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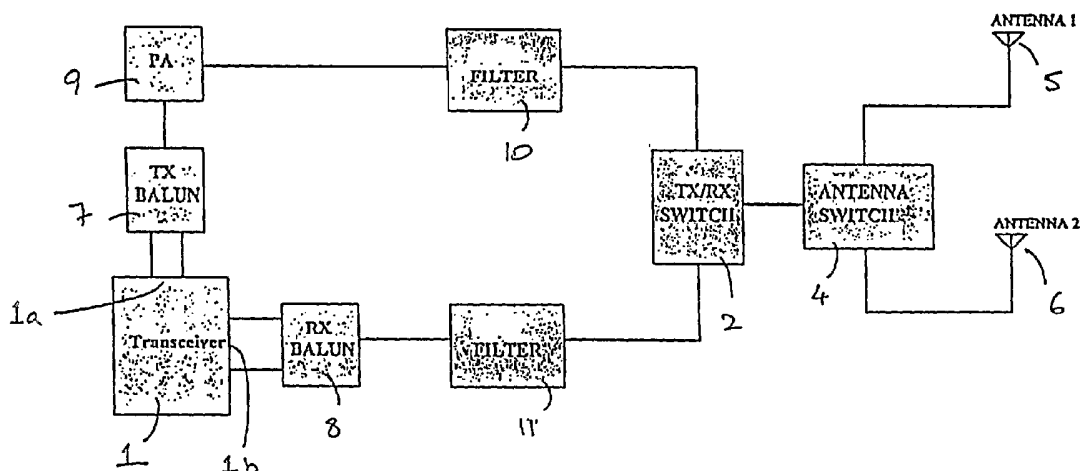
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(54) Title: A RADIO FREQUENCY CIRCUIT



(57) Abstract: A radio frequency circuit for TDMA applications is described which comprises a transceiver (1) having a transmitter and a receiver (1a, 1b); an antenna (5) for wireless transmission and reception of a RF signal; a switch (2) coupled to the antenna (5) and selectively connecting the antenna (5) to the transmitter (1a) to transmit a said RF signal to the antenna (5) or to the receiver (1b) to receive a said RF signal from the antenna (5); a first filter (10) arranged to process a said RF signal between the transmitter (1a) and the switch (2); and a second filter (11) arranged to process a said RF signal between the switch (2) and the receiver (1b).

A Radio Frequency Circuit

Background and Field of the Invention

- 5 This invention relates to a radio frequency (RF) circuit for use in Time Division Multiple Access (TDMA) applications.

TDMA has been widely used for wireless communications and recently, cordless telephones have also adopted this telecommunication technique. In particular, the Digital Enhanced Cordless Telephone (DECT) standard employs
10 TDMA-Time Division Duplex (TDD) for the wireless transmission and reception of RF signals to facilitate wireless communication between a base station and a cordless hand set.

- 15 Each cordless hand set and base station comprises a RF circuit having an antenna for the wireless transmission of RF signals. Typically, the antenna is coupled to a transceiver incorporating a transmitter and a receiver and is used for processing the RF signals for transmission by the antenna or after reception from the antenna. Such an arrangement lowers design costs and saves
20 component space. Accordingly, a switching mechanism common to both the transmitter and receiver is needed to switch between transmission and reception of the RF signals. This is accomplished by using a RF Tx/Rx switch, typically in the form of a PIN diode.

Conventionally, a discrete band pass filter is arranged along the path between the Tx/Rx switch and the antenna. This band pass filter serves a dual purpose of attenuating spurious signals and harmonics from the transmitter, and attenuating unwanted signals from the antenna to the receiver. This means that
5 the same filter is being used for transmission and reception purposes. Such a configuration has an ease of implementation since the filter is available off-the-shelf. In addition, with the filter characteristics provided by the filter manufacturer, the rest of the RF circuit can be designed around these known characteristics.

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However, such a filter is expensive and contributes to a significant cost of the cordless phones using such a technology. A further problem of the conventional design is that the Tx/Rx switch is common to both the transmitter and receiver of the transceiver. With the isolation of the Tx/Rx switch at about
15 12dB, the RF signals transmitted to the Tx/Rx switch may leak to the receiver. With this poor isolation, it is also difficult to "tune" the transmitting and receiving circuitry to improve the performance of the RF circuit. In addition, if the transmission path from the transmitter to the antenna is not matched, some harmonics or components of the RF signals being transmitted to the antenna
20 may be reflected back to the receiving end. These reflected signals and the spurious signals from the transmitter that leak to the receiver will degrade the receiver's performance, in particular causing the frequency offset parameter to jitter and at times destabilising the receiver operation.

