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CMOS Compound Pair Wide Band Bio-Amplifier

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ABSTRACT:
In the present paper we study about CMOS compound pair (RKTG Pair) circuit with proper choice of inductor as additional circuit element. The proposed circuit work for very low input voltage signal like pulse rate of heart beat with higher gain wide band frequency response. The proposed circuit shows excellent temperature stability in the temperature range -50, 27 and 100 ˚C. We have also study about input voltage gain, output voltage gain, Fast Fourier Transform, current gain, input admittance, input impedance, output impedance and voltage gain at various frequencies for inductor range 10H to 10nH and it is found that proposed circuit works as Bio amplifier with the help of Bio-medical sensor for suitable value of inductor.

KEYWORDS: *CMOS compound Pair, Frequency response, Input Impedance, Output Impedance, temperature stability, voltage gain, current gain.*

I. INTRODUCTION

In the present time cardiac arrhythmia, disorder of cardiac rhythm, may cause serious heart diseases or the person can be dying. Early diagnosis of cardiac arrhythmia and choose appropriate medical treatment in daily life prevent from disorder of cardiac rhythm. Therefore, there is a maximum demand of a portable Electrocardiogram (ECG) monitoring system. In general, an ECG acquisition system consists of Bio-medical sensor, transducer, amplifier, filter, ADC and DSP. Fig.1 shows a block diagram of analog front-end Bio-medical Instrument. The analog front-end circuit is the interface between physical signal and digital processor and several methods for arrhythmia detection have been developed. In order to accurately process the ECG data for exact arrhythmia detection, required high quality signal. In the portable devices, it is most important for the analog front-end Bio-medical instrument to operate with small-size implementation while providing proper signal conditioning and low-power dissipation [1, 2].

Biosensor investigated by Arnold & Mayerhoff in 1998. The Biosensor is self contained analytical devices that incorporate a Biological recognition element combined with an artificial transducer [3]. Biosensor senses the heartbeat in the form of mechanical energy. Transducer converts it in electrical energy or electrical signal. Then amplifier amplify signal and filter is use for filtrate the signal then signal precede to ADC and DSP.

The amplifiers find wide applications, particularly in a system that require a low power supply voltage in biomedical system, communication system and instrumentation system. Complementary metal–oxide–semiconductor (CMOS) uses complementary and symmetrical pairs of p-type and n-type metal oxide semiconductor field effect transistors (MOSFETs) for logic functions. Literature survey [4-11] shows that CMOS devices have high noise immunity and low static power consumption because CMOS devices do not produce as much waste heat as other forms of logic families, like transistor–transistor logic (TTL) or NMOS logic. So in present investigation we use CMOS compound pair (also known as RKTG Pair) model that works for low voltage and high speed application having high current gain with good temperature stability as compare to reference devices [12]. All the simulation result has been obtained by PSPICE OrCAD 9.2 student version [13].

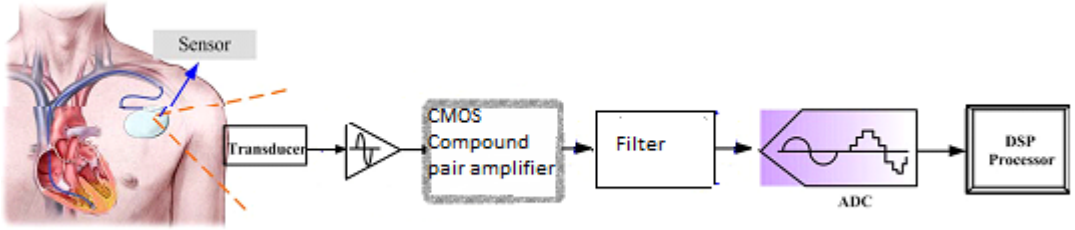

Fig.1 Block diagram of analog front-end Bio-medical Instrument.

