



Description

Field of the Invention

The present invention relates to a circuit having a controlled impedance and more particularly to a circuit suitable for use at the input of an IF amplifier stage which is responsive to a gain control signal for varying the capacitance across a tuned bandpass filter coupled to the input of the IF amplifier stage for varying the frequency response thereof.

Description of the Prior Art

It is generally known that the bandpass characteristics of a tuned circuit can be varied by varying the reactance components comprising the same. Additionally, it is also known how to utilize tuned stages for providing bandpass characteristics to IF amplifier stages used in radio and television applications. For instance, see B. Grob, Basic Television (Fourth Edition 1975) pages 513-541 for a good description of a picture IF section of a typical television receiver. It has generally been established that the required video IF bandwidth of a television receiver should change with signal strength for optimum picture quality. Hence, with a strong input signal and a high signal to noise ratio, the bandwidth should be as wide as possible within the limitations of the incoming signal. Generally, the video carrier should be at -6 dB relative to the main bandpass to achieve correct transient performance for the video signal as is understood.

However, under low signal conditions, i.e. weak input signals with poor signal to noise to ratio, a superior picture is obtained when the bandwidth of the video IF amplifier section of the television receiver is narrower and the picture carrier is only -1 or -2 dB relative to the main bandpass characteristics of the amplifier stage.

In the past this "blocking" of the IF bandpass circuit has been achieved by appropriate matching of filter elements of the IF amplifier stage to one or more discrete transistor amplifier elements which are under AGC control; i.e., the input or output impedance variation produced by gain control of the discrete transistor is used to move the filter pole/poles appropriately. A problem with this scheme is that the characteristic of the discrete transistor stage is subject to large variations between devices and so the characteristics of the bandpass modification is somewhat unpredictable.

Typically, integrated circuit structures such as the Motorola MC1349 "IF Amplifier" used for IF amplifier stages in a television receiver did not lend themselves easily to the aforescribed treatment because they are designed for direct current coupling to following stages. Thus, large parameter changes are quite difficult to accommodate.

One known method of providing a variable capacitance using one or more capacitors in combination with variable impedance means is known from US 3,717,826 where the impedance is varied in response to an applied control signal.

However, a need exists for a circuit to be utilized

with an integrated IF amplifier circuit that can be used to vary the IF bandpass characteristics of the amplifier section to compensate for varying signal strengths while providing maximum picture quality in a television receiver.

Summary of the Invention

Accordingly, it is an object of the present invention to provide a variable capacitance circuit which may be utilized with tuned IF amplifier sections of radio and television receivers for varying the bandpass characteristics thereof to compensate for varying levels of incoming input signals.

A further object of the present invention is to provide a variable capacitance circuit which is responsive to an automatic gain control signal for changing the IF filter characteristics of a tuned IF amplifier stage.

Still another object of the present invention is to provide a variable capacitance circuit suitable for utilization in a large scale integrated television receiver chip for varying the bandpass characteristics of the IF amplifier section thereof.

In accordance with the above and other objects there is provided a variable reactance circuit having a pair of terminals, capacitive means coupled between the terminals and a variable impedance circuit the impedance of which is varied in response to receiving an applied control signal so that the reactance between the pair of terminals is varied, characterized in that the variable impedance circuit comprises first and second power supply conductors, first and second diode means each having first and second electrodes, said first electrode of said first diode means being coupled to a first electrode of a first capacitor the other electrode of said first capacitor being connected to the first terminal of the pair of terminals, said first electrode of said second diode means being coupled to a first electrode of a second capacitor the other electrode of which is connected to the second one of the pair of terminals, the second electrodes of said first and second diode means being coupled to the first power supply conductor; first and second resistors connected in series between said first electrodes of said first and second diode means; and switch means connected between the interconnection of said first and second serially connected resistors and the second power supply conductor, said switch means being responsive to the control signal to render said first and second diode means conductive to vary the impedance appearing between said first and second capacitors.

