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IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF PENNSYLVANIA

Bala IC, Inc. 118 Cornell Road Bala Cynwyd, PA 19004 Plaintiff, v. Integrated Device Technology, Inc. 6024 Silver Creek Valley Road San Jose, California 95138 Defendant.	:	Civil Action No. 11 7403 COMPLAINT JURY TRIAL DEMANDED

Plaintiff, Bala IC, Inc., brings this Complaint against Defendant, Integrated Device Technology, Inc., for claims arising under the Patent Laws of the United States as is set forth below:

SUBJECT MATTER JURISDICTION

1. As the claims alleged herein arise under the Patent Laws of the United States, in particular, 35 U.S.C. §§ 271-287, this Court has exclusive subject matter jurisdiction over this action under 28 U.S.C. § 1338(a).

PERSONAL JURISDICTION

2. As is set forth more fully in what follows herein, this Court has personal jurisdiction over Integrated Device Technology by virtue of its contacts with the Commonwealth of Pennsylvania, which includes, among other things, having a sales office located in the Eastern District of Pennsylvania and conducting business

on a continuing basis within this district. Said sales office is located at 820 Adams Ave. Suite 100, Norristown, Pennsylvania 19403.

VENUE

3. Venue is proper in this district under 28 U.S.C. §§ 1391 (b-c) and 1400(b).

DEMAND FOR JURY TRIAL

4. Pursuant to Federal Rule of Civil Procedure 38, Plaintiff demands a trial by jury of any and all issues so triable.

PARTIES

5. Plaintiff, Bala IC, Inc. ("Plaintiff" or "Bala"), is a corporation organized and existing under the laws of the Commonwealth of Pennsylvania with its offices located at the above address.

6. On information and belief, Defendant, Integrated Device Technology, Inc. ("Defendant" or "Integrated Device Technology"), is a corporation organized and existing under the laws of Delaware, with its corporate headquarters at 6024 Silver Creek Valley Road, San Jose, California 95138.

BACKGROUND FACTS

7. On August 31, 1993, U.S. Patent No. 5,241,286 (the "286 Patent") was duly and legally issued by the U.S. Patent and Trademark Office to Fred Mirow, inventor.

8. A true and correct copy of the 286 Patent as issued is annexed hereto as Exhibit 1 hereof and incorporated by reference herein just as if such were once again fully set out herein.

9. The 286 Patent is titled "FET Oscillator using voltage and temperature compensated amplifier".

10. The 286 Patent is presumed valid pursuant to 35 U.S.C. § 282.

11. On June 9, 2005, Fred Mirow assigned all right, title, and interest in the 286 Patent to Bala IC, Inc.

12. Said assignment of all right, title, and interest in the 286 Patent to Bala IC, Inc. was duly recorded at the United States Patent and Trademark Office.

COUNT 1: PATENT INFRINGEMENT BY INTEGRATED DEVICE TECHNOLOGY

13. Plaintiff re-alleges and incorporates by reference herein all of the preceding paragraphs just as if such were fully set forth again herein.

14. Defendant Integrated Device Technology has actual notice of the 286 Patent.

15. Defendant Integrated Device Technology has been infringing one or more claims of the 286 Patent by making, using, selling, offering for sale, and/or contributing to or inducing the making, use, sale or offer for sale by others, products that fall within the scope of one or more of the claims of the 286 Patent, including, but not limited to, Oscillators such as Integrated Device Technology's Monolithic Clock Synthesizer.

16. Defendant Integrated Device Technology has been indirectly infringing one or more claims of the 286 Patent by contributing to one or more third party's making, use, importation, sale or offering for sale of products, which directly infringe one or more claims of the 286 Patent, including, but not limited to, Oscillators such as Integrated Device Technology's Monolithic Clock Synthesizer.

