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Analysis of EMI Effects on 555 Timer

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Abstract

When electromagnetic interference takes place with the input pins of 555 Timer it can cause operation variation. This paper deals with the investigation of EMI effects in 555 timer circuit[2][4]. 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 1KHz/10V original input signal[1]. 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: EMI, 555 Timer circuit.

Introduction

Electromagnetic interference (or EMI, also called radio frequency interference or RFI) is a disturbance that affects an electrical circuit due to either electromagnetic conduction or electromagnetic radiation emitted from an external source. The disturbance may interrupt, obstruct, or otherwise degrade or limit the effective performance of the circuit. The source may be any object, artificial or natural, that carries rapidly changing electrical currents, such as an electrical circuit, the Sun .The fundamental concept of electrical and electromagnetic interference involves an emanating source and an affected device or system. The transfer of energy between systems can occur through radiation, conduction, or induction. The actual transfer of energy is facilitated respectively through a transmission path, conductive path, or

through magnetic coupling. The interference that affects wireless communication links is typically the result of radiated or conductive energy transfer. The condition of a conductive affect occurs when the signal is picked-up by a conductor attached to the affected system. 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[5][6][7]. The results of these studies indicate that EMI may cause significant changes and incorrect operation of electronic circuits[3].

In this paper, we focused at EMI effects on 555 Timer circuit. The EMI effects on the 555 Timer IC are investigated with the utilization of simulator ORCAD, with interesting results.

Table 1: EMI Signas Used at Different Frequencies

Input signal	EMI Signal Frequency range	EMI signal Amplitude
1Khz/10V	300Hz- 5Mhz	10V
1Khz/10V	300Hz-50Mhz	100mV

Table 2 : EMI Signas Used at Different Amplitude

Input signal	EMI Signal Frequency	EMI signal Amplitude range
1Khz/10V	5Mhz	100mV-10V
1Khz/10V	15Mhz	100mV-2V
1khz/10V	30Mhz	100mV-1V

Test Circuit

555 Timer IC

555 TimerThe 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.

The 555 Timer used in the oscillating circuit has applications that include precision timing, pulse generation, sequential timing, time delay generation and pulse width modulation (PWM). These are functions that are essential in the design. The 555 Timer used in the oscillating circuit has applications that include precision timing, pulse generation, sequential timing, time delay generation and pulse width modulation (PWM). These are functions that are essential in the design.

In this paper, test circuit is presented on which the EMI effects will be analysed according to configuration shown in Table 1 and Table 2. Fig. 1 shows the 555 Timer IC with input signal 1Khz/10V and the output waveform of this IC shown in Fig. 2.

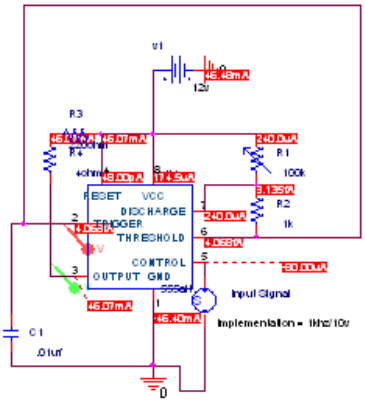


Figure 1: 555 Timer circuit with 1Khz/10V input signal

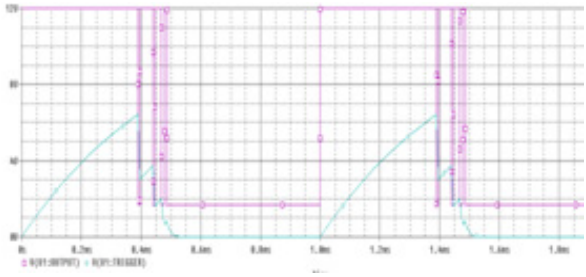


Figure 2: Transient Analysis of 555 Timer IC

555 Timer IC with EMI Signal

In Fig. 3 EMI signal is injected in series with input signal and applied between Pin 5 (control voltage) and Pin 1(ground).

