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Analysis of EMI effects on Monostable Multivibrator

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Abstract: **Electromagnetic interference (EMI) has a negative effect upon the performance of circuit communication systems. The present study considers the case of EMI and it is shown that the harmonic noise increases with an increasing interference amplitude and frequency. When electromagnetic interference takes place with the input pins of 555 Timer using as an Monostable Multivibrator it can cause operation variation. This paper deals with the investigation of EMI effects in 555 timer circuit. This work presents evaluation of the EMI effects in 555 timer by applying a range of EMI signals varying from 5MHz-30MHz at constant magnitude of 100mV in series along with the 5Hz/5V original input signal. The EMI effects on the test 555 timer are predicted using ORCAD in terms of total job time, time step and output waveform. All the results compiled in the paper are simulated from the same. For easier understanding Bar graph is shown.**

Keywords: **Electromagnetic Interference, Electromagnetic Wave Propagation, Monostable multivibrator, 555 timer .**

I. INTRODUCTION

Electromagnetic interference also called radio frequency interference (RFI) is a disturbance that affects an electrical circuit due to either electromagnetic conduction or electromagnetic radiation emitted from an external source[1-4]. With the prevalence of Radio Frequency (RF) applications nowadays, such as TVs and radios, amateur radio,wireless \walkie-talkies", cell phones, wireless remote controllers, Blue Tooth communication systems, and so on, the environment is rapidly becoming saturated with electromagnetic waves. They are undesirable since they interfere with the performance of other electrical or electronic devices. For example, it is well known that a cell phone used in close proximity to a computer may cause a distortion of the image on the screen or a static blast from the speakers. Similarly, cell phones may disrupt the delicate flight instrumentation onboard an aircraft and are therefore banned in flight [5-10]. Finally, in a communications / broadcasting context, interference may be manifested in the form of “cross talk", a phenomenon in which the conversations of others are detected when speaking over the cell phone, or may result in the reception of two different radio stations at the same frequency[11-16]. As a result, it is essential that the effects of EMI on common electronic components are thoroughly understood . Accordingly, the present study considers the EMI response of a monostable multivibrator[9]. Several studies related to EMI effects on electronic devices and circuits have been reported in the literature and EMI effects on Passive circuit elements such as resistor and the circuits containing these components have been investigated and analysed by experimental and simulation studies[17-23]. The results of these studies indicate that EMI may cause significant changes and incorrect operation of electronic circuits.

Table 1: EMI SIGNAS USED AT DIFFERENT FREQUENCIES HAVING DIFFERENT AMPLITUDES

Input signal	EMI Signal Frequency range	EMI signal Amplitude
5Hz/5V	5Hz- 100Khz	100mV
5Hz/5V	5Hz- 50Khz	500mV
5Hz/5V	5Hz- 40Khz	1V
5Hz/5V	5Hz- 25Khz	2V
5Hz/5V	5Hz- 25Khz	3V

II. TEST CIRCUIT

555 TIMER IC AS MONOSTABLE MULTIVIBRATOR

The 555 timer is an integrated circuit (chip) implementing a variety of timer and multivibrator applications. The 555 Timer is a monolithic timing circuit that can produce accurate and highly stable time delays or oscillations. A Multivibrator is an electronic circuit used to implement a variety of simple two state systems such as oscillators, timers and flip-flops. The name “multivibrator” was initially applied to free running oscillator version of the circuit because its output waveform was rich in harmonics. A monostable multivibrator is one in which one of the state is stable but the other state is unstable (Transient). A trigger causes the circuit to enter the unstable state, After entering the unstable state, the circuit will return to the stable state after a set time. A monostable multivibrator is pulse generating circuit having one stable state and one quasi stable state. The duration of output pulse is determined by RC network connected externally to the 555 timer. The stable state output is approximately zero or at logic low level. An external trigger pulse forces the output to become high. After predetermined length of time the output automatically switches back to stable state and remains low until the trigger pulse is again applied . The cycle then repeats. That is each time a trigger pulse is applied ,the circuit produces a single pulse. Such a circuit is useful for creating a timing period of fixed duration in response to some external event. This circuit is also known as one shot. In this paper, test circuit is presented on which the EMI effects will be analysed according to configuration shown in Table1 [1]. Fig.1 shows the monostable multivibrator with input signal 5hz/5V and the output waveform of this IC shown in Fig.2.

