(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 426 812 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
28.08.1996 Bulletin 1996/35

(21) Application number: **90907888.3**

(22) Date of filing: **25.04.1990**

(51) Int Cl.[6]: **H03D 7/12**

(86) International application number:
PCT/US90/02284

(87) International publication number:
WO 90/14150 (29.11.1990 Gazette 1990/27)

(54) **GALLIUM-ARSENIDE SWITCHING MIXER**

GALLIUM-ARSENID SCHALTMISCHSTUFE

MELANGEUR A COMMUTATION A L'ARSENIURE DE GALLIUM

(84) Designated Contracting States:
AT BE CH DE DK ES FR GB IT LI LU NL SE

(30) Priority: **01.05.1989 US 345269**

(43) Date of publication of application:
15.05.1991 Bulletin 1991/20

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Description

Technical Field

This invention relates generally to mixers, and more specifically to gallium-arsenide (GaAs) switching mixers, and is particularly directed toward a GaAs switching mixer employing enhancement mode GaAs switching devices.

Background Art

It is known that the distortion products generated in a switching mixer are proportional to the rise time of the injection signal provided by a local oscillator as well as by the other parameters some of which are internal to the devices in the mixer. Therefore, these distortion products can be minimized by reducing the injection signal's rise time.

Known designs of GaAs switching mixers have attempted to vary device geometries of GaAs depletion mode devices to minimize the turn-on (switching point) of the devices. While helpful, such variation of depletion mode GaAs devices has not been able to satisfactorily reduce the required local oscillator drive level or harmonic distortion . Accordingly, a need exists for a superior GaAs switching mixer.

An article entitled "A double-conversion broad band TV Tuner with GaAs ICs" by Mueller et. al in the Proceedings of the IEEE GaAs IC Symposium, Oct. 1984, pages 97-100, New York, USA discloses a double balanced GaAs mixer IC which is relevant to the present invention.

Summary of the Invention

Accordingly, it is an object of the present invention to provide a GaAs mixer that overcomes the detriments of the prior art.

In accordance with the present invention there is provided a gallium-arsenide switching mixer for providing an output signal representing the sum and difference frequency, the mixer comprising:

first means for receiving an information signal, said first means comprising at least a first transistor; and second means for receiving an injection signal, said second means comprising at least a second transistor coupled to the first transistor such that the information signal and the injection signal are combined to provide the output signal, the mixer being characterised in that said second transistor is an enhancement mode transistor so as to provide reduced local oscillator drive level and harmonic distortion.

The absolute value of threshold voltages in GaAs enhancement mode devices is significantly less than the absolute value of pinchoff voltages in depletion mode devices. Thus, according to the invention, a GaAs switching mixer receives an information signal and an injection signal to provide an intermediate frequency signal. The injection signal controls enhancement mode GaAs devices so as to minimize the required injection drive level and distortion products.

Brief Description of the Drawings

Figure 1 illustrates a GaAs mixer in accordance with the present invention.

Detailed Description of the Preferred Embodiment

Referring to Figure 1, a switching mixer circuit 10 is arranged in what is commonly known as a double-balanced mixer configuration. A current source 12 is coupled from the sources of a differential pair of gallium-arsenide depletion mode field effect transistors 14 and 14' to ground.

Transistors 14 and 14' are coupled in what is known as a single-balanced configuration. Thus, the source of transistor 14 is coupled to the source of transistor 14'. The drain of transistor 14 is coupled to the sources of a differential pair of enhancement mode gallium-arsenide transistors 18 and 22 and the drain of transistor 14' is coupled to the sources of the differential pair of transistors 18' and 22'. Transistors 14 and 14' are as close to being geometrically symmetrical as possible, as are the 18 and 18' transistors and 22 and 22' transistors, respectively.

The drain of transistor 18 is coupled to a primary terminal 26 of transformer coupling 24 and the drain of transistor 18' is coupled to the opposite primary terminal 26' of transformer coupling 24. The drain of transistor 22 is coupled to the drain of transistor 18' and, similarly, the drain of transistor 22' is coupled to the drain transistor 18. The primary winding of transformer 24 is center-tapped at terminal 28 to provide a balanced output. The secondary coupling of transformer 24 extends between terminals 30 and 30'.

Radio-frequency information signal 16 is applied to the gate of transistor 14 and radio-frequency signal 16' (i.e., the compliment or negative of signal 16') is applied to the gate of transistor 14'. Signals 16 and 16' are known as complementary-phased signals. A local oscillator injection signal 20 is applied to the gates of transistors 18 and 18'. Signal 20', (the complement of signal 20) is applied to the gates of transistors 22 and 22'. The complementary-phased signals 16, 16' cause the source currents in differential pairs 18, 22 and 18', 22' to vary. Thus, multiplication of complementary-phased signals 16, 16' and complementary-phased signals 20, 20' is accomplished in each of the differential pairs 18, 22 and 18', 22'. The output signal appears between terminals 30 and 30'.