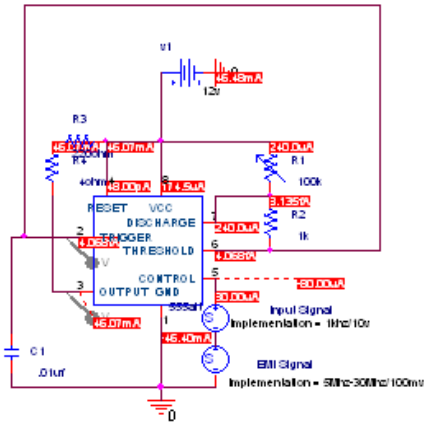
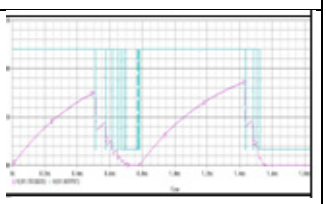
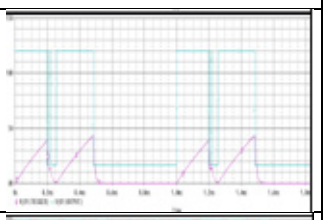
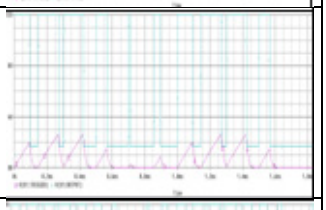
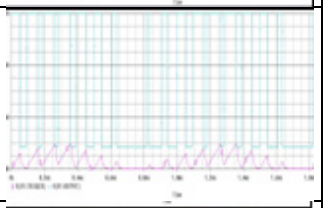
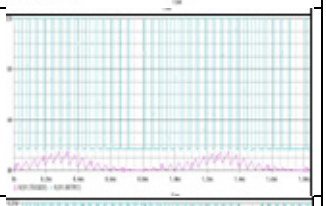
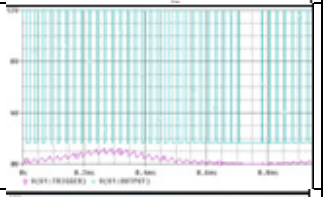
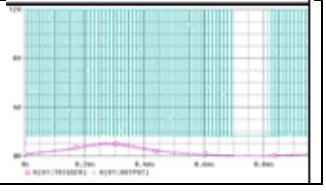


Figure 3: 555Timer circuit with 1Khz/10V input Signal and 5Mhz-30Mhz/100mv EMI signal.

Experimental Results

EMI Effects with EMI Signal at Frequency 300Hz- 5Mhz/10V

Input Signa	EMI Signal	Time Ste	Total Job Tim (sec)	Power Dissipatio	Simulation
1KHz/10V	300Hz/10V	$6.202e^{-06}$	2.09	$5.58e^{-01}$ watt	
1KHz/10V	3KHz /10V	$106.5e^{-09}$	1.27	$5.58e^{-01}$ watt	
1KHz/10V	6KHz /10V	$32.32e^{-09}$	1.70	$5.58e^{-01}$ watt	
1KHz/10V	10KHz/10V	$1.581e^{-06}$	2.61	$5.58e^{-01}$ watt	
1KHz/10V	20KHz/10V	$6.067e^{-06}$	5.73	$5.58e^{-01}$ watt	
1KHz/10V	40KHz/10V	$3.079e^{-06}$	10.72	$5.58e^{-01}$ watt	
1KHz/10V	80KHz/10V	$320.8e^{-09}$	20.06	$5.58e^{-01}$ watt	