17. Defendant Integrated Device Technology has been indirectly infringing one or more claims of the 286 Patent by actively inducing the making, use, sale or offer for sale by third party direct infringers, with knowledge of the 286 Patent and with the intent to encourage such direct infringement, of products that fall within the scope of one or more claims the 286 Patent, including, but not limited to, Oscillators such as Integrated Device Technology's Monolithic Clock Synthesizer.

18. Upon information and belief, Integrated Device

Technology's infringing activities have been willful.

19. Plaintiff is entitled to recover damages under 35 U.S.C. § 284, and/or enhanced damages under 35 U.S.C. § 285 as a result of Integrated Device Technology's infringing activities and/or willful infringement of the 286 Patent in an amount to be determined at trial.

COUNT 2: PLAINTIFF'S CLAIM FOR ATTORNEYS' FEES AND COSTS

20. Plaintiff re-alleges and incorporates by reference herein all of the preceding paragraphs just as if such were fully set forth again herein.

21. Plaintiff contends that this is an exceptional case, under 35 U.S.C. § 285, for which Plaintiff should be awarded attorneys' fees and costs incurred in prosecuting this action.

PRAYER FOR RELIEF

Plaintiff respectfully requests that this Honorable Court enter judgment in favor of plaintiff Bala IC and against defendant Integrated Device Technology and grant to plaintiff Bala IC all relief that this Court deems just and necessary including, but not limited to, the following relief:

A. A determination that Integrated Device Technology has infringed U.S. Patent No. 5,241,286.

B. An award of damages adequate to compensate for Integrated Device Technology's infringement of the 286 Patent;

C. A determination that Integrated Device Technology's infringement of 286 Patent has been willful;

D. A determination that this case is "exceptional" under 35 U.S.C. § 285, thereby entitling Plaintiff to an award of its reasonable attorneys' fees and costs incurred in prosecuting this action;

E. An accounting of damages resulting from Integrated Device Technology's infringement of the 286 Patent;

F. An award of enhanced damages based on the willful nature of Integrated Device Technology's infringement;

G. An award of prejudgment and postjudgment interest on all damages computed; and

H. Whatever other, and further, relief this Court deems fair, just, and appropriate.

Dated: November 30, 2011

Respectfully submitted,

Steven B. Mirow, Esquire
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Phila., PA 19107-5635
Tel.: 215-923-1301
email: sbmirow@verizon.net

EXHIBIT 1

US005241286A

United States Patent [19]

Mirow

[11] Patent Number: 5,241,286

[45] Date of Patent: Aug. 31, 1993

[54] FET OSCILLATOR USING VOLTAGE AND TEMPERATURE COMPENSATED AMPLIFIER

[76] Inventor: Fred Mirow, 2725 W. Country Club Rd., Philadelphia, Pa. 19131

[21] Appl. No.: 952,194

[22] Filed: Sep. 28, 1992

Related U.S. Application Data

[63] Continuation of Ser. No. 751,122, Aug. 28, 1991, abandoned.

[51] Int. Cl.[5] H03B 5/04; H03B 5/20; H03B 5/24

[52] U.S. Cl. .... 331/108 B; 331/135; 331/176

[58] Field of Search .... 331/108 B, 116 R, 116 FE, 331/117 R, 117 FE, 135, 176, 177 V, 136, 137