In response to an applied gain control signal the first and second diodes are rendered conductive to substantially place the capacitors in series with one another across a pair of input terminals; in the absence of the gain control signal the diodes are rendered non-conductive such that the first and second capacitors are essentially disconnected from each other whereby the capacitance appearing at the input terminals of the variable capacitance circuit is made variable.

Brief Description of the Drawings

Fig. 1A is a schematic diagram of the variable capacitance circuit of the preferred embodiment of the present invention;

Fig. 1B is a schematic representation of a first equivalent circuit of the variable capacitance circuit of Fig. 1A;

Fig. 1C is a second schematic diagram of the equivalent circuit of Fig. 1A;

Fig. 2 is a partial schematic and block diagram of an IF amplifier section incorporating the variable capacitance circuit of the present invention;

Fig. 3 shows waveforms useful in describing the operation of the present invention;

Fig. 4 is a partial schematic in block diagram showing the variable capacitance circuit of Fig. 1 coupled with a typical amplifier stage.

Detailed Description of the Preferred Embodiment

Turning to Fig. 1A there is shown variable capacitance circuit 10 comprising a pair of capacitors 12 and 14 each having one plate thereof coupled to input terminal 16 and 18 of the circuit. The other plates of capacitors 12 and 14 are connected respectively to nodes 20 and 22 in series with resistors 24 and 26 coupled therebetween. Capacitors 12 and 14 are also coupled in series with diode coupled connected transistors 32 and 34. Resistors 38 and 40 are coupled in parallel with the diodes 32 and 34 between nodes 20 and 22 and power supply conductor 36 which is adapted to receive a source of operating potential. The interconnection between resistors 24 and 26 are coupled to a gain control transistor 28 having its collector to emitter path coupled in series with a resistor 30 to ground reference. The base of gain control transistor 28 is adapted to receive a gain control signal at terminal 41.

In operation, without any gain control being supplied to terminal 41, transistor 28 is rendered non-conductive. In this condition, diode connected transistors 32 and 34 are also maintained non-conductive such that the series connection of resistors 38 and 40 are coupled in parallel with the series resistors 24 and 26 which essentially produces an open circuit between input terminal 16 and 18 as shown in Fig. 1B. However, in response to the gain control signal being supplied to the input terminal 41 transistor 28 will be rendered conductive to render transistor 32 and 34 conductive which in the extreme limitations will substantially short nodes 20 and 22 together except for the small diode resistance of the two transistors as is shown in Fig. 1C. In this condition, the input impedance appearing at input terminal 16 and 18 is made capacitive and being equal to the capacitance resulting from the series connection of capacitors 12 and 14.

In a preferred embodiment, although not limited thereto, variable capacitance circuit 10 may be utilized in conjunction with the intermediate frequency (IF) amplifier section of a radio or television receiver for changing the bandpass characteristics in response to an automatic gain control

signal. As an example, variable capacitance circuit 10 is shown in Fig. 2 as being coupled with the input of an IF amplifier stage in a typical television receiver. As generally understood, a tuned IF amplifier stage is utilized in the television having at least one tuned section 42 which is coupled at the input thereof at input terminals 44 and 46 to the RF tuner and mixer portion of the television receiver. The IF amplifier stage 48 is coupled to terminals 16 and 18 with variable capacitance circuit 10 with the output of the amplifier stage being coupled to the video detector of the television receiver at terminal 50. An automatic gain control signal is applied via lead 52 to both the variable capacitance circuit 10 and the IF amplifier stage 48 in order to maintain a substantially constant output to the video detector portion of the television receiver.