II. EXPERIMENTAL CIRCUITS

The reference CMOS compound pair amplifier circuit shown in the Fig.2 have been simulated having an a.c. input signal V1=1nVac and 0Vdc, Ci=1µf, Ri=500Ω, R1=47kΩ, R2=5KΩ, Rd=10kΩ, Rs=2kΩ Rl=10kΩ, Vd=5Vdc, Cs=10µf, Co=10µf and the CMOS as combination of M1=M2=MbreakP and M3=M4=MbreakN is used as an active component to design the circuit.

Proposed CMOS compound pair bio-amplifier circuit shown in the Fig.3, an inductor (Dl) is connected in series drain resistance and remainning all components are same as in Fig.2.

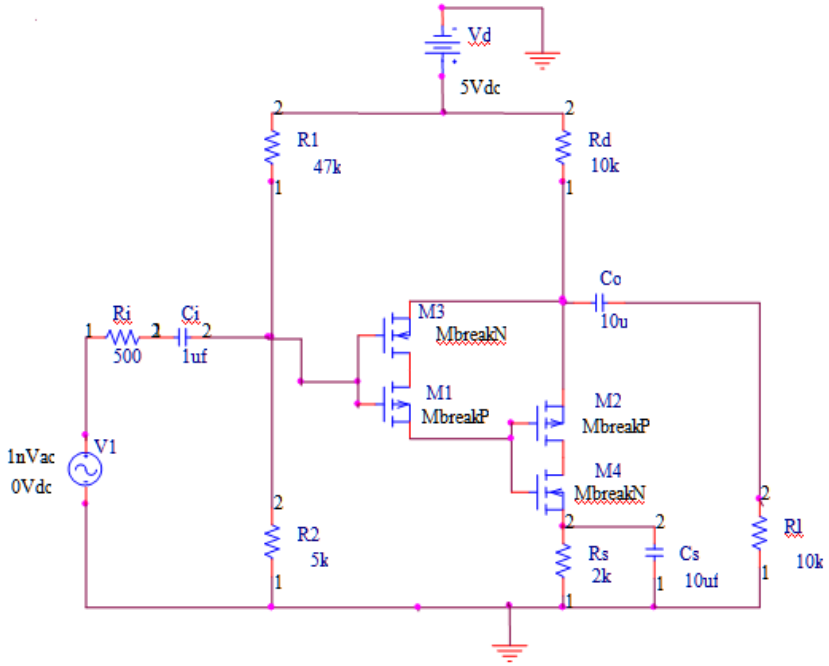

Fig.2 CMOS compound Pair (RKTG Pair) reference circuit.

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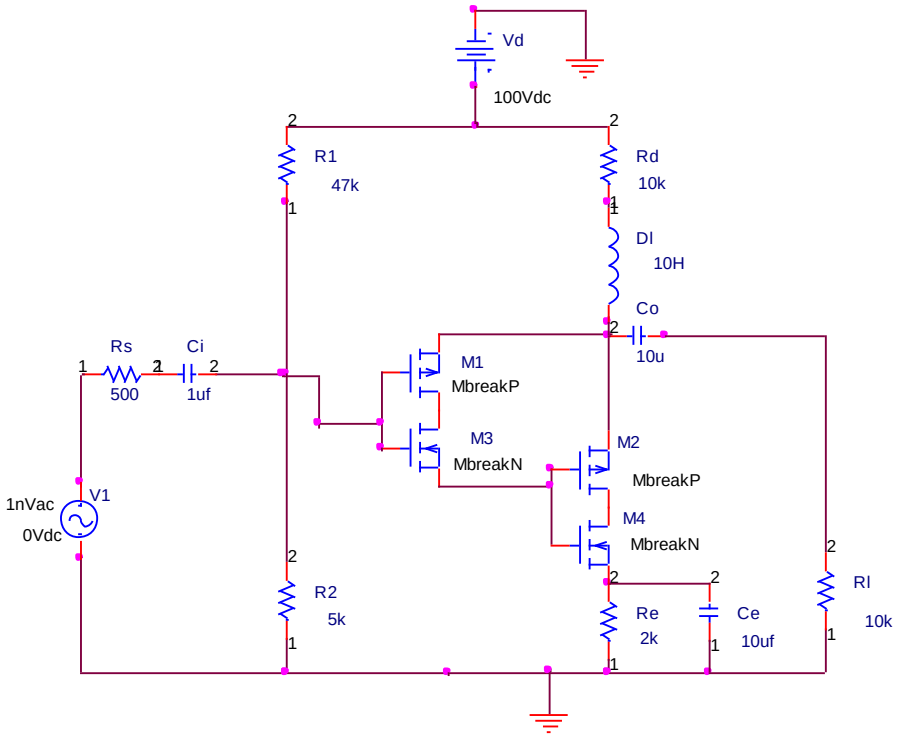

