DESIGN OF A QUEUEING MODEL FOR ANALYSISING THE BEHAVIOUR OF POWER TRANSMISSION SYSTEM

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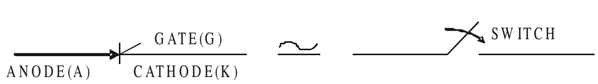
ABSTRACT

This paper deals with the Difference Queueing model for the power transmission system. The device called "Thyristor" which consists of three terminals modeled with queues. Gohain et al. (1979) have explained the difference equation technique which is applied for bulk service queues. Later on, Pochee(1998) has discussed about the performance of computer mirroring system. In this paper a comparison is made between the two queueing models M/M/1 and M/DTQ/1. Under high load conditions it is proved that M/DTQ/1 model, approximated the behaviour of the transmission system. Generation of pulses and utilization can be made moderate by using this queueing model. Based on the numerical calculations and graphical representations M/DTQ/1 can be considered as an appropriate model for transmission system.

Keywords: Difference queueing transmission model, pulse generator, inverter, rectifier, thyristor,.

I. INTRODUCTION

Electronics essentially deals with the study of semiconductor devices and circuits for processing information at the lower power level. Normally while transmitting power from the generating station to remote houses or localities, Alternating Current (AC) transmission is comparatively lower than any other transmission. But this type of AC transmission is feasible only for small distances. Hence, the generated AC voltage is converted to DC and is then transmitted via DC cables. Again at the receiving end, the DC is converted to AC, which is needed for different types of supply to various fields. White (1975) has made an analysis on queueing models. The quqeueing model considered for power transmission system is M/DTQ/1. Singh (2004) has discussed the function of the Thyristor, Let us consider the model in which the thryistor has 3 terminals as follows:



A. Thyristor Construction

Bimbhra (2002) has designed the block diagram of the Thyristor.

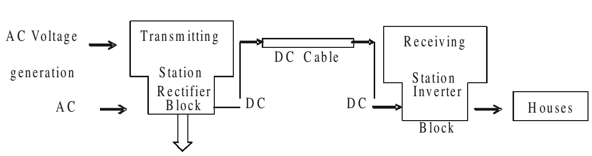


Fig. 1 : Construction of a Thyristor

The detailed diagram of rectifier and inverter block is shown in Fig 2

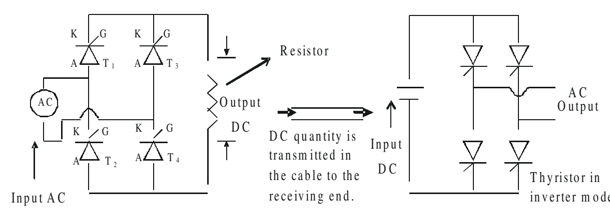
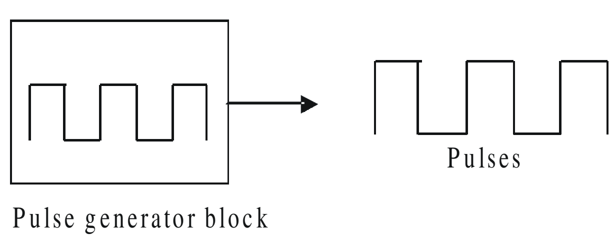


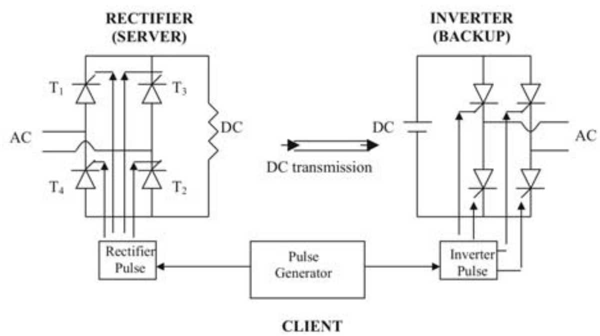
Fig. 2 : Detailed diagram of rectifier and inverter block

A thyristor is a switch, when the gate pulse is given to it, the switch closes and allows the current to pass through it. When the gate pulse is removed, the switch opens and does not allow current to pass through it. The gate pulse is a triggering pulse that makes the switch "ON". Free wheeling diodes D_1 to D_4 are used as anti parallel connection to the thyristor to avoid damage to the thyristor.