In a typical television receiver the automatic gain control signal is a function of the received incoming composite television signal and it is generally increased with stronger signals in order to reduce the gain of the IF amplifier stage of the television receiver. In outlying areas or when the television composite signal is weak, the gain of the IF amplifier stage is increased by reducing the gain control signal to this stage. Thus, with strong input signal, there will be supplied via lead 52 to both variable capacitance circuit 10 and IF amplifier stage 48 a gain control signal as known. For optimum picture quality with the strong input signal the bandwidth of the IF amplifier should be as wide as possible as shown by waveform 56 of Fig. 3 such that the picture carrier which occurs at the frequency 45.75 megaHertz is approximately 6 dB down from the center of the bandpass. In this condition, the automatic gain control signal would be supplied to terminal 41 of variable capacitor circuit 10 to render it conductive and therefore to place the series capacitors 12 and 14 in parallel with the capacitor of the tuned stage 42. The bandpass characteristics of the tuned stage can be so designed that with series capacitors 12 and 14 adding to the total capacitance of the tuned stage the bandpass characteristics as shown by waveform 56. However, with weak input signals (no AGC signal) transistor 28 of variable capacitor circuit 10 would be rendered non-conductive thereby reducing the total capacitance of the tuned stage 42. This results in a narrowing of the bandwave bandpass characteristics of the tuned circuit and a shifting of the center frequency upwards as shown by waveform 54. By narrowing the bandpass characteristics of the tuned stage and shifting the center frequency thereof, the picture carrier frequency is moved up such that as shown it occurs only at a -1 or 2 dB below the center pass band of the bandpass characteristics. This results in a walking of the IF bandpass circuit to compensate for varying levels of input signals. Hence, the variable capacitor circuit 10 which is suitable to be utilized in integrated circuit form may be used in a large scale integrated television receiver circuit to maximize the picture qualities of the television receiver between strong and weak received signals.

Variable capacitor circuit 10 could very well be utilized with existing integrated IF amplifier circuits as for example the Motorola MC 1349 IF amplifier circuit as previously mentioned. Moreover, as shown in Fig. 4, variable capacitor circuit 10 may be utilized with the input amplifier stage 62 of a multistage IF amplifier section including further IF amplifier stages 64 which can be fabricated in a single large scale integrated circuit. The output of the IF amplifier section taken at output terminal 66 and 68 could be supplied to a video detector. Hence, in response to the gain control signal supplied at terminals 58 the bandpass characteristics of the tuned input stage coupled to input terminals 16 and 18 would be varied as previously described as the gain of amplifier stage 62 is also varied. The gain of amplifier stage 62 is maximum in the absence of an AGC signal and is decreased to a minimum by transistor 70 being rendered by the AGC signal which tends to decouple the differential transistor pairs of amplifier 62 from one another such that the differential gain is decreased.

Thus, what has been described, is a variable capacitor circuit which may be utilized to vary the bandpass characteristics of an IF amplifier section and which is a completely balanced circuit to both direct current and alternating current signals to maintain maximum gain and stability over the full AGC range of the automatic gain controlled signal which is applied thereto. By utilizing nitride capacitors in series with diodes with impedance controlled by the automatic gain control signal the aforementioned balance conditions were achieved with the direct current control signal being isolated from the amplifier input by use of the capacitors. The capacitors being of small value typically 9 picofarads allows for the same to be fabricated onto the integrated circuit chip comprising the variable capacitor circuit.

A variable capacitance circuit was fabricated using the aforescribed teachings with a resistors 24, 26, 38 and 40 being approximately 6,000 ohms and capacitors 12 and 14 being 9 picofarads. It has been shown with these values that a net 4—5 picofarad capacitance change occurs across input terminals 16 and 18 as transistor 28 is changed from a non-conductive to a full conducting state by application of a direct current signal at the base thereof.