[56] **References Cited**

U.S. PATENT DOCUMENTS

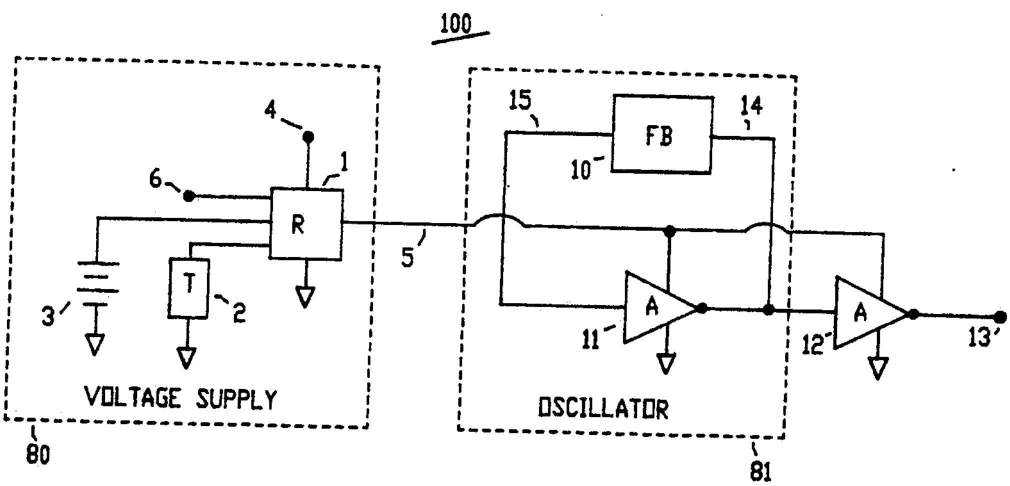
3,246,258	4/1966	Boreen	331/177 R
4,343,219	8/1982	Vetrecht	331/177 R X
4,851,792	7/1989	Ochiai et al.	331/176
5,072,197	12/1991	Anderson	331/57
5,075,643	12/1991	Einbinder	331/185 X
5,097,228	3/1992	McJunkin	331/185 X

Primary Examiner—David Mis

[57] **ABSTRACT**

A FET oscillator with increased frequency stability. This is accomplished by using a controlled voltage supply to power the amplifier stage of the oscillator. This voltage changes as the FET amplifier temperature increases in order to reduce the variation in frequency, caused by the amplifier's gain and phase shift changes. By using this compensated amplifier as the active section of an oscillator, the oscillator frequency stability is increased.