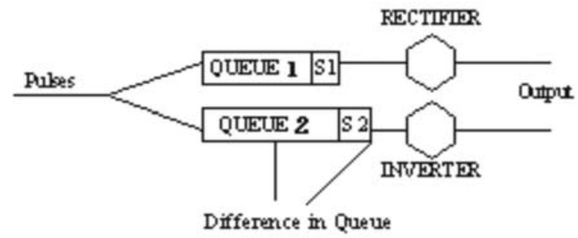
The pulses generated are in the form of voltage values that are converted into binary codes, where 'one' represents the occurrence of pulses and 'zero' represents the non-occurrence of pulses.

II. QUEUEING MODEL FOR TRANSMISSION SYSTEM

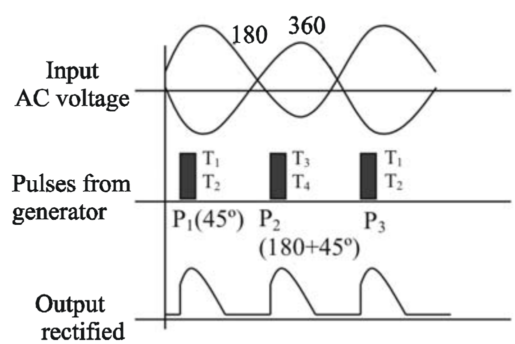


The inverted waveforms for the inverter to get back the same ac output is shown in Fig.3. In power generation, the reliability requirement is taken into account and the reliability does not always affect the availability of the system. It is very important to note that for any critical system, there is a backup system, such that in the event of any problem in the main system, the backup works to finish the jobs. But in this model, both the main system and backup work simultaneously. Gross (1985), Kleinroch (1975) and Saaty (1961) have discussed the fundamental concepts of queueing theory. Dshalalow (1997) has explained the concept of frontier concepts in queueing theory. Senthamarai Kannan et al.(2005) have discussed about the two server queueing model with single vacation and the concept of general bulk queueing system for limited batches have been analysed by Vijayalakshmi et al.(2007). In this paper, the queuing transmission model consists of the pulse generator (client), rectifier (server) and inverter (backup). In transmission system, if there is any problem in the rectifier, then the inverter will work, as the inverted waveforms of the inverter will transmit the same AC output. It should be noted that the inverter will maintain the processing speed of the rectifier system.

The difference queuing model concept is implemented for the power transmission system by noting the delays in the operations of the rectifier and the inverter. The generation of pulses to the rectifier and the inverter are done simultaneously, although it is passed in different queues. However, there is a possibility for the pulses given to rectifier to lag in time or angle with respect to the pulses given to the inverter. The difference queueing model is considered for the analysis of performance in the transmission system.



The input in terms of voltage values are assumed to be completely and randomly synchronized with the exponential probability density function for inter arrival times. The service times are independent and identically distributed. The magnitude of the pulse is high, for a small period i.e one milliseconds when it is in the "OFF" state and here the pulses are sent in inter arrival times $(180° + 45°)$. Consider the wave forms graph, where there are four points T_1, T_2, T_3 and T_4. At point P_1, thyristor T_1 and T_2 are triggered and made "ON" for the positive input AC wave. At point P_2 , T_3 and T_4 are triggered and made 'ON' for the negative input AC wave.



Let λ be the arrival rate and μ the exponential rate and traffic intensity is defined as $\rho = \lambda/\mu$ in terms of pulses such that the arrival rate is defined by $\lambda = [v/360 \times 1/50]$. The pulses from the pulse generator are triggered simultaneously in both the systems. The arrival and service rates be given as $\lambda_1, \lambda_2 \& \mu_1, \mu_2$ respectively. The design of a parallel network of queues in a computer system explained in Saaty (1961) where there is an exception that the same poisson process generates pulses in both the queues.