Claims

1. A gallium-arsenide switching mixer (10) for providing an output signal representing the sum and difference frequency, the mixer comprising:

   first means (14, 14') for receiving an information signal, said first means comprising at least a first transistor (14); and
   second means (18, 18', 22, 22') for receiving an injection signal, said second means comprising at least a second transistor (18) coupled to the first transistor (14) such that the information signal and the injection signal are combined to provide the output signal, the mixer being characterised in that said second transistor is an enhancement mode transistor so as to provide reduced local oscillator drive level and harmonic distortion.

2. The mixer according to claim 1 wherein said second means for receiving an injection signal includes at least two enhancement mode gallium-arsenide transistors (18, 22) coupled in a single-balanced configuration.

3. The mixer according to claim 1 wherein said second means for receiving an injection signal includes four enhancement mode gallium-arsenide transistors (18, 22, 18', 22') coupled in a double-balanced configuration.

4. The mixer of claim 1, 2 or 3 wherein the first means for receiving an information signal includes a pair of transistors (14, 14').

5. The mixer of claim 1, 2, 3 or 4 further comprising a means for providing a balanced output (24).

6. The mixer of claim 1, 2, 3, 4 or 5 wherein the first means for receiving an information signal includes a pair of depletion mode transistors (14, 14').

7. The mixer of claim 6 wherein the first means for receiving an information signal includes a pair of gallium-arsenide depletion mode transistors (14, 14').

8. The mixer of claim 1, 2, 3, 4 or 5 wherein the first means for receiving an information signal includes a pair of enhancement mode transistors.

9. The mixer of claim 8 wherein the first means for receiving an information signal includes a pair of gallium-arsenide enhancement mode transistors.

Patentansprüche

1. Eine Gallium-Arsenid Schaltmischeinrichtung (10) zum Bereitstellen eines Ausgangssignals, das die Summen- und Differenzfrequenz darstellt, wobei die Mischeinrichtung umfaßt:

   eine erste Einrichtung (14, 14') zum Erhalten eines Informationssignals, wobei die genannte erste Einrichtung mindestens einen ersten Transistor (14) umfaßt; und

   eine zweite Einrichtung (18, 18', 22, 22') zum Erhalten eines Injektionssignals, wobei die genannte zweite Einrichtung mindestens einen zweiten Transistor (18) umfaßt, der mit dem ersten Transistor (14) so gekoppelt ist, daß das Informationssignal und das Injektionssignal kombiniert werden, um das Ausgangssignal zu liefern, wobei die Mischeinrichtung **dadurch gekennzeichnet** ist, daß der genannte zweite Transistor ein Transistor vom Anreicherungstyp ist, so daß ein verringerter Ansteuerpegel des örtlichen Oszillators und eine verringerte harmonische Verzerrung geschaffen werden.

2. Die Mischeinrichtung gemäß Anspruch 1, worin die genannte zweite Einrichtung zum Erhalten eines Injektionssignals mindestens zwei Gallium-Arsenid Transistoren (18, 22) vom Anreicherungstyp einschließt, die in einer Einzelgegentaktausgestaltung gekoppelt sind.

3. Die Mischeinrichtung gemäß Anspruch 1, worin die genannte zweite Einrichtung zum Erhalten eines Injektionssignals vier Gallium-Arsenid Transistoren (18, 22, 18', 22') vom Anreicherungstyp einschließt, die in einer Doppelgegentaktausgestaltung gekoppelt sind.

4. Die Mischeinrichtung gemäß Anspruch 1, 2 oder 3, worin die erste Einrichtung zum Erhalten eines Injektionssignals ein Paar von Transistoren (14, 14') einschließt.

5. Die Mischeinrichtung gemäß Anspruch 1, 2, 3 oder 4, die ferner eine Einrichtung zum Bereitstellen eines abgestimmten Ausgangs (24) umfaßt.

6. Die Mischeinrichtung gemäß Anspruch 1, 2, 3, 4 oder 5, worin die erste Einrichtung zum Erhalten eines Informationssignals ein Paar Transistoren (14, 14') vom Verarmungstyp einschließt.

7. Die Mischeinrichtung gemäß Anspruch 6, worin die erste Einrichtung zum Erhalten eines Informationssignals ein Paar Gallium-Arsenid Transistoren (14, 14') vom Verarmungstyp einschließt.

8. Die Mischeinrichtung gemäß Anspruch 1, 2, 3, 4 oder 5, worin die erste Einrichtung zum Erhalten eines Informationssignals ein Paar Transistoren vom Anreicherungstyp einschließt.

9. Die Mischeinrichtung gemäß Anspruch 8, worin die erste Einrichtung zum Erhalten eines Informationssignals ein Paar Gallium-Arsenid Transistoren vom Anreicherungstyp einschließt.

Revendications

1. Mélangeur de commutation à l'arséniure de gallium (10) permettant de fournir un signal de sortie représentant la fréquence somme et différence, le mélangeur comprenant :

   un premier moyen (14, 14') permettant de recevoir un signal porteur d'information, ledit premier moyen comprenant au moins un premier transistor (14) ; et
   un deuxième moyen (18, 18', 22, 22') permettant de recevoir un signal d'injection, ledit deuxième moyen comprenant au moins un deuxième transistor (18) couplé au premier transistor (14) de sorte que le signal porteur d'information et le signal d'injection sont combinés pour fournir le signal de sortie, le mélangeur étant caractérisé en ce que ledit deuxième transistor est un transistor à enrichissement de façon à fournir un niveau d'attaque et une distorsion harmonique réduits de l'oscillateur local.