9 Claims, 2 Drawing Sheets



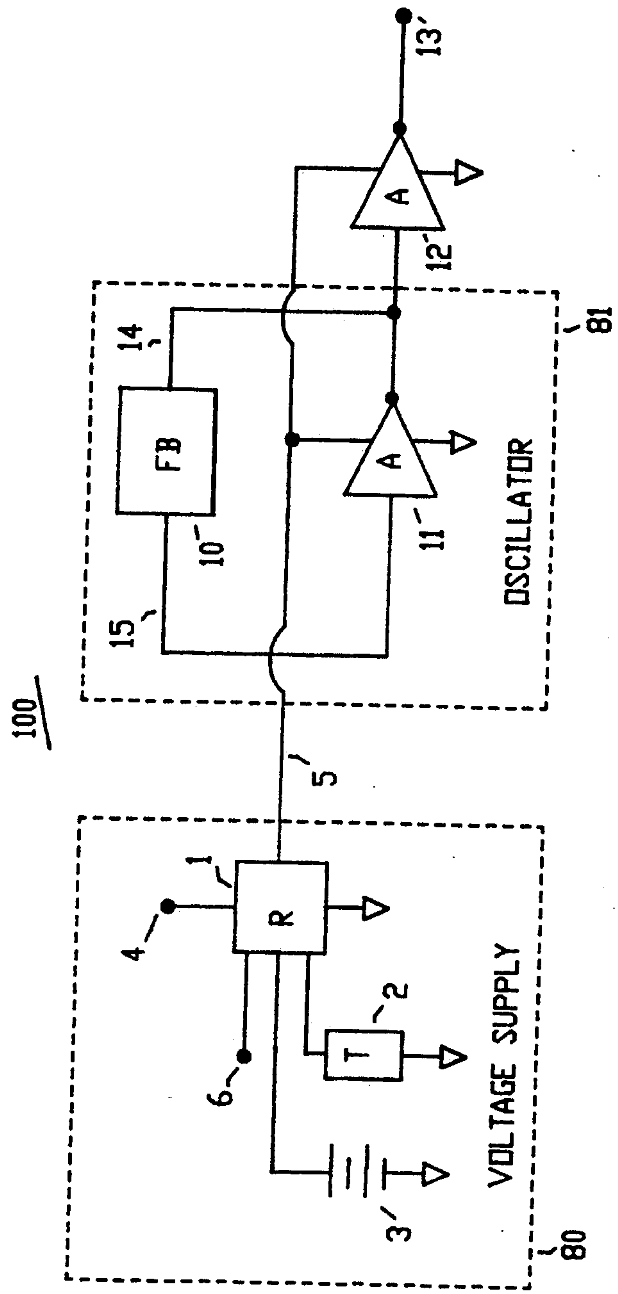

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FIG. 1

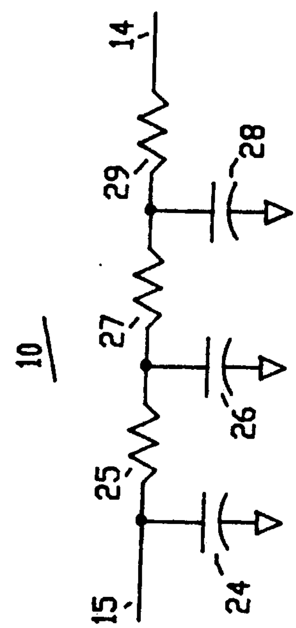
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FIG. 2

FIG. 3

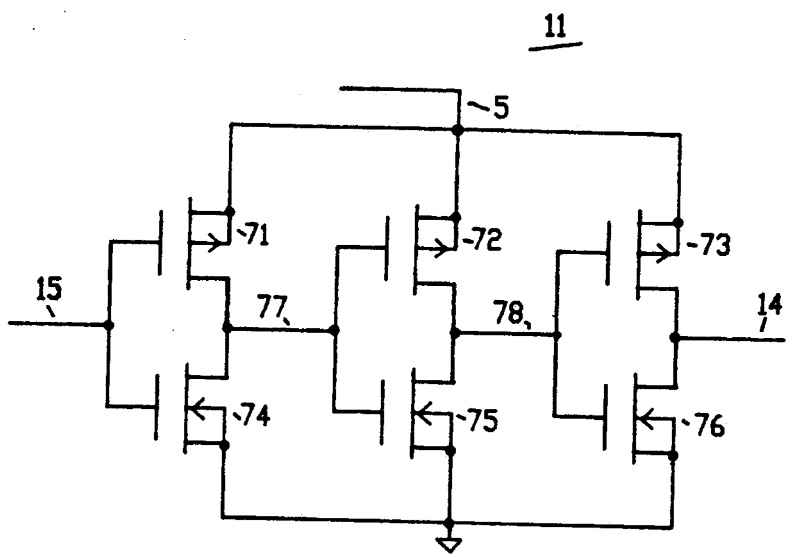


FIG. 4

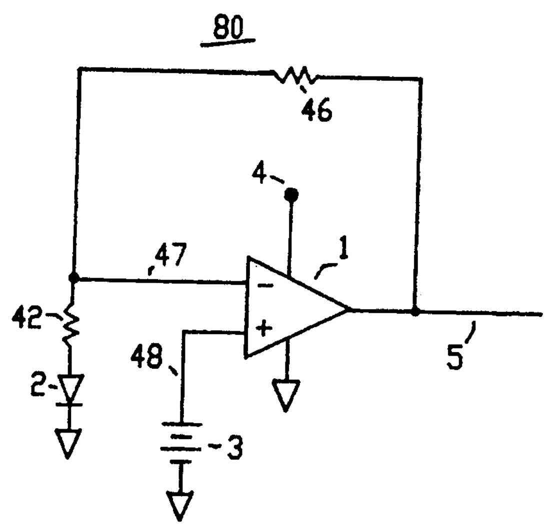
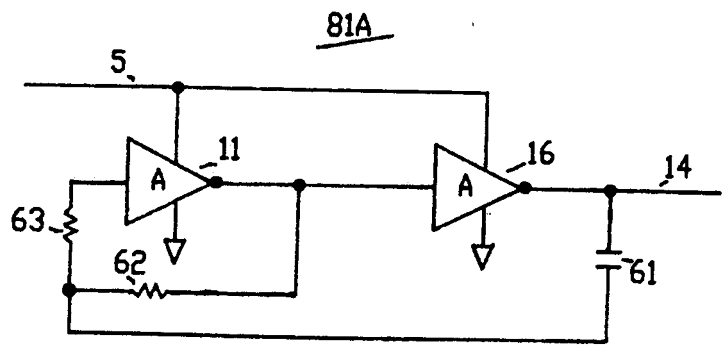