A. Generation of Pulses

In this model, the queue length differs for the individual generation of pulses. Initially the pulses from the generator have to be triggered at 45° in the rectifier and in the inverter the pulses are triggered at 30° which is defined as lag in time. The inverter has to execute the remaining generation of pulses in order to reach the same queue level in the rectifier. In the behaviour of the transmission with the difference queues, an additional synchronization is placed in order to reduce the error without having the "block". The difference lag in time will be noted between 30° and 45° and the error can be reduced. Thus difference transmission queue is a realistic queuing model for transmission system and the length is always positive. Vijayalakshmi et al.(2007) has analysed the design of a queueing model for transmission system.

III. NUMERICAL CALCULATION

The service times in generation of pulses in both rectifier and inverter follows exponential distribution μ_1&μ_2. The probability density function is defined as $f(t_1)$

Let $k = \mu_2 - \rho_1 \mu_1$

$S = \mu_2 - \rho_1 \mu_1$

$f(t_1) = ke^{-st2}$

where t_2 is the time in the difference queue.

$$E(L) = \frac{\lambda}{\mu - \lambda} \quad \text{... (1)}$$

Input given in terms of voltage is converted in terms of time. If the degree of the triggering pulse is reduced from the actual instant, then the time occurrence of output increases as shown in table 1. Similarly the generation of pulses for the inverter is calculated as μ_2, and λ_2 by using the formula

$$\lambda_1 = \left[\frac{\theta_1}{360^\circ} \times \frac{1}{50}\right] \text{and service time } \mu_1 = \frac{180}{360^\circ} \times \frac{1}{50} - \lambda_1$$

Table I – Generation of Pulses (Rectifier)

SL.No.	Pulses (Degrees)	λ	μ	Traffic Intensity	E(L)
1	50	0.002777	0.007222	0.384519524	0.624746907
2	53	0.002944	0.007056	0.41723356	0.715953307
3	56	0.0031111	0.006888	0.45166957	0.823717864
4	59	0.0032777	0.0067222	0.487593347	0.951574975
5	61	0.0033888	0.0066111	0.512592458	1.051671167
6	64	0.003555	0.006444	0.551675978	1.230529595
7	67	0.0037222	0.0062777	0.59292416	1.456544707
8	70	0.003888	0.0061111	0.636219339	1.748909181
9	73	0.0040555	0.0059444	0.682238746	2.147016782
10	76	0.004222	0.005777	0.73082915	2.71511254

Table II – Generation of Pulses (Inverter)

S.No.	Pulses (Degrees)	λ	μ	Traffic Intensity	E(L)
1	47	0.002611	0.0073889	0.35336789	0.546474393
2	49	0.0027222	0.0072777	0.374046746	0.597563385
3	51	0.002833	0.007167	0.39528394	0.653668666
4	53	0.002944	0.007056	0.41723356	0.715953307
5	55	0.003055	0.00694	0.440201729	0.786357786
6	57	0.003166	0.006834	0.463271876	0.863140676
7	59	0.003277	0.0067222	0.487489215	0.951178451
8	61	0.00338	0.00662	0.510574018	1.043209877
9	63	0.0035	0.0065	0.538461538	1.166666667
10	65	0.003611	0.006381	0.565898762	1.303610108

Table III - M/M/1 Model

Sl.No.	Λ	μ	Traffic Intensity	E(L)
1	0.002611	0.007222	0.361534201	0.566254609
2	0.002722	0.007056	0.38579932	0.628132355
3	0.002833	0.006888	0.411295006	0.69864365
4	0.002944	0.006722	0.437951861	0.77920703
5	0.003055	0.006611	0.462101617	0.859087202
6	0.003166	0.006444	0.491309745	0.965832825
7	0.003277	0.006278	0.522006467	1.092078515
8	0.00338	0.006111	0.553091915	1.237596573
9	0.0035	0.005944	0.588789449	1.431844215
10	0.003611	0.005777	0.625064913	1.667128347