It is an object of the invention to provide a RF circuit which alleviates at least one of these disadvantages.

Summary of the Invention

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In a first aspect of the invention, there is provided a radio frequency circuit for TDMA applications, the circuit comprising

a transceiver having transmitting and receiving means;

an antenna for wireless transmission and reception of a RF signal;

10 a switch coupled to the antenna and selectively connecting the antenna to the transmitting means to transmit a said RF signal to the antenna or to the receiving means to receive a said RF signal from the antenna;

a first filter arranged to process a said RF signal between the transmitting means and the switch; and

15 a second filter arranged to process a said RF signal between the switch and the receiving means.

In the described embodiment, having a dedicated filter at the transmitting path before the switch gives an advantage that during transmission from the transmitting means to the antenna, any spurious signals or unwanted harmonics
20 will be filtered or reduced by the first filter such that these unwanted signals will not affect the receiving means of the transceiver. A second filter arranged between the switch and the receiving means of the transceiver has a further advantage of further reducing or eliminating any spurious signals or reflected
25 signals due to the mismatched transmission lines.

A further advantage of the described embodiment in having separate filters at the transmitting and receiving paths is that the performance of the filters can be improved thereby improving the overall performance of the RF circuit. The filters
5 can also be formed from lower cost components, so the cost of providing two filters instead of one as in the prior art can actually be reduced rather than increased.

Preferably, the first and/or second filter comprises a component formed using a
10 printed coil. Typically, the component is an inductor and which is formed in a printed circuit board. An advantage of using a printed coil is the lower cost.

The invention also relates to a digital cordless telephone having a base station or a cordless handset comprising a RF circuit according to the first aspect of the
15 invention. The digital cordless telephone may use the DECT standard or operates in the 2.4Ghz frequency range.

Brief Description of the Drawings

20 An embodiment of the invention will now be described, by way of example, with reference to the accompanying drawings in which,

Figure 1 illustrates a block diagram of a conventional RF circuit;

Figure 2 illustrates a block diagram of a RF circuit having a first and second
25 filter according to a preferred embodiment of the invention;

Figure 3 illustrates a detailed circuit diagram of the RF circuit of Figure 2, showing components of the first and second filter in detail;

Figure 4 illustrates a typical frequency characteristic of the first filter of Figure 3; and

- 5 Figure 5 illustrates a typical frequency characteristic of the second filter of Figure 3.

Detailed Description of the Preferred Embodiment

- 10 Figure 1 illustrates a block diagram of a conventional RF circuit comprising a transceiver 1 having transmitting means 1a and receiving means 1b, a Tx/Rx switch 2, a band pass filter 3, an antenna switch 4, a first antenna 5 and a second antenna 6.

- 15 In this prior art, the transceiver 1 is a single integrated circuit and the transmitting means 1a and the receiving means 1b incorporated within the transceiver chip 1. The transmitting and receiving means 1a,1b are each matched to the transmission lines by a "balance-to-unbalance" (BALUN) circuit 7,8. When the transceiver 1 wished to transmit a signal, for example a voice
20 data, the signal modulates a suitable RF frequency for transmission by the transmitting means 1a. The modulated RF signal is then amplified by a power amplifier 9 prior to the switching operation of the Tx/Rx switch 2.

- The other end of the Tx/Rx switch 2 is coupled to the receiving means 1b of the
25 transceiver 1. The Tx/Rx switch 2 is also coupled to the band pass filter 3 such

that at any one time, the band pass filter 3 is either connected to the transmitting means 1a or to the receiving means 1b via the Tx/Rx switch 2.

In the case of a RF signal being transmitted, the band pass filter 3 limits the frequency of the RF signal in accordance with its frequency response before the filtered RF signal is transmitted by the first antenna 5 or the second antenna 6, as determined by the antenna switch 4. The first and second antennae 5, 6 are operating at a different time and depending on the signal strength either the first or the second antenna will be used for both the transmission and reception using TDMA-TDD.