2. Mélangeur selon la revendication 1, dans lequel ledit deuxième moyen permettant de recevoir un signal d'injection comporte au moins deux transistors à l'arséniure de gallium à enrichissement (18, 22) couplés selon une configuration symétrique simple.

3. Mélangeur selon la revendication 1, dans lequel ledit deuxième moyen permettant de recevoir un signal d'injection comporte quatre transistors à l'arséniure de gallium à enrichissement (18, 22) couplés selon une configuration symétrique double.

4. Mélangeur selon la revendication 1, 2 ou 3, dans lequel le premier moyen permettant de recevoir un signal porteur d'information comporte une paire de transistors (14, 14').

5. Mélangeur selon la revendication 1, 2, 3 ou 4 comprenant en outre un moyen de fourniture d'une sortie symétrique (24).

6. Mélangeur selon la revendication 1, 2, 3, 4 ou 5, dans lequel le premier moyen permettant de recevoir un signal porteur d'information comporte une paire de transistors à déplétion (14, 14').

7. Mélangeur selon la revendication 6, dans lequel le premier moyen permettant de recevoir un signal porteur d'information comporte une paire de transistors à déplétion à l'arséniure de gallium (14, 14').

8. Mélangeur selon la revendication 1, 2, 3, 4 ou 5, dans lequel le premier moyen permettant de recevoir un signal porteur d'information comporte une paire de transistors à enrichissement.

9. Mélangeur selon la revendication 8, dans lequel le premier moyen permettant de recevoir un signal porteur d'information comporte une paire de transistors à enrichissement à l'arséniure de gallium.

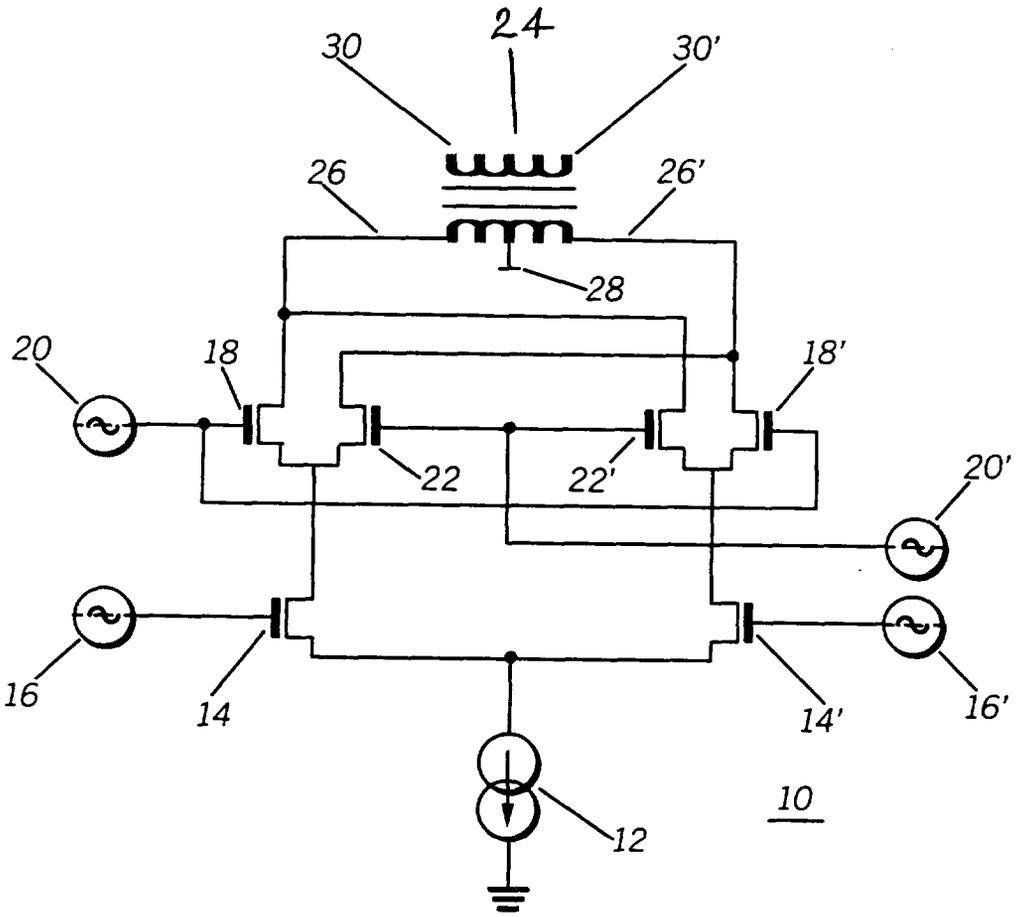

FIG.1