Fig. 3 CMOS compound pair (RKTG Pair) with inductor (Proposed circuit).

III. RESULTS AND DISCUSSIONS

Proposed CMOS compound pair Bio-amplifier circuit provides high voltage gain as compared to reference circuit as shown in fig.4. The Fast Fourier Transform of fig.4 is shown in fig.5. The Fast Fourier Transform curve is instantly varied at 0s then straight line which is shows the circuit is stable. Fig.6 shows excellent temperature stability curve between -50 to 100℃. Fig.7 shows that the current gain of reference and proposed circuits The current gain of CMOS compound Pair amplifier circuit is shown by symbol (□) and green line, the current gain of CMOS compound pair Bio-amplifier circuit shown by symbol (◊) and red line in fig.7. Current gain of proposed circuit initially high after 1 KHz frequency becomes low while current gain of reference circuit is constant. Fig. 8 shows input Admittance of reference and proposed circuit. The input Admittance of proposed circuit is higher than reference circuit. Fig. 9 shows input impedance, input impedance of the proposed CMOS compound pair Bio-amplifier circuit is lower as compare to reference CMOS compound pair amplifier circuit. Fig.10 shows output impedance of CMOS compound pair Bio-amplifier circuit and CMOS compound pair amplifier. The output impedance of both circuits is initially low after 1THz increase the output impedance of the proposed circuit. Fig.11 shows variation of voltage gain with frequency for the value of inductance from 10nH to 10H. It is found that the value of voltage gain shifted from high frequency range to low frequency range with the value of inductance 10nH to 10H respectively. The important outcome of the present study is that one can use proposed new CMOS compound pair Bio-amplifier circuit for very high (Terahertz reason) frequency as well as for very low frequency with proper choice of inductance. Table1 shows voltage gain of proposed CMOS compound pair Bio-amplifier at various values of Inductor at output capacitor 10µf.