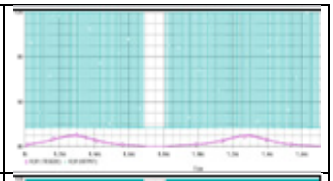
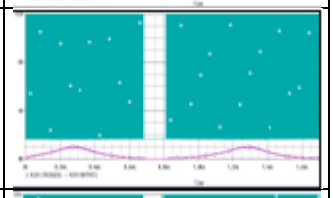
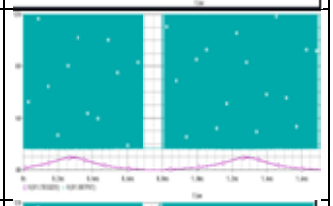
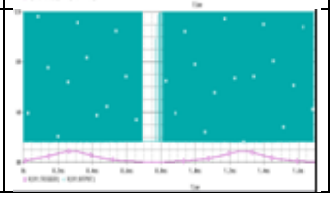
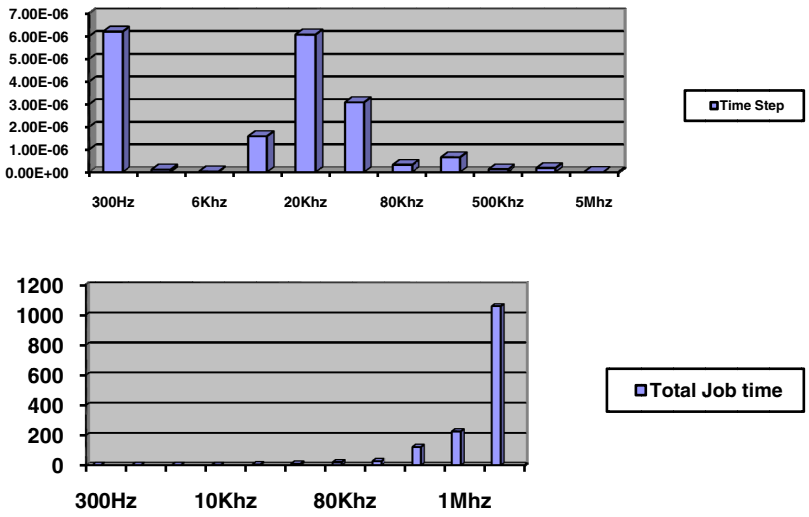
1KHz/10V	100KHz/10V	653.8e^{-09}	27.70	5.58e^{-01} watt	
1KHz/10V	500KHz/10V	178.9e^{-09}	121.31	5.58e^{-01} watt	
1KHz/10V	1MHz /10V	125.7e^{-09}	224.70	5.58e^{-01} watt	
1KHz/10V	5MHz /10V	425.4e^{-12}	1055.19	5.58e^{-01} watt	

Figure 4: Output Waveform of 555 Timer

A range of EMI signals varying from 300Hz-5MHz is applied keeping magnitude constant of 10V. As we can see from fig.4 that as the frequency varies from 300hz to 5Mhz total job time and time step keep on changing but power dissipation is constant for all frequencies. At each frequency output waveform is predicted and if EMI signal Frequency is increased beyond 5Mhz the system is highly unstable.



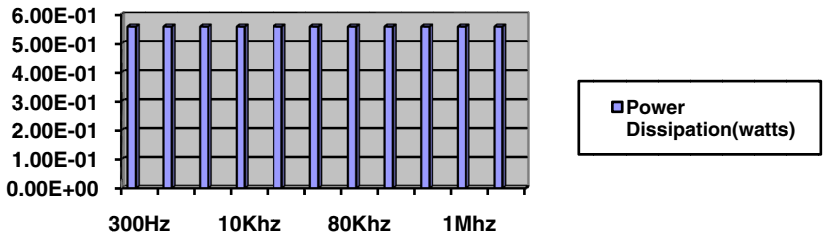
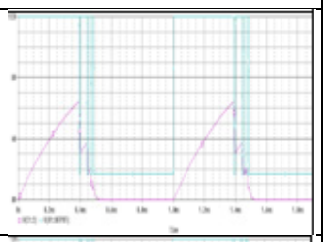
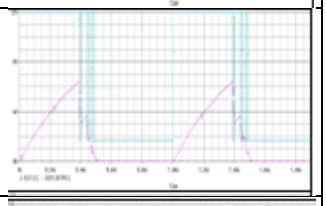
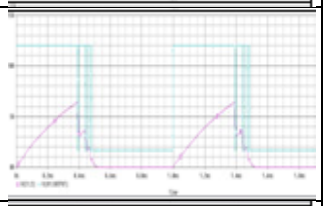
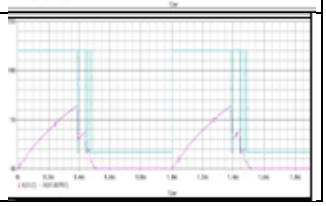
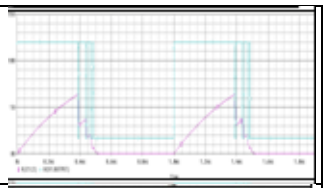
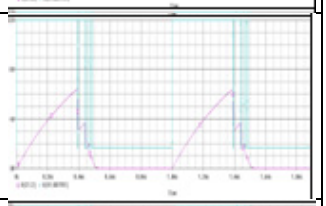
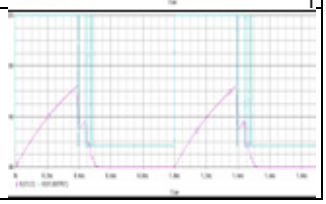