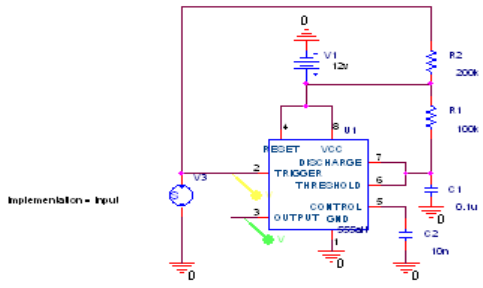


Fig.1: Monostable Multivibrator with 5Hz/5V input signal

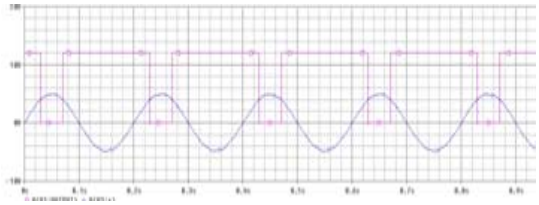


Fig.2: Transient Analysis of Monostable Multivibrator

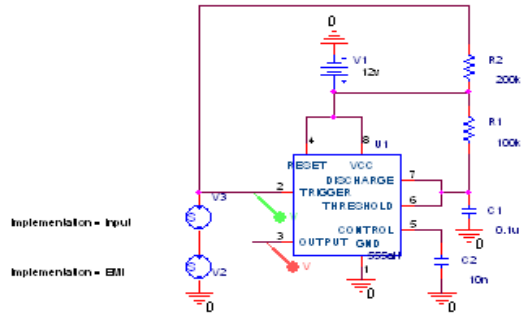


Fig.3: Monostable Multivibrator with 5Hz/5V input signal and 5Hz-100Khz/100mv EMI signal

As shown in Fig.3 EMI signal having frequency range varying from 5Hz-100KHz keeping magnitude constant of 100mV is injected in series with input signal.. As we can see from Fig.4 that as the frequency varies from 5Hz-100Khz /100mV total job time and time step keep on changing. At each frequency output waveform is predicted and if EMI signal Frequency is increased beyond 100Khz the system is highly unstable.

A. EXPERIMENTAL RESULTS

- *EMI EFFECTS WITH EMI SIGNAL AT FREQUENCY 5Hz-100Khz/100mV*

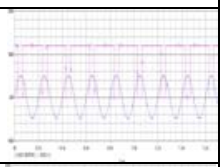
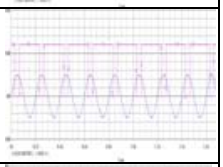
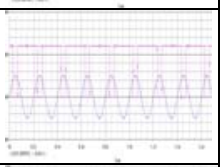
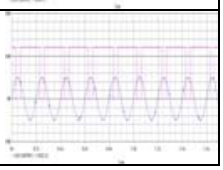
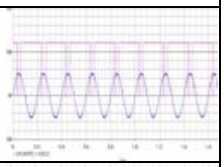
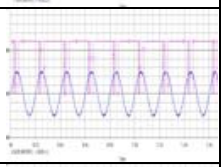
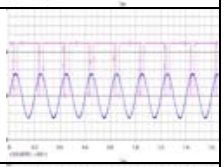
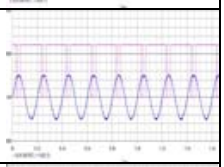
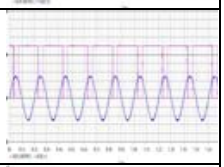
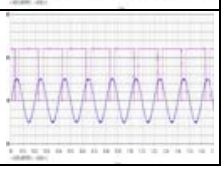
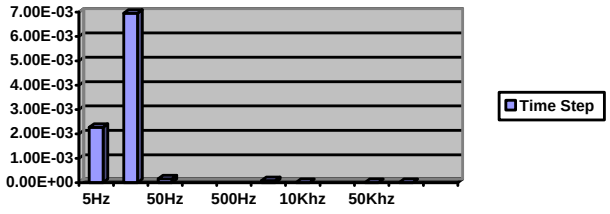
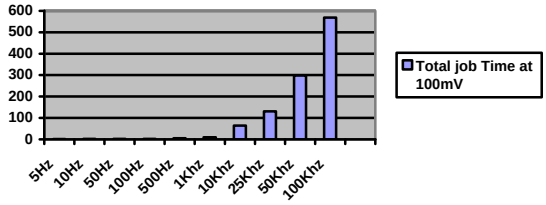
Input Signal	EMI Signal	Time Step	Total Job Time(sec)	Simulation
5Hz/5 V	5Hz/100mV	$2.273e^{-03}$	1.86	
5Hz/5 V	10Hz/100m V	$6.946e^{-03}$	1.89	
5Hz/5 V	50Hz/100m V	$157.6e^{-06}$	2.20	
5Hz/5 V	100Hz/100m V	$267.2\ e^{-06}$	1.94	
5Hz/5 V	500Hz/100m V	$121.6\ e^{-06}$	5.19	
5Hz/5 V	1KHz/100m V	$80.95e^{-06}$	9.45	
5Hz/5 V	10KHz/100 mV	$4.861e^{-06}$	64.03	
5Hz/5 V	25Khz/100m V	$4.971\ e^{-06}$	130.44	
5Hz/5 V	50KHz/100 mV	$1.441e^{-06}$	297.80	
5Hz/5 V	100KHz/100mV	$775.2e^{-9}$	569.02	