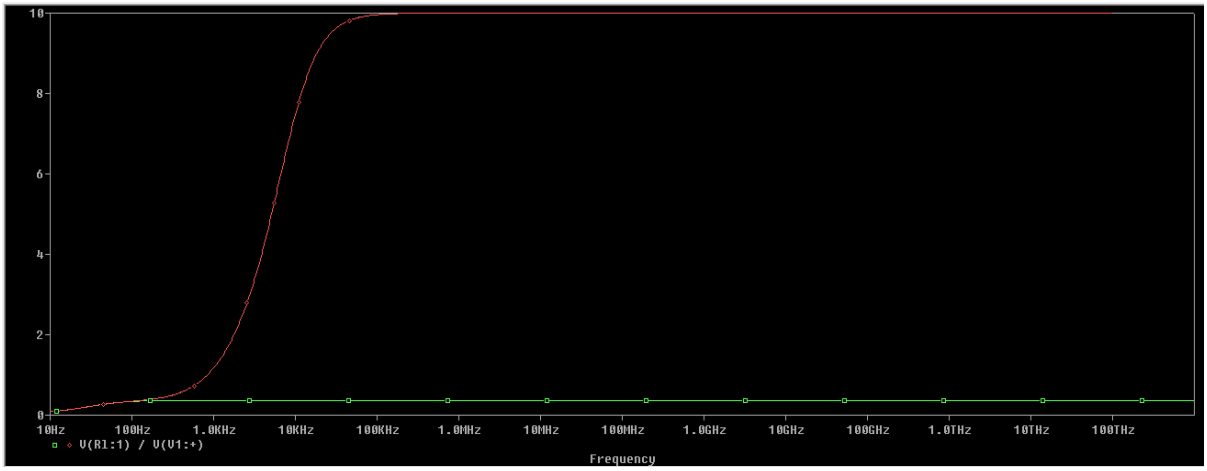

Fig.4 Frequency response of CMOS compound pair (RKTG Pair) and CMOS compound pair (RKTG Pair) with inductor.

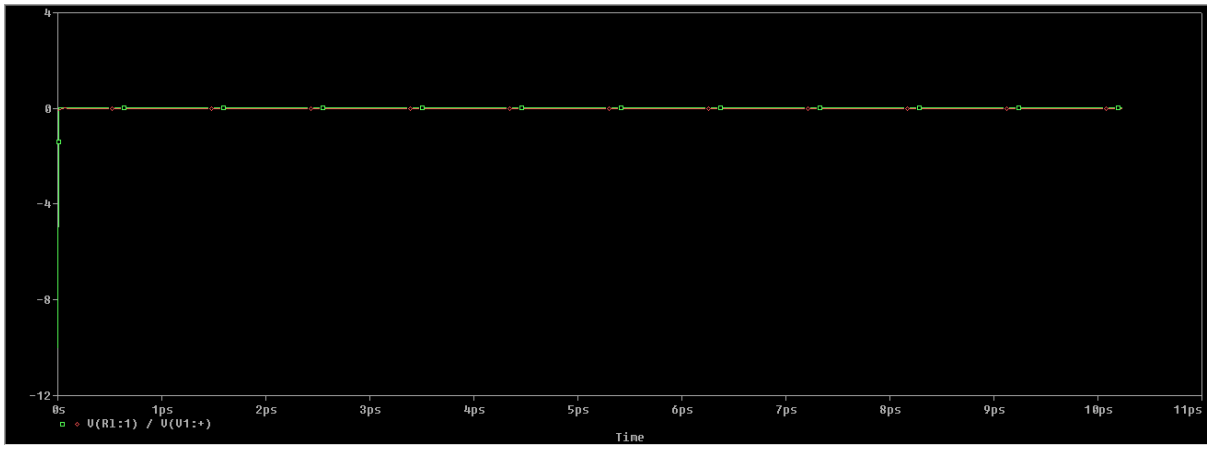

Fig.5 Fast Fourier Transform of CMOS compound pair (RKTG Pair) and CMOS compound pair (RKTG Pair) with inductor.