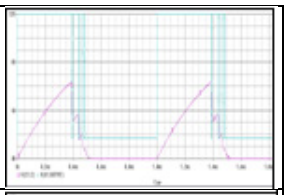
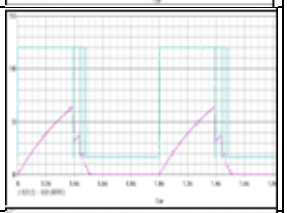
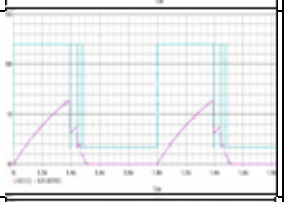
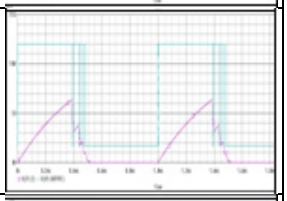
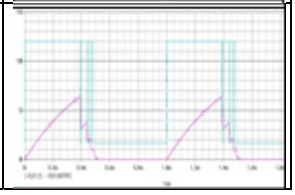
Figure 5: Bar Chart Of Time step ,Total job Time and Power Dissipation Of 555 Timer

As shown in Figure 5 at 300hz and 20khz time step is maximum and after this time step is decreasing .On the other hand Total job time is increasing with the increase in frequency and at 5Mhz total job time in seconds is maximum.

EMI Effects with EMI Signal at Frequency 300Hz- 5Mhz/100mV

Input Signal	**EMI Signal**	**Time Step**	**Total Job Time (sec)**	**Power Dissip-ation**	**Simulation**
1KHz/10V	300Hz/100mv	$23.19e^{-06}$	1.50	$5.58e^{-01}$ watt	
1KHz/10V	3KHz/100mv	$484.4e^{-09}$	1.47	$5.58e^{-01}$ watt	
1KHz/10V	6KHz/100mv	$228.4e^{-09}$	1.30	$5.58e^{-01}$ watt	
1KHz/10V	10KHz/100mv	$625.4e^{-09}$	1.50	$5.58e^{-01}$ watt	

1KHz/10V	20KHz/100mv	$267.0e^{-09}$	1.24	$5.58e^{-01}$ watt	
1KHz/10V	40KHz/100mv	$208.4e^{-09}$	1.84	$5.58e^{-01}$ watt	
1KHz/10V	80KHz/100mv	$315.2e^{-09}$	1.59	$5.58e^{-01}$ watt	

1KHz/10V	100KHz/100mv	$229.3e^{-09}$	1.64	$5.58e^{-01}$ watt	
1KHz/10V	500KHz/100mv	$103.0e^{-09}$	4.94	$5.58e^{-01}$ watt	
1KHz/10V	1MHz/100mv	$120.8e^{-09}$	8.86	$5.58e^{-01}$ watt	
1KHz/10V	5MHz/100mv	$20.48e^{-09}$	39.86	$5.58e^{-01}$ watt	
1KHz/10V	30MHz/100mv	$645.2e^{-12}$	208.77	$5.58e^{-01}$ watt	

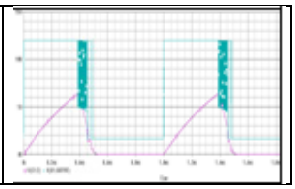
1KHz/10V	50Mhz/100mv	$1.875e^{-09}$	634.49	$5.58e^{-01}$ watt	

Figure 6: output Waveform of 555 Timer

Here a range of EMI signals varying from 300Hz-50MHz is applied keeping magnitude constant of 100mV. As we can see from figure 5 that as the frequency varies from 300hz to 50Mhz total job time and time step keep on changing but power dissipation is constant for all frequencies . At each frequency output waveform is predicted and if EMI signal Frequency is increased beyond 50Mhz the system is highly unstable. It is clear from fig 6 that EMI effect is maximum at 50Mhz frequency.