Fig.4: Output Waveform of monostable multivibrator at 5Hz- 00Khz/100mV



(a)



(b)

Fig.5(a) ,(b): Bar chart of Time Step and Total job Time of monostable multivibrator at 5Hz-100Khz/100mV

Fig.5 shows that at 10Khz Time Step is Maximum and as the frequency further increases it goes on decreasing while Total job time keep on increasing with the increase in frequency. As

we can see from Figure 6 that as the frequency varies from 5Hz-50Khz/500mV total job time and time step keep on changing. At each frequency output waveform is predicted and if EMI signal Frequency is increased beyond 50Khz the system is highly unstable when amplitude of EMI signal is increased.

B. EXPERIMENTAL RESULTS

- *EMI EFFECTS WITH EMI SIGNAL AT FREQUENCY 5Hz-50Khz/500mV*

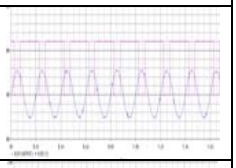
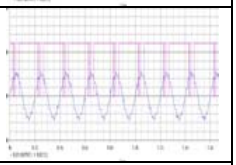
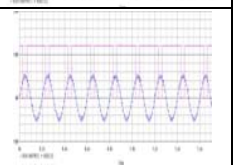
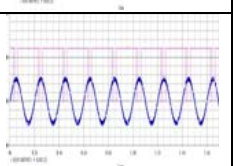
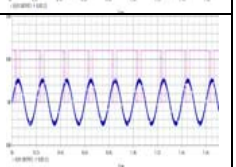
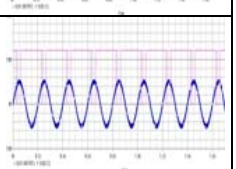
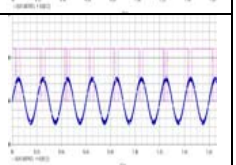
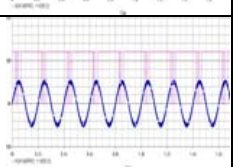
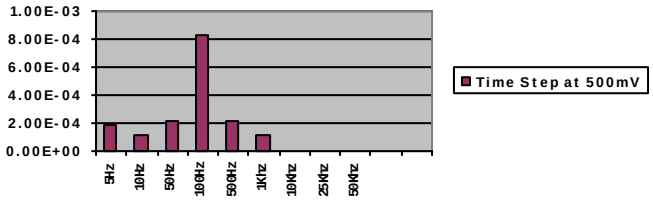
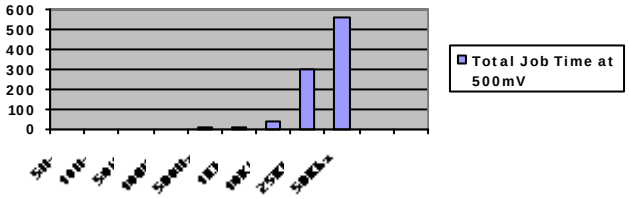
Input Signal	EMI Signal	Time Step	Total Job Time(sec)	Simulation
5Hz/5V	5Hz/500mV	$0.18e^{-03}$	1.56	
5Hz/5V	10Hz/500mV	$0.12e^{-03}$	1.63	
5Hz/5V	50Hz/500mV	$219.2e^{-06}$	3.06	
5Hz/5V	100Hz/500mV	$822.6e^{-06}$	3	
5Hz/5V	500Hz/500mV	$217.8e^{-06}$	9.22	
5Hz/5V	1KHz/500mV	$116.8e^{-06}$	11.42	
5Hz/5V	10KHz/500mV	$1.497e^{-06}$	39.94	
5Hz/5V	25Khz/500mV	$834.9\ e^{-09}$	299.0	
5Hz/5V	50KHz/500mV	$1.204e^{-06}$	559.98	