FIG. 5



FET OSCILLATOR USING VOLTAGE AND TEMPERATURE COMPENSATED AMPLIFIER

This is a continuation of copending application Ser. No. 07/751,122, filed on Aug. 28, 1991, now abandoned.

BACKGROUND ART

This invention relates to FET oscillators in which the oscillation frequency is relatively independent of supply voltage and ambient temperature. The term FET is used to refer to CMOS, MOSFET, JFET and other variation of the Field Effect Transistor.

One of the problems associated with FET oscillators at high frequency is that the oscillation frequency is very sensitive to changes in ambient temperature and power supply voltage. To reduce this instability some form of compensation is necessary. One of the methods used is to use a FET as a resistor to control the charging time of a capacitor. The FET resistance value is controlled by a temperature dependent voltage which varies to maintain a constant capacitor charging time. This is described in U.S. Pat No. 4,547,749 issued to Clinton Kuo. Another method is to use a constant current source circuit, which is designed to be temperature independent, to charge and discharge a timing capacitor. This is described in U.S. Pat No. 4,714,901 issued to Jain et al.

In these methods the variation in oscillator frequency has been reduced by controlling the charging time of capacitors, but nothing has been done to correct an other large error source, the high sensitivity of the FET amplifier to temperature and supply voltage change.

SUMMARY OF THE INVENTION

The object of this invention is a FET oscillator in which the frequency stability is increased by reducing the change in the amplifier circuit gain and phase shift due to variations in ambient temperature and power supply voltage. This reduction is accomplished by powering the amplifier from a power supply in which the output voltage level varies with temperature.

An oscillator can be described by dividing it into two sections, the amplifier and feedback network. The amplifier provides the necessary level of gain at the operating frequency. Ideally the amplifier has stable gain and phase shift, or in the time domain propagation delay time. The feedback network selects the frequency at which oscillation will occur by providing at the operating frequency the proper value of phase shift for oscillation to occur. The feedback network phase shift should also be constant against voltage and temperature variations. In oscillators using high quality passive components (capacitors, resistors, etc.) in the feedback network, the FET amplifier section has the greater parameter variation with supply voltage and temperature. The FET parameter changes cause the amplifier gain and phase shift to change which in turn changes the frequency of oscillation. In an oscillator that uses inductor or quartz crystal elements, the selectivity or Q of the feedback network is high enough that the amplifier variations have little effect on the frequency of oscillation. However, there are many oscillators with low selectivity feedback networks in which the amplifier variation has significant effect, such as the resistor capacitor ladder phase shift feedback network oscillators. Integrated circuits can incorporate high quality thin film resistors and MOS capacitors that are stable with voltage and temperature, however the FET amplifier section is not stable. The invention being described here is the most beneficial in oscillators with low values of selectivity in their feedback network, but can also improve all oscillators.