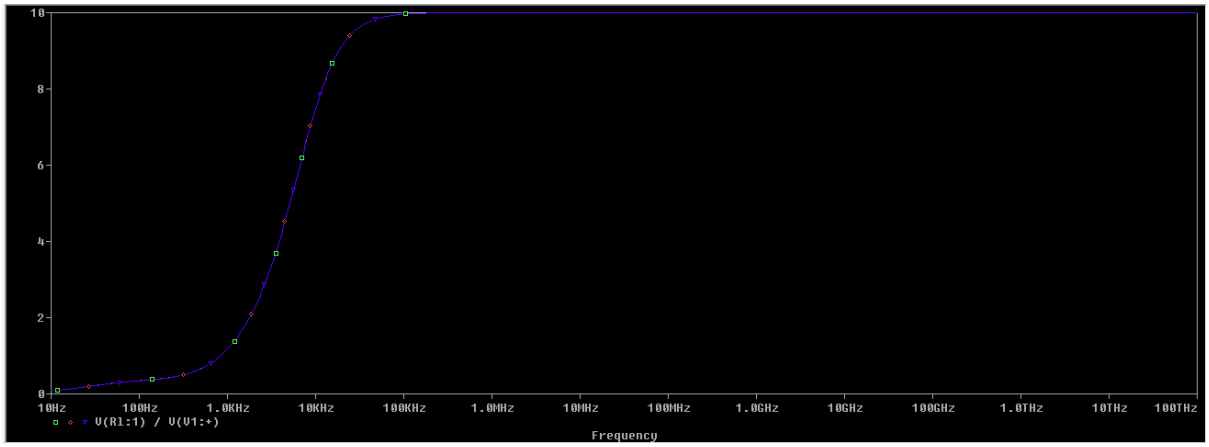

Fig.6 Frequency response of CMOS compound pair (RKTG Pair) with inductor at -50, 27 and 100℃.

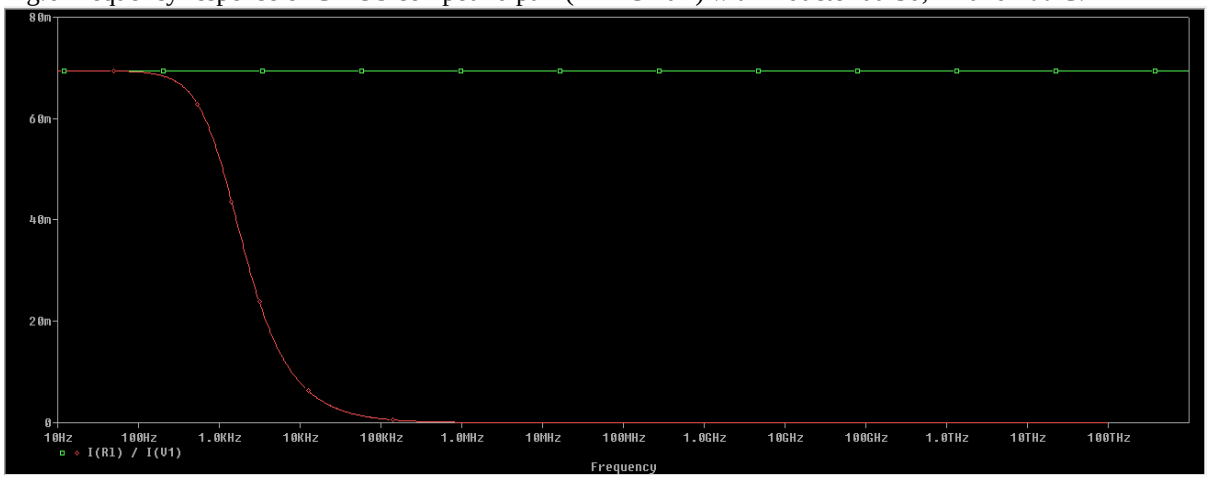

Fig.7 Current gain of CMOS compound pair (RKTG Pair) and CMOS compound pair (RKTG Pair) with inductor.