Fig.6: Output Waveform of monostable multivibrator at 5Hz-50Khz/500mV



(a)



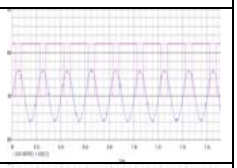
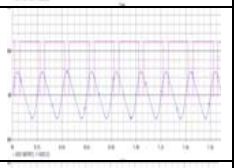
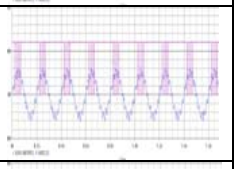
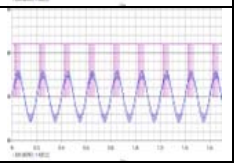
(b)

Fig.7(a), (b): Bar chart of Time Step and Total job Time of monostable multivibrator at 5Hz-50Khz/500mV

As shown in Fig.7 Time step is maximum at 100Hz and as the frequency is increased beyond 100Hz to 50Khz it goes on decreasing while total job time is maximum at 50Khz means monostable multivibrator takes more time at 50Khz to produce an output waveform because EMI effect is maximum at that frequency.

C. EXPERIMENTAL RESULTS

- *EMI EFFECTS WITH EMI SIGNAL AT FREQUENCY 5Hz-40Khz/1V*

Input Signal	EMI Signal	Time Step	Total Job Time(sec)	Simulation
5Hz/5V	5Hz/1V	$9.580e^{-03}$	1.55	
5Hz/5V	10Hz/1V	$9.361e^{-03}$	1.58	
5Hz/5V	50Hz/1V	$1.790e^{-03}$	4.45	
5Hz/5V	100Hz/1V	$290.4e^{-06}$	7.11	

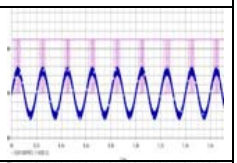
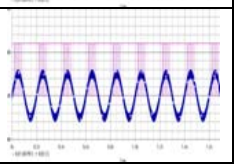
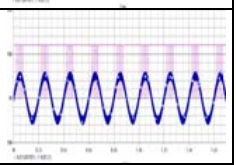
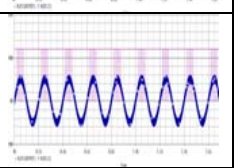
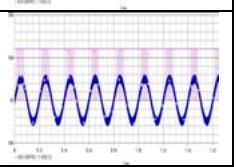
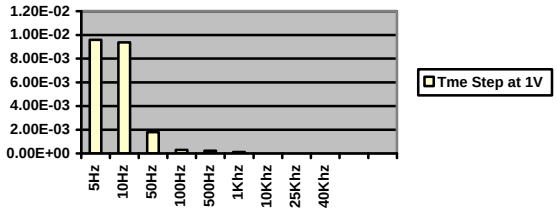
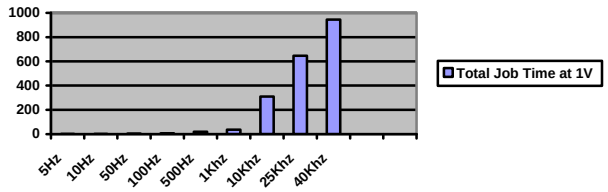
Input Signal	EMI Signal	Time Step	Total Job Time(sec)	Simulation
5Hz/5V	500Hz/ 1V	223.0e^{-06}	20.17	
5Hz/5V	1KHz/ 1V	118.3e^{-06}	36.95	
5Hz/5V	10KHz /1V	1.782e^{-06}	309.0	
5Hz/5V	25Khz/ 1V	1.636 e^{-06}	645.13	
5Hz/5V	40Khz/ 1V	3.000 e^{-06}	944.56	

Fig.8: Output Waveform of monostable multivibrator at 5Hz-40Khz/1V

As we can see from Fig.8 that as the frequency varies from 5Hz- 40Khz/1V total job time and time step keep on changing. At each frequency output waveform is predicted and if EMI signal Frequency is increased beyond 40Khz the system is highly unstable when amplitude of EMI signal is increased. It is clearly shown that beyond 50hz/1V output waveform is highly unstable.