Claims

1. A variable reactance circuit (10, 60) having a pair of terminals, capacitive means (12, 14) coupled between the terminals and a variable impedance circuit (24, 26, 28, 32, 34) the impedance of which is varied in response to receiving an applied control signal so that the reactance between the pair of terminals is varied, characterized in that the variable impedance circuit comprises first (36) and second (ground reference) power supply conductors, first (32) and second (34) diode means each having first and second electrodes, said first electrode of said first

diode means (32) being coupled to a first electrode of a first capacitor (12) the other electrode of said first capacitor being connected to the first (16) terminal of the pair of terminals, said first electrode of said second (34) diode means being coupled to a first electrode of a second capacitor (14) the other electrode of which is connected to the second one (18) of the pair of terminals, the second electrodes of said first and second diode means being coupled to the first power supply conductor; first (24) and second (26) resistors connected in series between said first electrodes of said first and second diode means; and switch means (28) connected between the interconnection of said first and second serially connected resistors and the second power supply conductor, said switch means being responsive to the control signal to render said first and second diode means conductive to vary the impedance appearing between said first and second capacitors.

2. A variable reactance circuit according to claim 1 wherein said switch means is a transistor (28) having first, second and control electrodes, said first and second electrodes being coupled between said interconnection of said first and second serially connected resistors and said second power supply conductor, and said control electrode receiving said control signal.

3. An amplifier section having a balanced tuned input, characterised in that a first side and a second side of the balanced tuned input are connected to respective ones of the pair of terminals of a variable reactance circuit (10, 60) as claimed in either claim 1 or claim 2.

4. A large scale integrated television receiver including an intermediate frequency amplifier (48) having a balanced tuned input and an automatic gain control circuit for providing a gain control signal, characterised in that the first side and the second side of the balanced tuned input of the amplifier (48) are connected to respective ones of the pair of terminals of a variable reactance circuit (10, 60) as claimed in either claim 1 or claim 2 with the gain control signal corresponding to said control signal that is supplied to said switch means (28) whereby the bandpass characteristic of the amplifier is varied.

Patentansprüche

1. Schaltkreis (10, 60) variabler Reaktanz mit einem Paar Anschlüssen, Kapazitäten (12, 14), die zwischen die Anschlüsse und einen Schaltkreis (24, 26, 28, 32, 34) variabler Impedanz geschaltet sind, dessen Impedanz in Abhängigkeit vom Empfang eines zugeführten Steuersignals so variiert wird, daß die Reaktanz zwischen dem Anschlußpaar verändert wird, dadurch gekennzeichnet, daß der Schaltkreis variabler Impedanz enthält: erste (36) und zweite (Massebezugs-)Stromversorgungsleiter, erste (32) und zweite (34) Dioden, die jeweils erste und zweite Elektroden haben, wobei die erste Elektrode der ersten Diode (32) an eine erste Elektrode eines ersten Kondensators (12) angeschlossen ist, die andere Elektrode des

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Thus, what has been described, is a variable capacitor circuit which may be utilized to vary the bandpass characteristics of an IF amplifier section and which is a completely balanced circuit to both direct current and alternating current signals to maintain maximum gain and stability over the full AGC range of the automatic gain controlled signal which is applied thereto. By utilizing nitride capacitors in series with diodes with impedance controlled by the automatic gain control signal the aforementioned balance conditions were achieved with the direct current control signal being isolated from the amplifier input by use of the capacitors. The capacitors being of small value typically 9 picofarads allows for the same to be fabricated onto the integrated circuit chip comprising the variable capacitor circuit.

A variable capacitance circuit was fabricated using the aforescribed teachings with a resistors 24, 26, 38 and 40 being approximately 6,000 ohms and capacitors 12 and 14 being 9 picofarads. It has been shown with these values that a net 4-5 picofarad capacitance change occurs across input terminals 16 and 18 as transistor 28 is changed from a non-conductive to a full conducting state by application of a direct current signal at the base thereof.

Claims

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diode means (32) being coupled to a first electrode of a first capacitor (12) the other electrode of said first capacitor being connected to the first (16) terminal of the pair of terminals, said first electrode of said second (34) diode means being coupled to a first electrode of a second capacitor (14) the other electrode of which is connected to the second one (18) of the pair of terminals, the second electrodes of said first and second diode means being coupled to the first power supply conductor; first (24) and second (26) resistors connected in series between said first electrodes of said first and second diode means; and switch means (28) connected between the interconnection of said first and second serially connected resistors and the second power supply conductor, said switch means being responsive to the control signal to render said first and second diode means conductive to vary the impedance appearing between said first and second capacitors.