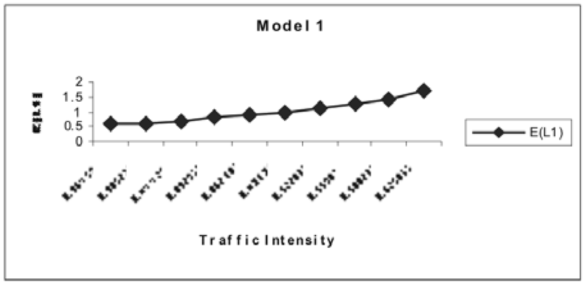
Considering the point, that inverter does not generate pulses faster than rectifier such that $\mu_2 > \mu_1$, then the mean length in the transmission system is given by

$$E\left[\,L_{DTQ}\,\right] = \frac{\rho_2^2}{2\,(1-\rho_2)} - \frac{\rho_1^2}{2\,(1-\rho_1)}$$

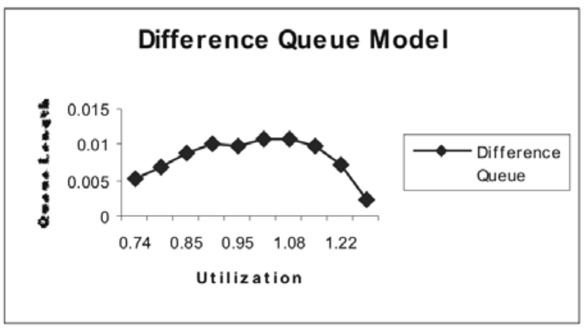
If the traffic intensity ρ_2 approaches 1 and $\rho_2 \geq \rho_1$ in which the rate generation of pulses increases and difference queue also increases.

Table IV – Difference Queueing Model

Traffic Intensity I	Traffic Intensity II	Utilization	LD1	LD2	DIFFERENCE QUEUE
0.35336789	0.384519524	0.737887414	0.045501014	0.040372109	0.005128905
0.374046746	0.41723356	0.791280306	0.050725111	0.043788863	0.006936248
0.39528394	0.45166957	0.84695351	0.055931184	0.047243259	0.008687926
0.41723356	0.487593347	0.904826907	0.060911642	0.050725111	0.010186531
0.440201729	0.512592458	0.952794187	0.064033416	0.054238172	0.009795244
0.463271876	0.551675978	1.014947854	0.068222898	0.057596518	0.01062638
0.487489215	0.59292416	1.080413375	0.0715556	0.060898001	0.010657599
0.510574018	0.636219339	1.146793357	0.073624667	0.063793209	0.009831458
0.538461538	0.682238746	1.220700284	0.073950941	0.066909422	0.007041519
0.565898762	0.73082915	1.296727912	0.071883589	0.069508596	0.002374993



Graph I – M/M/1 Model



Graph II – M/DTQ/1 Model

Tables 1 and 2 reveals the fact if the traffic intensity increases, then E(L) also increases. Comparing the two models M/M/1 and M/DTQ/1, $E(L_{DTQ})$ initially increases, then decreases and at one point it becomes constant as per table II in which it is proved that M/M /DTQ/1 can be an appropriate model for controllers in the direct current transmission system. From the graphical representations it can be seen that the value lies between 0.005 and 0.01 for any amount of utilization. Thus it is proved that M//DTQ/1 can be an appropriate model for controllers in the direct current transmission system. Most of the values are distributed around the interval length of 10 msec. Internal length deviation is caused by changes in the input pulses because of external factors.

IV. CONCLUSION

Based on the above numerical results and graphical representations it is proved that the generation of pulses in the rectifier and the inverter closely approximated the behaviour of the transmission system. The utilization is made moderate and it is proved that the variation in service time is minimized. Numerical results reveals the fact that the queueing model M/DTQ/1 closely approximates the behaviour of the transmission system and it gives approximate results for low utilization. Since the value of $\rho^1 + \rho^2 < 1.5$, the difference queueing model gives 30% of the generation of pulses in both rectifier and inverter. Hence the queuing model M/DTQ/1 can be considered as deterministic and realistic model for power transmission system.

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