Practical Implementation and Analysis of EMI Effects on Transistor as an Amplifier circuit in CE & CB configurations

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Abstract: When electromagnetic interference takes place with the input pins of transistor working as an amplifier in Common emitter and Common Base Configurations, it can cause operation variation when practically implemented[9]. This paper deals with the investigation of EMI effects in amplifier circuit using different configurations[2][4]. This work presents evaluation of the EMI effects in transistor as an amplifier circuit by applying a range of EMI signals varying from 3KHz-30MHz with constant magnitude of 10V in series with input signal of 6Khz/10V. The EMI effects on the test circuit 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. The work presented shows the maximum range of EMI signals that a circuit can withstand and a range is also defined in which the circuit output is unaffected from EMI signal.
Keywords: EMI, Transistor as an amplifier, Common Emitter and Common Base Configuration.

1. INTRODUCTION

The basic 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 basic circuit of transistor as an amplifier in CE and CB configurations.. The EMI effects 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
6KHz/10V	3KHz- 30Mhz	10V

2. TEST CIRCIT
Transistor as an amplifier using CE configuration
A **common emitter** amplifier is one of three basic single-stage bipolar-junction-transistor amplifier, which provides medium input and output impedance levels, typically used as a voltage amplifier. In this circuit the base terminal of the transistor serves as the input, the collector is the output, and the emitter is *common* to both (for example, it may be tied to ground reference or a power supply.)
In this paper, test circuit is presented on which the EMI effects will be analysed according to configuration shown in Table 1. The circuit of amplifier without EMI signal using CE configuration is shown in Fig. 1and the output waveform of this circuit is shown in Fig. 2.
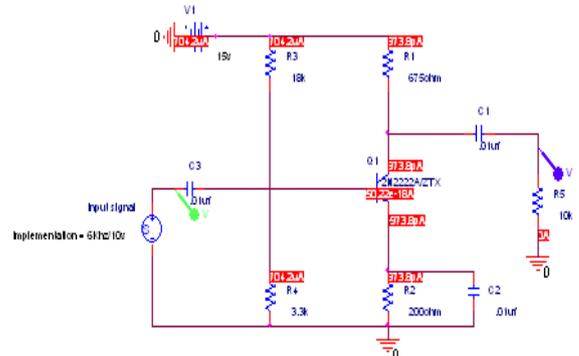

Figure 1: CE amplifier without EMI signal and input signal 6Khz/10V
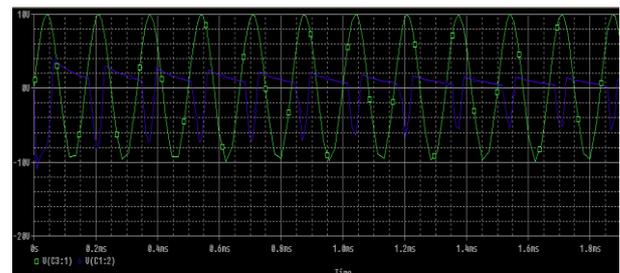

Figure 2: Transient Analysis of CE amplifier without EMI Signal

Fig. 3 shows amplifier circuit   with EMI signal in CE configuration is shown in Fig. 1and the output waveform of this circuit is shown in Fig. 4.
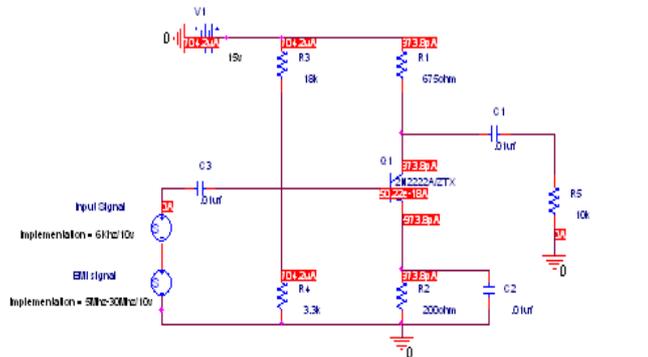
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Figure 3: CE amplifier with EMI signal from 3KHz-30MHz/10V and input signal 6Khz/10V