2. A variable reactance circuit according to claim 1 wherein said switch means is a transistor (28) having first, second and control electrodes, said first and second electrodes being coupled between said interconnection of said first and second serially connected resistors and said second power supply conductor, and said control electrode receiving said control signal.

3. An amplifier section having a balanced tuned input, characterised in that a first side and a second side of the balanced tuned input are connected to respective ones of the pair of terminals of a variable reactance circuit (10, 60) as claimed in either claim 1 or claim 2.

4. A large scale integrated television receiver including an intermediate frequency amplifier (48) having a balanced tuned input and an automatic gain control circuit for providing a gain control signal, characterised in that the first side and the second side of the balanced tuned input of the amplifier (48) are connected to respective ones of the pair of terminals of a variable reactance circuit (10, 60) as claimed in either claim 1 or claim 2 with the gain control signal corresponding to said control signal that is supplied to said switch means (28) whereby the bandpass characteristic of the amplifier is varied.

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1. Schaltkreis (10, 60) variabler Reaktanz mit einem Paar Anschlüssen, Kapazitäten (12, 14), die zwischen die Anschlüsse und einen Schaltkreis (24, 26, 28, 32, 34) variabler Impedanz geschaltet sind, dessen Impedanz in Abhängigkeit vom Empfang eines zugeführten Steuersignals so variiert wird, daß die Reaktanz zwischen dem Anschlußpaar verändert wird, dadurch gekennzeichnet, daß der Schaltkreis variabler Impedanz enthält: erste (36) und zweite (Massebezugs-)Stromversorgungsleiter, erste (32) und zweite (34) Dioden, die jeweils erste und zweite Elektroden haben, wobei die erste Elektrode der ersten Diode (32) an eine erste Elektrode eines ersten Kondensators (12) angeschlossen ist, die andere Elektrode des



genannten ersten Kondensators mit dem ersten (16) Anschluß des Anschlußpaares verbunden ist, die erste Elektrode der zweiten (34) Diode an eine erste Elektrode eines zweiten Kondensators (14) angeschlossen ist, dessen andere Elektrode mit dem zweiten (18) des Anschlußpaares verbunden ist, die zweiten Elektroden der ersten und zweiten Dioden mit dem ersten Stromzuführungsleiter verbunden sind; erste (24) und zweite (26) Widerstände in Serie zwischen die genannten ersten Elektroden der ersten und zweiten Dioden geschaltet sind; und Schalteinrichtung (28) zwischen die Verbindung der ersten und zweiten in Serie geschalteten Widerstände und den zweiten Stromzuführungsleiter geschaltet sind, wobei die Schalteinrichtung auf das Steuersignal ansprechen, um die ersten und zweiten Dioden leitfähig zu machen, um die Impedanz zu verändern, die zwischen den ersten und zweiten Kondensatoren erscheint.

2. Schaltkreis mit variabler Reaktanz nach Anspruch 1, bei dem die Schalteinrichtung ein Transistor (28) ist, der erste, zweite und Steuerelektroden hat, wobei die ersten und zweiten Elektroden zwischen die Verbindung der ersten und zweiten in Serie geschalteten Widerstände und den zweiten Stromversorgungsleiter geschaltet sind und die Steuerelektrode das genannte Steuersignal erhält.

3. Verstärkerstufe mit symmetrisch abgestimmtem Eingang, dadurch gekennzeichnet, daß eine erste Seite und eine zweite Seite des symmetrisch abgestimmten Eingangs mit jeweils einem eines Paares von Anschlüssen eines Kreises (10, 60) variabler Reaktanz nach Anspruch 1 oder Anspruch 2 verbunden sind.