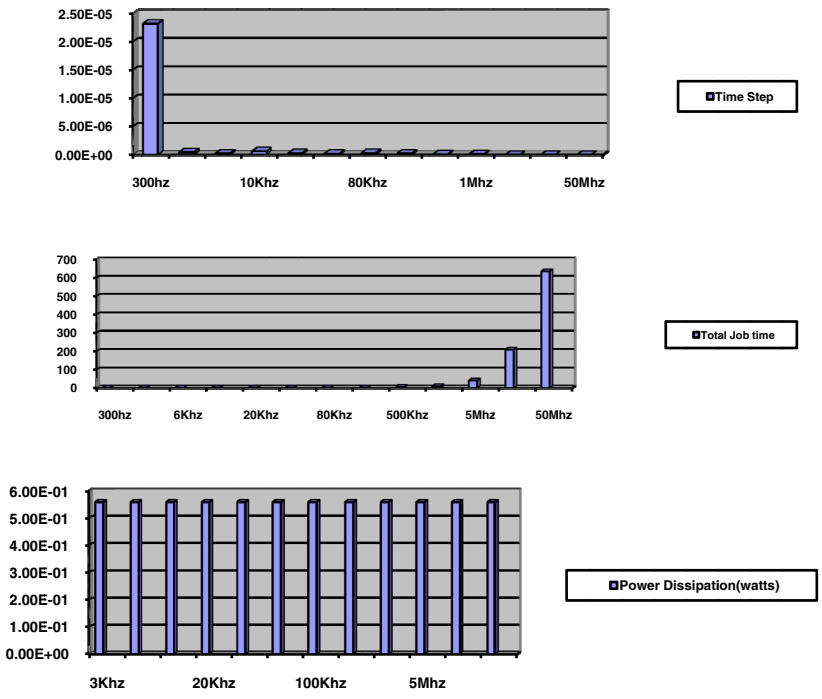


Figure 7: Bar chart of Time step, Total Job Time and Power Dissipation of 555 Timer Circuit

As shown in Figure7 at 300hz time step is maximum and after this time step is negligible .On the other hand Total job time is increasing with the increase in frequency and at 50Mhz total job time in seconds is maximum.

EMI Effects with EMI Signal at Frequency 5Mhz/100mV-10V

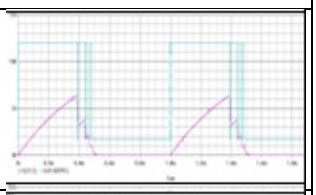
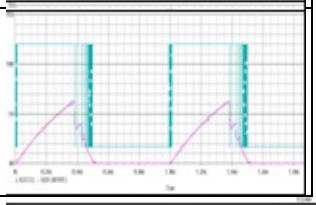
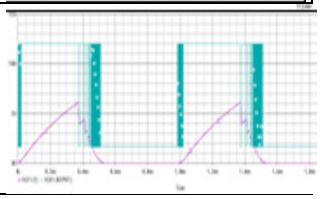
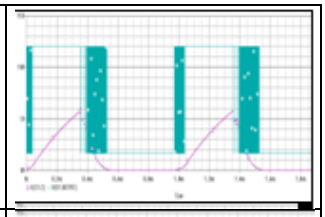
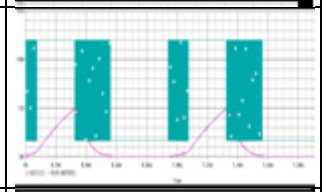
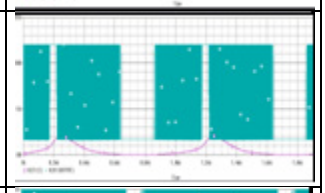
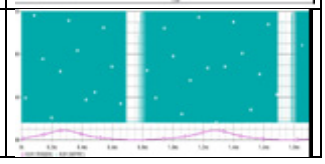
Input Signa	EMI Signal	Time Ste	Total Job Tim (sec)	Power Dissipa-tio	Simulation
1KHz/10V	5Mhz/100mv	$20.48e^{-09}$	39.86	$5.58e^{-01}$ watt	
1KHz/10V	5Mhz/500mv	$19.65e^{-09}$	93.91	$5.58e^{-01}$ watt	
1KHz/10V	5Mhz/1V	$21.28e^{-09}$	166.59	$5.58e^{-01}$ watt	
1KHz/10V	5Mhz/2V	$12.77e^{-09}$	296.22	$5.58e^{-01}$ watt	
1KHz/10V	5Mhz/4V	$8.822e^{-09}$	534.55	$5.58e^{-01}$ watt	
1KHz/10V	5Mhz/8V	$16.79e^{-09}$	849.17	$5.58e^{-01}$ watt	
1KHz/10V	5Mhz/10V	$425.4e^{-12}$	1055.19	$5.58e^{-01}$ watt	