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As shown in Fig 4, the output waveform is much affected when EMI signal is applied along with the input as compared to the output shown in Fig. 2 when there no EMI signal present.
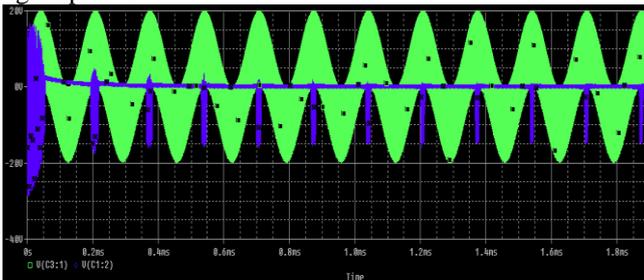

Figure4: Transient Analysis of CE amplifier with EMI Signal

3. EXPERIMENTAL RESULTS

In Fig. 3 EMI signal is injected in series with input signal and applied between base and emitter of transistor. The simulation results are shown at different frequencies of EMI signal in Fig 5.

- **EMI EFFECTS WITH EMI SIGNAL AT FREQUENCY 30KHz- 30Mhz/10V**

Input Signal	EMI Signal	Time Step	Total Job Time (sec)	Power Dissipation	Simulation
6KHz/10V	3kHz	16.23e-06	0.24	1.06 e-02w	
6KHz/10V	10KHz	6.496e-06	0.30	1.06 e-02w	
6KHz/10V	20KHz	6.160e-06	0.33	1.06 e-02w	
6KHz/10V	40KHz	3.113e-06	0.38	1.06 e-02w	
6KHz/10V	80KHz	1.167e-06	0.30	1.06 e-02w	
6KHz/10V	100KHz	824.7e-09	0.34	1.06 e-02w	
6KHz/10V	500KHz	105.4e-09	1.31	1.06 e-02w	
6KHz/10V	1MHz	103.0e-09	2.20	1.06 e-02w	
6KHz/10V	5MHz	18.97e-09	10.95	1.06 e-02w	
6KHz/10V	30MHz	3.307e-09	69.09	1.06 e-02w	

Figure 5: Output Waveform of CE configuration type transistor as an amplifier

A range of EMI signals varying from 3KHz-30MHz is applied keeping magnitude constant of 10V. As we can see from fig.4 that as the frequency varies from 3KHz to 30Mhz 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 30Mhz the system is highly unstable.

4. TEST CIRCIT

Transistor as an amplifier using CB configuration

A **common base** amplifier is one of three basic single-stage bipolar-junction-transistor amplifier,   provides   low input impedance and offering a high output impedance. In this circuit the emitter terminal of the transistor serves as the input, the collector is the output, and the base is *common* to both (for example, it may be tied to ground reference or a power supply.)

In this paper, test circuit is presented on which the EMI effects will be analysed according to configuration shown

in Table 1. The circuit of amplifier without EMI signal using CB configuration is shown in Fig. 6 and the output waveform of this circuit is shown in Fig. 7
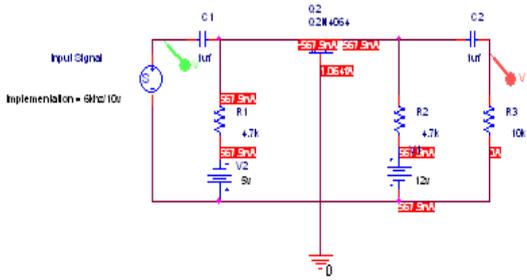

Figure 6: CB amplifier without EMI signal and input signal 6Khz/10V

Figure 7: Transient Analysis of CB amplifier without EMI Signal

Fig. 8 shows amplifier circuit with EMI signal in CB configuration and the output waveform of this circuit is shown in Fig. 9.
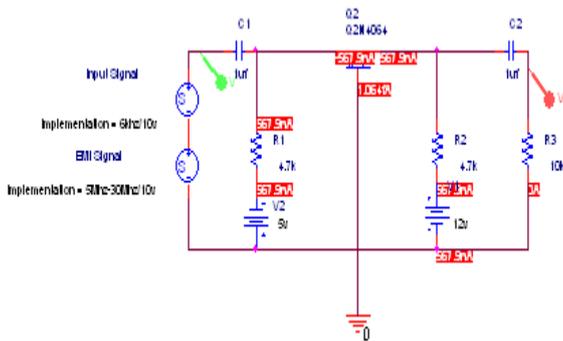