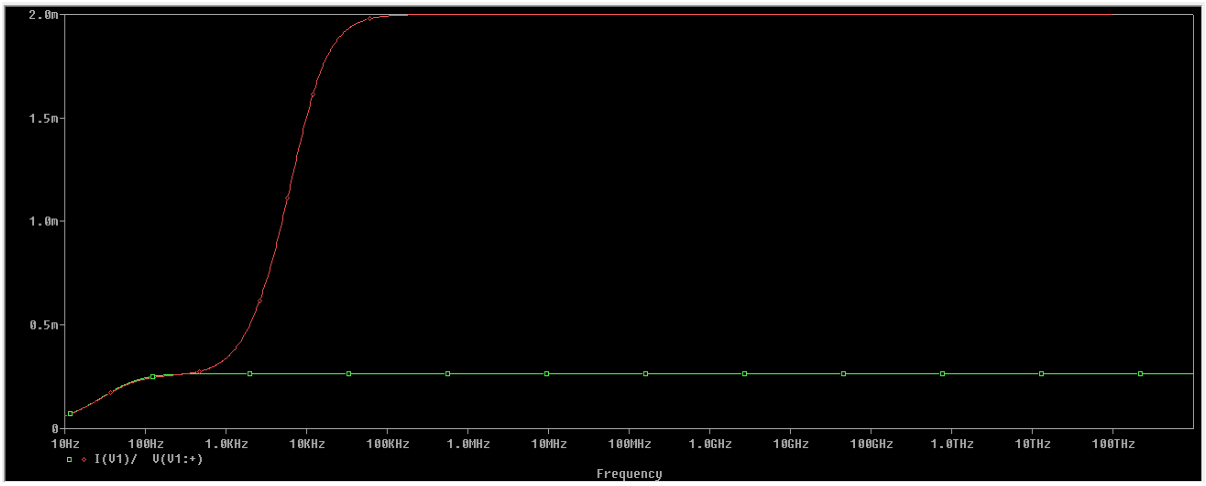

Fig.8 Input admittance of CMOS compound pair (RKTG Pair) and CMOS compound pair (RKTG Pair) with inductor.

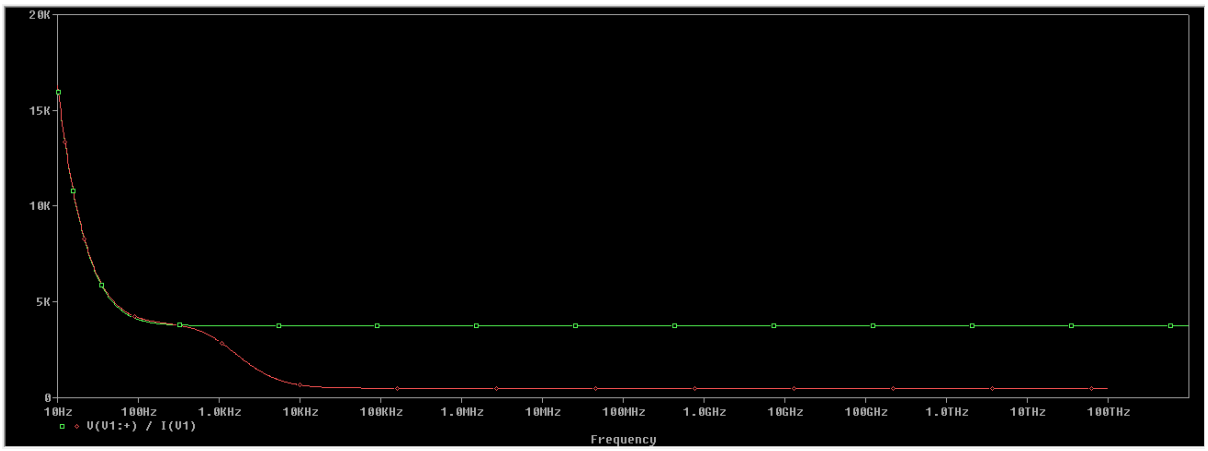

Fig.9 Input impedance of CMOS compound pair(RKTG Pair) and CMOS compound pair (RKTG Pair) with inductor.