(a)



(b)

Fig.9 (a),(b): Bar chart of Time Step and Total job Time of monostable multivibrator at 5Hz-40Khz/1V

It is clearly shown in Fig.9 that time step is maximum at 5Hz and 10Hz but it goes on decreasing as the frequency is increased beyond 10Hz/1V. Also Total job time starts increasing beyond 1Khz which shows that EMI effect is increasing as we increase frequency from 10Khz-40Khz.

D. EXPERIMENTAL RESULTS

- *EMI EFFECTS WITH EMI SIGNAL AT FREQUENCY 5Hz-25Khz/2V*

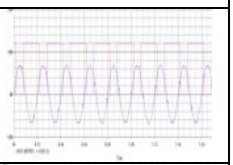
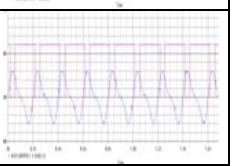
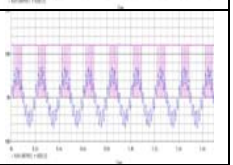
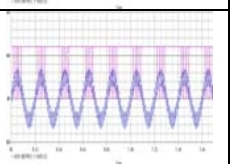
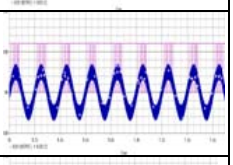
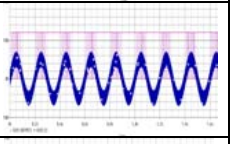
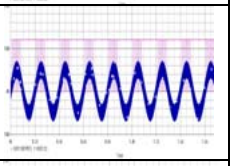
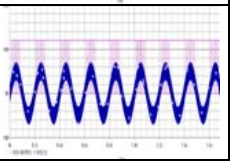
Input Signal	EMI Signal	Time Step	Total Job Time(sec)	Simulation
5Hz/5V	5Hz/2 V	5.184e^{-03}	1.52	
5Hz/5V	10Hz/ 2V	3.463e^{-03}	1.56	
5Hz/5V	50Hz/ 2V	2.335e^{-03}	5.81	
5Hz/5V	100Hz /2V	1.001e^{-03}	7.81	
5Hz/5V	500Hz /2V	155.4e^{-06}	27.25	
5Hz/5V	1KHz/ 2V	44.17e^{-06}	47.88	
5Hz/5V	10KHz/2V	146.3e^{-09}	370.08	
5Hz/5V	25Khz /2V	3.393e^{-16}	805.59	

Fig.10: Output Waveform of monostable multivibrator at 5Hz-25Khz/2V

It is clearly shown in Fig.10 that as the amplitude of EMI signal increases to 2V output waveform beyond 10Hz - 25Khz get distorted. And beyond 25Khz the system becomes very unstable so output cannot be predicted. From fig.11 it is clearly shown that EMI effect is increasing beyond 1Khz in terms of time step and total job time.

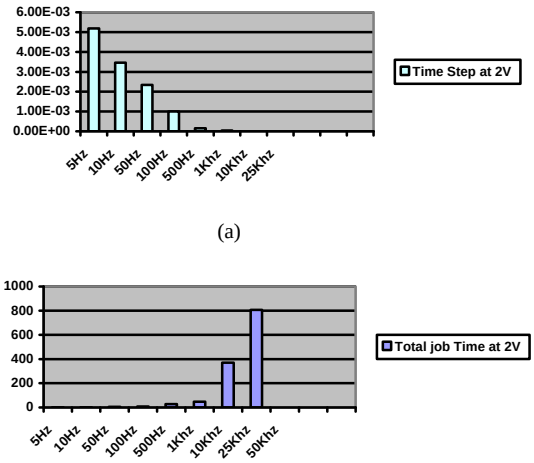


Fig.11(a), (b): Bar chart of Time Step and Total job Time of monostable multivibrator at 5Hz-25Khz/2V

E. EXPERIMENTAL RESULTS

- *EMI EFFECTS WITH EMI SIGNAL AT FREQUENCY 5Hz-25Khz/3V*

Input Signal	EMI Signal	Time Step	Total Job Time(sec)	Simulation
5Hz/5V	5Hz/3V	$2.608e^{-03}$	1.59	
5Hz/5V	10Hz/3V	$4.978e^{-03}$	1.68	
5Hz/5V	50Hz/3V	$2.436e^{-03}$	5.75	
5Hz/5V	100Hz/3V	$1.201e^{-03}$	9.50	
5Hz/5V	500Hz/3V	$182.8e^{-06}$	31.91	
5Hz/5V	1KHz/3V	$22.76e^{-06}$	54.33	
5Hz/5V	10KHz/3V	$2.004e^{-06}$	432.22	
5Hz/5V	25Khz/3V	$1.254e^{-06}$	923.33	