Figure 8: CB amplifier with EMI signal from 3KHz-30MHz/10V and input signal 6Khz/10V
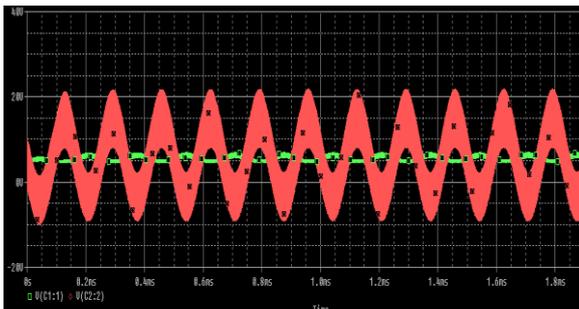

Figure 9: Transient Analysis of CB amplifier with EMI Signal

As shown in Fig 9, the output waveform is much affected when EMI signal is applied along with the input as compared to the output shown in Fig. 7 when there no EMI signal present

5. EXPERIMENTAL RESULTS

In Fig. 8 EMI signal is injected in series with input signal and applied between base and emitter of transistor. The simulation results are shown at different frequencies of EMI signal in Fig 10.

- **EMI EFFECTS WITH EMI SIGNAL AT FREQUENCY 3KHz- 30Mhz/100mV**

Input Signal	EMI Signal	Time Step	Total Job Time (sec)	Power Dissip-ation	Simulation
6KHz/10V	3kHz	12.76 e^{-06}	0.24	9.65 e^{-06}w	
6KHz/10V	10KHz	3.775 e^{-06}	0.19	9.65 e^{-06}w	
6KHz/10V	20KHz	3.230 e^{-06}	0.25	9.65 e^{-06}w	
6KHz/10V	40KHz	788.6 e^{-09}	0.16	9.65 e^{-06}w	
6KHz/10V	80KHz	429.4 e^{-09}	0.41	9.65 e^{-06}w	
6KHz/10V	100KHz	1.118 e^{-06}	0.55	9.65 e^{-06}w	
6KHz/10V	60.10e^{-09}	1.16	9.65 e^{-06}w	60.10e^{-09}	

6KHz/10V	1MHz	107.5e^{-09}	2.00	9.65e^{-06}w	
6KHz/10V	5MHz	10.39e^{-09}	8.63	9.65e^{-06}w	

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6KHz /10V	30M Hz	2.4 27e^{-09}	62.4 2	9.65e^{-06}w

Figure 10: Output Waveform of CB configuration type transistor as an amplifier

A range of EMI signals varying from 3KHz-30MHz is applied keeping magnitude constant of 10V. As we can see from fig.9 that as the frequency varies from 3KHz to 30Mhz 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 30Mhz the system has improved output response as shown in Fig. 10.

6. COMPARISION OF CE AND CB CONFIGURATION OF TRANSISTOR AS AN AMPLIFIER

Based on various factors like time step, Total Job Time and Power Dissipation, the common base and common emitter configurations are compared. The bar graphs of all factors is shown separately for both configurations to visualize the circuit which is more affected in the presence of EMI signal.