Figure 8: Output Waveform of 555 Timer

It is clear from the previous results that the effect of EMI is Maximum between 5Mhz-30Mhz range of frequencies. Now EMI signal of 5Mhz is applied and the

magnitude varying from range of 100mV-10V.The effect of EMI is studied at different amplitudes keeping EMI signal frequency constant at 5Mhz. As we can see from figure 8 that as the amplitude varies from 100mV to 10V at constant frequency, total job time is not changing fastly and time step keep on increasing linearly but power dissipation is constant for all frequencies . At each frequency output waveform is predicted and if EMI signal amplitude is increased beyond 10V the system is highly unstable.

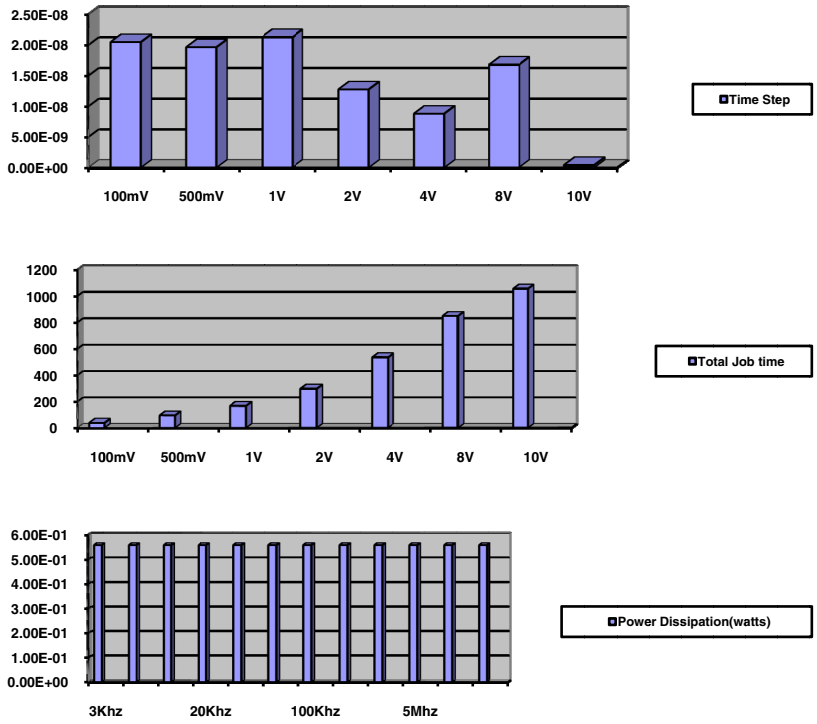
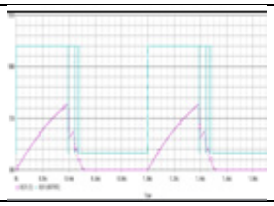


