a diode are conducting

The optimal filter to make smooth the output tension should be projected in the domain 150Hz-300Hz, so it cannot fulfill.

CONCLUSION: In the case of using the rectifier with several pulses, in witch a branch of the bridge uses the null of the electrical network, in order to have an optimal filter we have to use, in functioning each domain separately

We can say that we have 3 functioning domains for C input converters because the output differs: Dc for rectifier and AC for AC converters.

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