Using this approach a variable frequency oscillator can also be constructed by using a controlled voltage supply to power the oscillator's amplifier. The voltage supply's output voltage level changes in response to temperature and also in response to an additional frequency control input signal.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be described in detail hereinafter with reference to the accompanying drawings; in which

FIG. 1 is a schematic representation of the circuit of the present invention;

FIG. 2 is a schematic representation of Feedback network 10;

FIG. 3 is a schematic representation of Amplifier 11;

FIG. 4 is a schematic representation of Voltage supply 80;

FIG. 5 is a schematic representation of an alternate embodiment of Oscillator 81;

DETAILED DESCRIPTION OF THE INVENTION

Shown in FIG. 1 is compensated oscillator 100 comprising oscillator 81, buffer amplifier 12, and voltage supply 80. The oscillator 81 consist of feedback network 10 and amplifier 11. Feedback network 10 is connected to the input and output of amplifier 11 by lines 14 and 15. Amplifier 11 has a phase shift of about 180 degrees and feedback network 10 supplies the remaining phase shift necessary to make the total phase shift at the frequency of oscillation 360 degrees. If amplifier 11 is not an invertor, than the feedback network 10 will provide the required phase shift amount to have 360 degrees total. The phase shift provided by feedback network 10 varies with frequency but is relatively stable against any other variations such as temperature and voltage. There are many well known phase shift networks that can be used such as the twin T and the Wien bridge. Amplifier 11 phase shift and gain are effected by the voltage on line 5 and ambient temperature. Line 5 supplies the voltage to power the amplifier from voltage supply 80. The effect of temperature is that as the temperature increases the phase shift of amplifier 11 changes causing the frequency of oscillation to change. The effect of temperature on amplifier 11 is substantially canceled by changing the voltage on line 5. Thus the voltage on line 5 serves as a frequency control signal to adjust the output frequency of oscillator 81.

Voltage supply 80 consist of voltage regulator 1, voltage reference 3, and temperature sensor 2. Voltage regulator 1 receives unregulated DC voltage at terminal 4. The two input signals to voltage regulator 1 are voltage reference 3 and temperature sensor 2. Voltage regulator 1 output on line 5 is a DC voltage that is nominally set by voltage reference 3 and varies only in a controlled manner with the temperature change of temperature sensor 2 which is thermally coupled to amplifier 11. Voltage regulator 1 may use an operational amplifier or an other well known voltage regulator circuit. Temperature sensor 2 can be a diode or a temperature sensitive resistor. The ratio of line 5 voltage change to temperature change is a set value determined by voltage supply 80 circuit values. As the temperature of amplifier

11 varies the output signal of temperature sensor 2 causes the voltage on line 5 to vary in a direction to maintain the oscillation frequency nearly constant. Thus, voltage variations on line 5 compensate for frequency variations caused by changes in temperature.

Buffer amplifier 12 provides isolation between the output terminal 13 and the signal on line 14. It may be overdriven to provide a square wave output signal. The voltage to power this amplifier may come from terminal 4 instead of line 5.

Referring now to FIG. 2, a practical means of implementing feedback network 10 to provide 180 degrees phase shift is shown. The network 10, well known by those skilled in the art, is the resistor capacitor ladder phase shift network consisting of resistors 25, 27, and 29, and capacitors 24, 26, and 28.

Referring now to FIG. 3 a practical means of implementing amplifier 11 is shown. The amplifier uses CMOS and is well known by those skilled in the art. Transistors 71 through 73 are PMOS and 74 through 76 are NMOS. The PMOS and NMOS transistors exhibit essentially identical, but complemented characteristics. The signal on line 15 is placed on the gates of transistors 71 and 74. The amplified and inverted output signal on line 77 is connected to the next stage's input, the gates of transistor 72 and 75. The amplified and inverted output signal on line 78 is connected to the next stage's input, the gates of transistor 73 and 76. The amplified and inverted output signal of this stage is on line 14. The voltage to power each amplifier stage is supplied by line 5.