Figure 9: Bar chart of Time step, total job time and power dissipation of 555 Timer Circuit

EMI Effects with EMI Signal at Frequency 15Mhz/100mV-2V

Input Signal	EMI Signal	Time Step	Total Job Time (sec)	Power Dissipation	Simulation
1KHz/10 V	15Mhz/100 mv	205.5 e^{-12}	103.3 4	5.58e^{-01} watt	

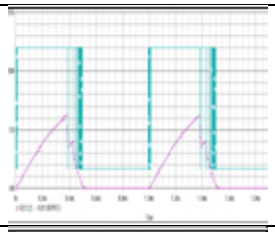
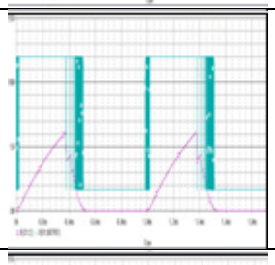
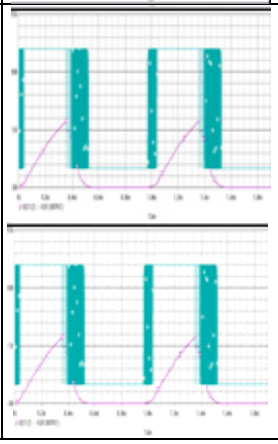
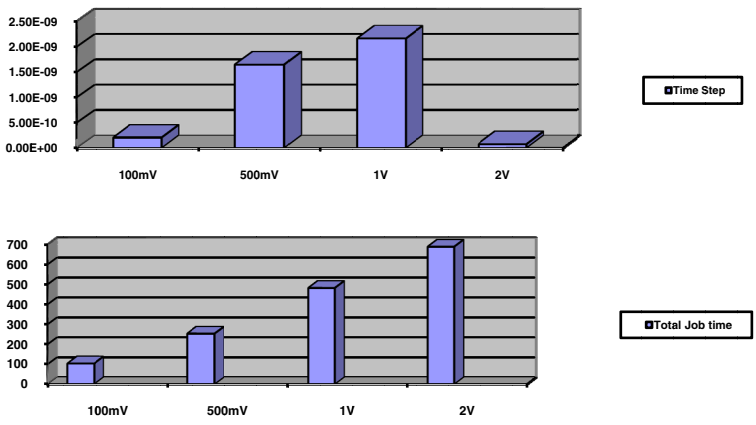
1KHz/10 V	15Mhz/500 mv	1.647 e^{-09}	253.5 3	5.58e^{-01} watt	
1KHz/10 V	15Mhz/1V	2.162 e^{-09}	482.5 0	5.58e^{-01} watt	
1KHz/10 V	15Mhz/2V	74.95 e^{-12}	689.1 1	5.58e^{-01} watt	

Figure 10: output Waveform of 555 Timer

When the EMI signal frequency is 15Mhz and amplitude is varying from 100mV-2V, the output waveforms are predicted and Time step, total job time are calculated as shown in fig.10.



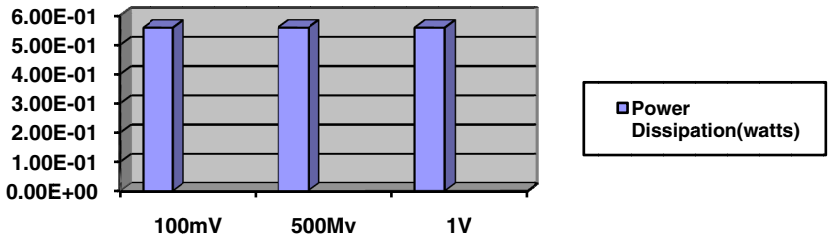
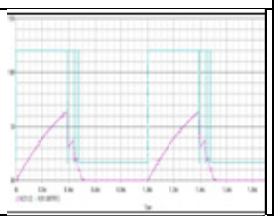
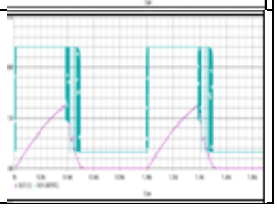


Figure11: Bar Chart Of Time step, Total job time and Power Dissipation Of 555 timer Circuit

It is clear from fig 11 that time step has small change between 500mV to 1V of amplitude and at 2V time step is very small means frequency is very high i.e. EMI effect is more at 2V because total job time is maximum at 2V. It is linearly increasing. If the amplitude of EMI signal is increased beyond 2V at 15Mhz frequency the system becomes highly unstable.