With such an arrangement, the Tx/Rx switch 2 is common to the transmitting means 1a and the receiving means 1b of the transceiver 1. Ideally, when the Tx/Rx switch 2 is switched to the transmitting means 1a, the receiving means 1b should be isolated from the transmitted RF signals. However, this is not the case in actual application. The isolation of the Tx/Rx switch is typically not adequate to prevent spurious signals such as the fundamental or other harmonic components of a RF signal being transmitted to leak to the receiving circuitry. This is more so since the RF signal is amplified by the power amplifier 9 before the Tx/Rx switch 2.

In addition, although BALUN circuits 7,8 are used to match the transmitting and receiving means 1a,1b to the transmission lines, this is difficult to achieve since the leakage affecting the transmitting circuitry and the receiving circuitry increases the difficulty to tune the respective circuits. Therefore, the RF signal

transmitted to the band pass filter 2 and subsequently to the first or second antennae 5, 6 may be reflected back to the receiving means 1b adding to the spurious signals from the transmitted RF signals. The reflected signals and the spurious signals will affect the VCO of the transceiver and thus the performance of the transceiver is affected.

To alleviate at least one of these disadvantages, the preferred embodiment of the invention proposes that a first filter 10 is arranged to process the transmitted RF signal prior to the Tx/Rx switch 2 and a second filter 11 is arranged to process the received RF signal between the Tx/Rx switch 2 and the receiving means 1b. This arrangement is shown in Figure 2. With this arrangement, the filtering of the transmitted RF signal will be performed prior to the switching operation. Therefore, the first filter 10 now removes a considerable amount of the unwanted spurious signals that may leak to the receiving end.

15

The second filter 11 is arranged to filter signals along the path between the Tx/Rx switch 2 and the receiving means of the transceiver 1 and thus any leakage from the transmitted signal and any reflected RF signal due to the mismatch of the transmission lines, will be further reduced by this second filter 11.

20

Figure 3 illustrates a detailed circuit diagram of the RF circuit according to the preferred embodiment of the invention which will be described by applying the RF circuit of the invention in a DECT environment for a cordless telephone.

25

A suitable transceiver 1 is a UAA 3544 HW Integrated DECT Transceiver from Philips Semiconductor. For transmission, a voice signal would be made to modulate a RF frequency for transmission by the transmitting means 1a of the transceiver 1. The RF signal is then amplified by the power amplifier 9. An
5 example of the power amplifier 9 is a CGY2032 BTS DECT Power Amplifier from Philips Semiconductor.

After amplification, the RF signal is subjected to a filtering operation by the first filter 10 to "shape" the RF signal. In this example, the first filter 10 is in the form
10 of a low pass filter which comprises L10, L19, C9, C3 and C50. The filtering process removes or eliminates unwanted signals according to the filter characteristics. After the filtering process, the transmitted RF signal is ready for transmission by the antenna 5,6, depending on the status of the Tx/Rx switch 2, arranged as shown in Figure 3. The Tx/Rx switch 2, in the form of two PIN
15 diodes 2a, 2b, is controlled by the T_EN (transmit enable) signal which, in turn, is generated by a baseband processor (not shown). The T_EN signal provides a DC signal to forward bias the first PIN diode 2a, depending on whether the RF circuit is transmitting or receiving.

20 If the T_EN signal is a "high", the first diode 2a would be forward biased and the RF signal is transmitted to the antenna switch 4. Two control signals ANT_SW0 and ANT_SW1, also generated by the baseband processor, control the operation of the antenna switch 4 and determines which of the two antennae 5, 6 is used for radiating the RF signal.

The RF circuit is placed in receiving mode by the R_EN (Receive Enable) signal which controls the second PIN diode 2b of the Tx/Rx switch 2. Similarly, the baseband processor determines when to activate the R_EN signal. At any one time, only one of the two diodes 2a, 2b of the Tx/Rx switch 2 is forward biased
5 as controlled by the T_EN and R_EN signals.

In this example, the second filter comprises a high pass and a low pass filter 11a,11b, arranged as shown in Figure 3. The low pass filter 11b comprises inductors L20, L21 and capacitors C62, C63, C64. The high pass filter 11a
10 comprises inductors L22, L23, L24 and capacitors C60, C61. When enabled by the R_EN signal, the diode 2b is forward biased and any RF signal received from the antenna 5,6 would be filtered accordingly by the filter configurations 11a,11b.