Referring now to FIG. 4, a practical means of implementing voltage supply 80 is shown. Operational amplifier 1 receives unregulated voltage at terminal 4. Amplifier 1 maintains the voltage level on line 5 at a value that makes the voltage level on line 47 equal to that on line 48. The voltage on line 48 is a fixed value determined by voltage reference 3. The voltage on line 47 is a ratio of the voltage on line 5. The ratio is determined by the value of resistors 42 and 46 and the forward voltage drop of diode 2. The diode 2 performs the function of temperature sensor 2. The forward voltage drop of the diode decreases as it's temperature increases causing the voltage on line 5 to increase. Diode 2 is thermally connected to Amplifier 11 so that they are both essentially at the same temperature. As the temperature of Amplifier 11 increases the voltage of line 5 also increases.

Diode 2 is not needed if resistor 46 is made of temperature sensitive material such as doped silicon. This resistor can be formed on the same substrate as Amplifier 11 transistors to provide good thermal coupling. When resistor 46 is used as the temperature sensor 2, diode 2 is removed from the circuit and the terminal of resistor 42 that was connected to diode 2 now is connected to ground.

Referring now to FIG. 5, oscillator 81A is shown. Oscillator 81A is one possible alternate embodiment of oscillator 81. Oscillator 81A is configured as a astable multivibrator. The astable multivibrator is well known by those skilled in the art. Two inverting amplifiers, amplifier 11 and 16, are used to provide the necessary gain. Amplifier 16 may be identical to amplifier 11. The oscillator frequency is primarily determined by the time constant of the feedback network consisting of resistor 62 and capacitor 61. The value of resistor 63 is much higher than resistor 62 to prevent the input impedance of amplifier 11 from effecting the time constant of the feedback network.

Although the above description has been directed to preferred embodiments of the invention, it will be understood and appreciated by those skilled in the art that other variations and modifications may be made without departing from the spirit and scope of the invention, and therefore the invention includes the full range of equivalents of the features and aspects set forth in the appended claims.

I claim:

1. A FET oscillator system having an oscillator with an active amplifier element and a feedback network, said an oscillator having oscillator output frequency and receiving a frequency control signal, said oscillator output frequency having first frequency variations induced by temperature variations and second frequency variations induced by variations in said frequency control signal, comprising:

adjusting means for providing said variations in said frequency control signal in accordance with said temperature variations;

said adjusting means having reference voltage means for determining said variations in said frequency control signal in accordance with said temperature variations;

means within said active amplifier element for receiving said variations in said frequency control signal to induce said second frequency variations; and,

said second frequency variations compensating said first frequency variations to provide a constant oscillator output frequency.

2. The FET oscillator system of claim 1, wherein said frequency control signal is a voltage level.

3. The FET oscillator system of claim 2, wherein said oscillator comprises a CMOS amplifier.

4. The FET oscillator system of claim 2, wherein said adjusting means comprises a diode.

5. The FET oscillator system of claim 2, wherein said adjusting means comprises a temperature sensitive resistor.

6. The FET oscillator system of claim 2, further comprising frequency control signal means for adjusting said frequency control signal in accordance with a further frequency control input signal.

7. The FET oscillator system of claim 2, wherein said adjusting means comprises frequency control signal feedback means for applying said frequency control signal to said adjusting means and feedback control signal providing means for determining said frequency control signal in accordance with said feedback control signal.

8. The FET oscillator system having an oscillator with an active amplifier element and a feedback network, said an oscillator having oscillator output frequency and receiving a frequency control signal, said oscillator output frequency having first frequency variations induced by temperature variations and second frequency variations induced by variations in said frequency control signal, comprising:

adjusting means for providing said variations in said frequency control signal in accordance with said temperature variations:

said adjusting means having frequency control signal feedback means for applying said frequency control signal to said adjusting means and feedback control signal providing means for determining said frequency control signal in accordance with said feedback control signal;

means within said active amplifier element for receiving said variations in said frequency control signal to induce said second frequency variations; and,

said second frequency variations compensating said

first frequency variations to provide a constant oscillator output frequency.

9. The FET oscillator system of claim 8, wherein said adjusting means comprises a temperature sensitive device.

* * * * *