EMI Effects with EMI Signal at Frequency 30Mhz/100mV-1V

When EMI signal frequency increased to 30Mhz and amplitude is varying from 100mV to 1V time step and total job time are calculated as shown in figure 12 .Power Dissipation is constant here also. It is shown in the figure 13 Total job time and time step are linearly increasing. If amplitude of EMI signal increases beyond 1V for 30Mhz EMI signal frequency the system becomes highly unstable.

Input Signal	EMI Signal	Time Step	Total Job Time (sec)	Power Dissipation	Simulation
1KHz/10V	30Mhz/100mv	$645.2e^{-12}$	208.77	$5.58e^{-01}$ watt	
1KHz/10V	30Mhz/500mv	$1.192e^{-09}$	510.55	$5.58e^{-01}$ watt	

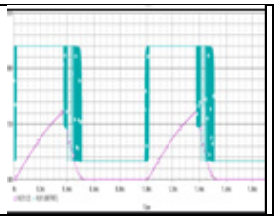
1KHz/10V	30Mhz/1V	$2.19e^{-09}$	867.28	$5.58e^{-01}$ watt	

Figure 12: output waveform of 555 Timer

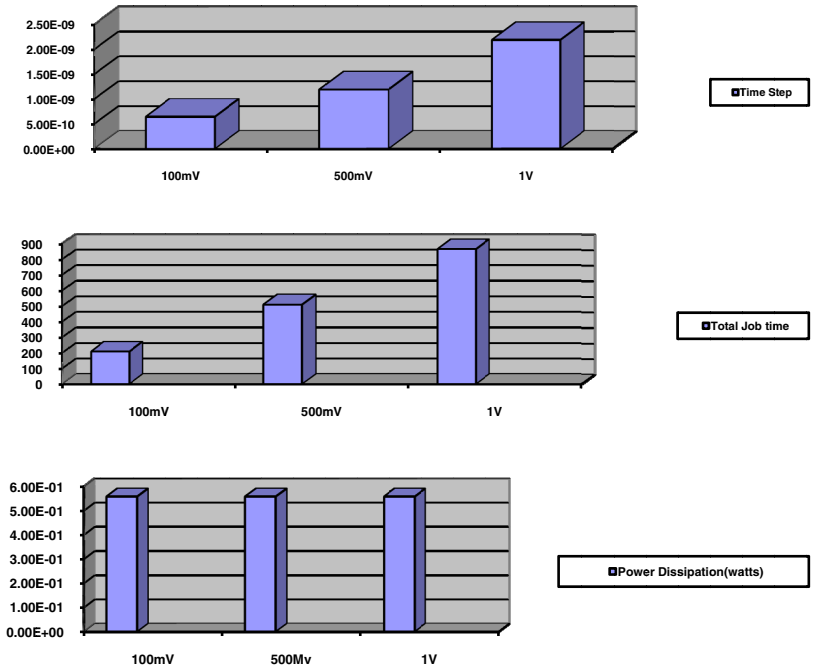


Figure 13: Bar Chart Of Time step, Total job time and Power Dissipation Of 555 timer Circuit.

Conclusion

In this paper the investigation of EMI effects on 555 timer circuit is analyzed and simulated. A detailed analysis is carried out for EMI signals used at different frequencies and Simulated results show that EMI can cause degradation of 555 timer operation mostly at 500Khz-5Mhz/10V and Beyond 30Mhz/100mV. When EMI signals used at different amplitudes then EMI can cause degradation of 555 timer operation mostly at 5Mhz/500mV-10V, 15Mhz/500mV-2V, 30Mhz/1V. So from simulation results it is concluded that EMI can cause degradation of 555 timer operation mostly when the magnitude of EMI signal is raised beyond 500mV and the frequency range is beyond 5Mhz .

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