4. Hochintegrierter Fernsehempfänger, enthaltend einen Zwischenfrequenzverstärker (48) mit symmetrisch abgestimmtem Eingang und einem automatischen Verstärkungsregelkreis zum Erzeugen eines Verstärkungsregelsignals, dadurch gekennzeichnet, daß die erste Seite und die zweite Seite des symmetrisch abgestimmten Eingangs des Verstärkers (48) mit jeweils einem von einem Paar von Anschlüssen eines Kreises (10, 60) variabler Reaktanz nach Anspruch 1 oder Anspruch 2 verbunden ist, wobei das Verstärkungsregelsignal dem genannten Steuersignal entspricht, das der genannten Schalteinrichtung (28) zugeführt ist, wodurch die Bandpaßcharakteristik des Verstärkers verändert wird.

Revendications

1. Circuit à réactance variable (10, 60) possédant une paire de bornes, un moyen capacitif (12, 14) couplée entre les bornes et un circuit à impédance variable (24, 26, 28, 32, 34), dont l'impédance varie en réponse à la réception d'un signal de commande appliqué, si bien que la réactance existant entre la paire de bornes varie, caractérisé en ce que le circuit d'impédance variable comprend un premier conducteur d'alimenta-

tion électrique (36) et un deuxième conducteur d'alimentation électrique (potentiel de référence de la terre), un premier moyen à diode (32) et un deuxième moyen à diode (34) possédant chacun une première et une deuxième électrode, la première électrode dudit premier moyen à diode (32) étant couplée à une première électrode d'un premier condensateur (12), l'autre électrode dudit premier condensateur étant connectée à la première borne (16) de la paire de bornes, ladite première électrode dudit deuxième moyen à diode (34) étant couplée à une première électrode d'un deuxième condensateur (14), dont l'autre électrode est connectée à la deuxième borne (18) de la paire de bornes, les deuxième électrodes desdits premier et deuxième moyens à diode étant couplées au premier conducteur d'alimentation électrique; une première résistance (24) et une deuxième résistance (26) connectées en série entre lesdites première électrodes desdits premier et deuxième moyens à diode; et un moyen de commutation (28) connecté entre l'interconnexion desdites première et deuxième résistances connectées en série et le deuxième conducteur d'alimentation électrique, ledit moyen de commutation répondant au signal de commande en redant conducteurs lesdits premier et deuxième moyens à diode façon à faire varier l'impédance apparaissant entre lesdits premier et deuxième condensateurs.

2. Circuit à réactance variable selon la revendication 1, où ledit moyen de commutation est un transistor (28) possédant une première électrode, une deuxième électrode et une électrode de commande, lesdites première et deuxième électrodes étant couplées entre ladite interconnexion desdites première et deuxième résistances connectées en série et ledit deuxième conducteur d'alimentation électrique, et ladite électrode de commande recevant ledit signal de commande.

3. Section amplificatrice possédant une entrée accordée équilibrée, caractérisée en ce qu'un premier côté et un deuxième côté de l'entrée accordée équilibrée sont connectés aux bornes respectives de la paire de bornes d'un circuit à réactance variable (10, 60) tel que revendiqué dans la revendication 1 ou la revendication 2.

4. Récepteur de télévision intégre à grande échelle comportant un amplificateur à fréquence intermédiaire (48) possédant une entrée accordée équilibrée et un circuit de commande automatique de gain servant à produire un signal de commande de gain, caractérisé en ce que le premier côté et le deuxième côté de l'entrée accordée équilibrée de l'amplificateur (48) sont connectés aux bornes respectives de la paire de bornes d'un circuit à réactance variable (10, 60) tel que revendiqué dans la revendication 1 ou 2, le signal de commande de gain correspondant audit signal de commande qui est délivré audit moyen de commutation (28), si bien que l'on peut faire varier la caractéristique de bande passante de l'amplificateur.