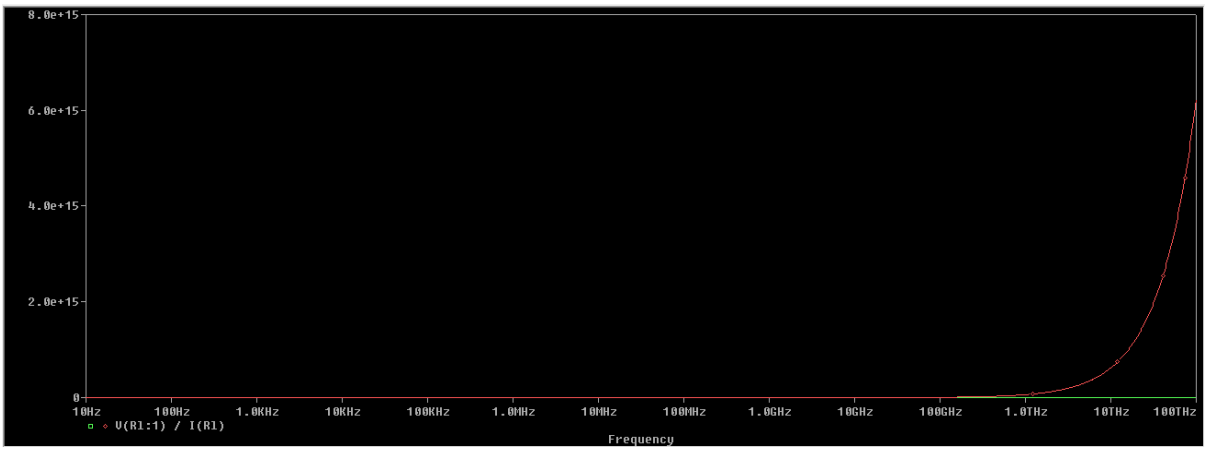

Fig.10 Output impedance of CMOS compound pair (RKTG Pair) and CMOS compound pair(RKTG Pair) with inductor.

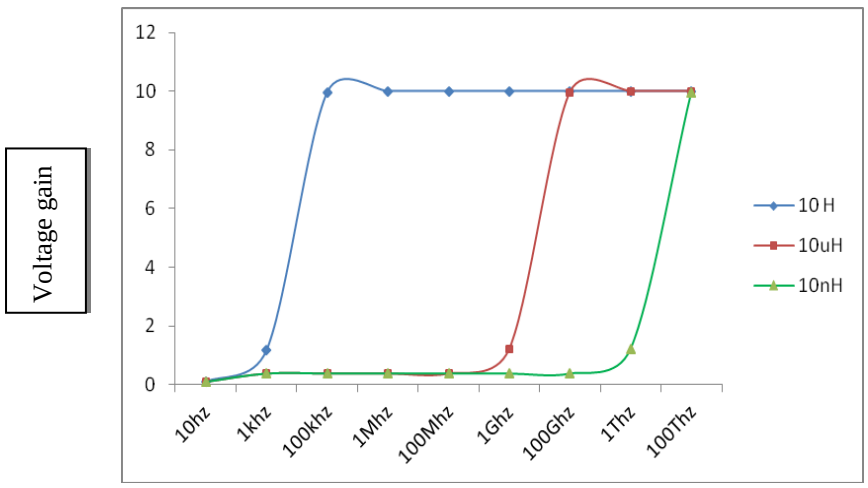

Fig.11 voltage gain of proposed circuit with various value of inductor at Co=10µf.

4. Tables

L	10hz	1khz	100khz	1Mhz	100Mhz	1Ghz	100Ghz	1Thz	100Thz
10 H	0.085	1.17	9.961	10	10	10	10	10	10
10uH	0.085	0.368	0.368	0.369	0.369	1.206	9.96	10	10
10nH	0.085	0.368	0.368	0.368	0.368	0.368	0.368	1.208	9.96

Table1 Voltage gain at various values of Inductor.

IV. CONCLUSION

From above discussion it is concluded that the proper choice of the circuit element play an important role to make CMOS compound pair(RKTG Pair) Bio-amplifier with inductor more flexible and versatile. Due to high voltage gain proposed circuit can be used as voltage amplifier for low voltage and high frequency applications. As the proposed CMOS compound pair (RKTG Pair) Bio-amplifier circuit is working at 1nVac, so together with Bio-medical sensor at the input terminal it can be use to design new portable Bio-medical instruments like ECG etc. That is capable of sensing extremely low level heart pulses. Present proposed CMOS Compound pair (RKTG Pair) amplifier can be also used to design low voltage high speed reversible logic devices. Due to its property of low power dissipation, such devices are capable to design reversible quantum computing electronic devices. This is demand of coming future reversible technology.

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