Fig.12: Output Waveform of monostable multivibrator at 5Hz-25Khz/3V

As the amplitude of EMI signal is increased to 3V as shown in fig.12 output waveform is predicted which clearly shows that EMI effect starts at 10Hz. As shown in fig.13 EMI effect is maximum at 10Khz and 25Khz in terms of time step and total job time.

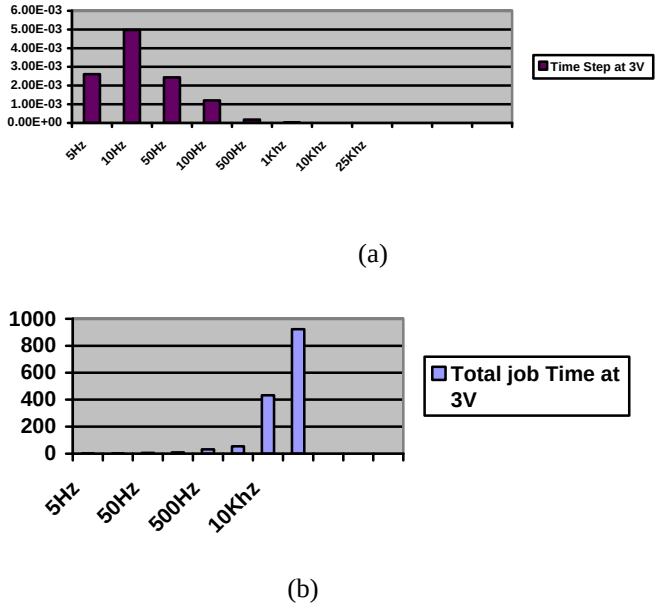
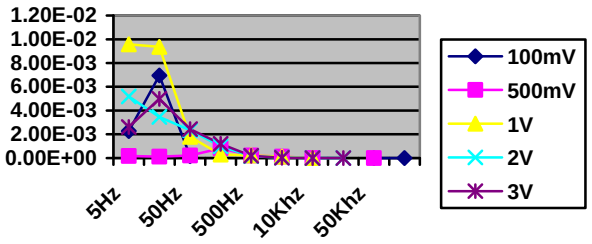


Fig.13(a), (b): Bar chart of Time Step and Total job Time of monostable multivibrator at 5Hz-25Khz/3V

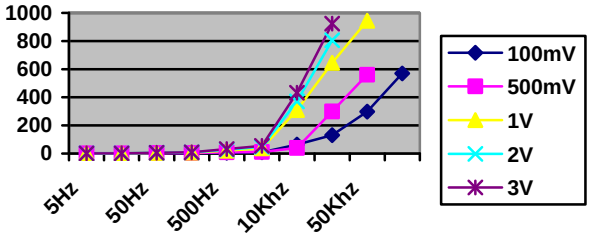
CONCLUSION

In this paper the investigation of EMI effects on monostable multivibrator using 555 timer circuit is analyzed and simulated. A detailed analysis is carried out for EMI signals used at different frequencies keeping amplitude of EMI signal variable and Simulated results show that EMI can cause degradation of multivibrator operation mostly beyond 25Khz/100mV-500mV and 10Khz/1V-3V in terms of total job time and time step. Therefore Output of monostable multivibrator is more degraded when we increase the amplitude of EMI signal. In this paper, it is shown in the output waveforms that monostable multivibrator can work properly under the influence of EMI signal upto 100Khz/100mV, 25Khz/500mV, 100Hz/1V,10Hz/2V,

5Hz/3V. Beyond these frequencies the output waveform is not predicted properly as shown in output waveforms of monostable multivibrator. Also from the Bar charts it is clear that influence of EMI increases beyond 25Khz/100mV-500mV and 10Khz/1V-3V. As it is clearly shown in Fig.14 that as the amplitude of EMI signal reaches at 1V time step and total job time is maximum and EMI effect is maximum at this 1V amplitude where the system enters into highly unstable state.



(a)



(b)

Fig.14(a),(b): Combined Bar chart of Time Step and Total job Time of monostable multivibrator at different amplitudes and different frequencies

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