TABLE 2: COMPARISION OF CE AND CB AMPLIFIERS BASED ON VARIOUS FACTORS

Input Signal	EMI Signal	Amplifiers					
		CB Amplifier			CE Amplifier		
		Time Step	Total Job time	Power Dissipation	Time Step	Total Job time	Power Dissipation
6KHz/ 10V	3KHz	12.76 e^{-06}	0.24	9.65e^{-06}w	16.23 e^{-06}	0.24	1.06e^{-02}w
6KHz/ 10V	10KHz	3.775 e^{-06}	0.19	9.65e^{-06}w	6.496 e^{-06}	0.30	1.06e^{-02}w
6KHz/ 10V	20KHz	3.230 e^{-06}	0.25	9.65e^{-06}w	6.160 e^{-06}	0.33	1.06e^{-02}w
6KHz/ 10V	40KHz	788.6 e^{-09}	0.16	9.65e^{-06}w	3.113 e^{-06}	0.38	1.06e^{-02}w
6KHz/ 10V	80KHz	429.4 e^{-09}	0.41	9.65e^{-06}w	1.167 e^{-06}	0.30	1.06e^{-02}w
6KHz/ 10V	100KHz	1.118 e^{-06}	0.55	9.65e^{-06}w	824.7 e^{-09}	0.34	1.06e^{-02}w
6KHz/ 10V	500KHz	60.10 e^{-09}	1.16	9.65e^{-06}w	105.4 e^{-09}	1.31	1.06e^{-02}w
6KHz/ 10V	1MHz	107.5 e^{-09}	2.00	9.65e^{-06}w	103.0 e^{-09}	2.20	1.06e^{-02}w
6KHz/ 10V	5MHz	10.39 e^{-09}	8.63	9.65e^{-06}w	18.97 e^{-09}	10.95	1.06e^{-02}w

6KHz/ 10V	30MHz	2.427 e^{-09}	62.42	9.65e^{-06}w	3.307 e^{-09}	69.09	1.06e^{-02}w

Fig11. Shows the bar chart of time step for both configurations and shows that time step of CE amplifier is higher than CB amplifier from 3KHz-80Khz and becomes equal above 100KHz.
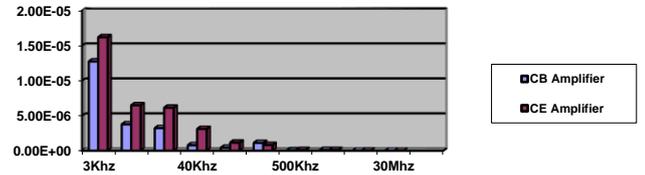

Figure11. Bar Chart Of Time step Of CE and CB configuration amplifiers

Fig.12 shows the total job time response of both CE and CB configurations which presents that total time taken by the circuit to simulate is more for CE configuration than CB configuration. Total Job Time of CE and CB amplifier is constant for the range 3KHz-100KHz and increased beyond 500KHz.
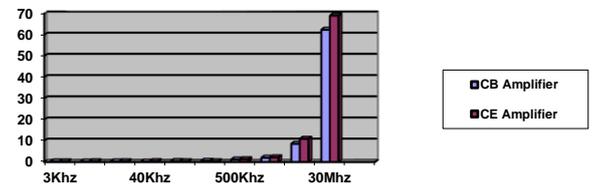

Figure12. Bar Chart Of Total Job Time Of CE and CB configuration amplifiers

Power dissipation graph is shown in Fig.13 which is constant of Both CE and CB configurations for the frequency range 3KHz-30MHz.
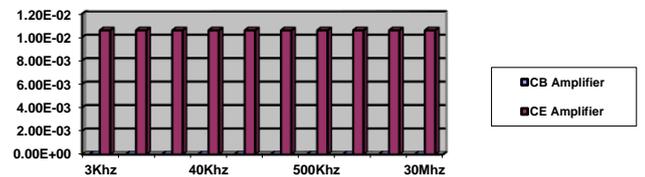

Figure13. Bar Chart Of Power Dissipation Of CE and CB configuration amplifiers

Power dissipation graph is shown in Fig.12 which is constant of Both CE and CB configurations for the frequency range 3KHz-30MHz.

CONCLUSION

In this paper the investigation of EMI effects on Transistor as amplifier circuit using two configurations like common base and common emitter is being 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 operation mostly at 80Khz-30Mhz/10V for both configurations (CE and CB) of

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transistor an amplifier. But this degradation decreases beyond 10MHz-30Mhz for CB configuration only and output has less effect of EMI signal as shown in Fig 10. So from simulation results it is concluded that EMI can cause degradation of transistor circuit operation mostly when the frequency range raised beyond 80KHz/10V and has no effect of EMI on amplifier circuit below 10 V.

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