15 Typically, the discrete components of the RF circuit are mounted on a printed circuit board (not shown). Preferably, the first and second filters 10,11 comprise components formed using printed coils embedded in the printed circuit board. Typically, the components formed using printed coils are inductors. In this way, the cost of the filter configuration can be substantially reduced. In addition, the
20 use of printed technology to fabricate some of the filter components also improves the performance of the filters 10,11 as compared to the conventional filter design.

The frequency spectrum used for wireless transmission of RF signals in a
25 DECT standard is in the preferred 1.88 Ghz to 1.90Ghz band. Typically, there

will be ten carrier frequencies spaced throughout the frequency spectrum with the lowest carrier at 1.881792Ghz and the highest at 1.897344Ghz with each carrier separated by a bandwidth of 1.728Mhz. As the DECT standard uses the TDMA-TDD transmission technology, the same carrier frequency is used for transmitting and receiving the RF signal at different times. This again explains the need for the Tx/Rx switch 2 to alternate between transmitting and receiving mode.

Therefore, the two antennae 5,6 may be operating at any one of the ten carrier frequencies and depending on the signal strength, only one will be active at any one time.

A typical frequency characteristic of the first filter 10, which is a low pass filter, in a typical DECT application is illustrated in Figure 4. The filter characteristic of filter 10 is then adapted to have a 3dB corner frequency of 2.25Ghz. In this way, spurious signals beyond the 3Ghz frequency will be filtered and minimised at least 30dB down.

Figure 5 illustrates a typical bandpass characteristics of the second filter 11 which comprises the low pass and high pass filter configuration 11a,11b. The band pass filter has a centre frequency of approximately 1.89Ghz so that more than 50dB attenuation is realised for frequency components in the 945Mhz range thereby rejecting or minimising interference from GSM signals.

Depending on the filter characteristics desired, the component values of the first and second filters 10,11 may be varied according to the application.

The described embodiment is not to be construed as limitative. For example,
5 instead of a single transceiver 1, the transceiver 1 may comprise a separate discrete transmitter chip and a discrete receiver chip. In addition, a notch filter circuit 11c may replace the highpass filter of the second filter configuration 11a,11b for filtering of GSM signals if the frequency response of the lowpass and highpass filter forming the second filter is not adequate.

10

The preferred embodiment comprises two antennae 5,6. However, it should be apparent to a skilled reader that a single antenna is adequate for TDMA-TDD applications since the same antenna is being used for transmission and reception of RF signals. In addition, although the DECT standard is described,
15 the RF circuit according to the invention can be applied in other operating frequencies, for example, the 2.4Ghz band.

Having now fully described the invention, it should be apparent to one of ordinary skill in the art that many modifications can be made hereto without
20 departing from the scope as claimed.

CLAIMS

1. A radio frequency circuit for TDMA applications, the circuit comprising
a transceiver having transmitting and receiving means;
5 an antenna for wireless transmission and reception of a RF signal;
a switch coupled to the antenna and selectively connecting the antenna
to the transmitting means to transmit a said RF signal to the antenna or
to the receiving means to receive a said RF signal from the antenna;
a first filter arranged to process a said RF signal between the transmitting
10 means and the switch; and
a second filter arranged to process a said RF signal between the switch
and the receiving means.
2. A radio frequency circuit according to claim 1, wherein the first and/or
15 second filter comprises a component formed using a printed coil.
3. A radio frequency circuit according to claim 2, wherein the component is
an inductor.
- 20 4. A radio frequency circuit according to claim 2 or claim 3, further
comprising a printed circuit board.
5. A radio frequency circuit according to claim 4, wherein the component is
formed in the printed circuit board.

6. A radio frequency circuit according to any one of the preceding claims,
wherein the switch includes a diode.
7. A radio frequency circuit according to any one of the preceding claims,
5 wherein the first filter is a low pass filter.
8. A radio frequency circuit according to any one of the preceding claims,
wherein the second filter is a bandpass filter.
- 10 9. A radio frequency circuit according to claim 8, wherein the bandpass filter
comprises a low pass filter and a high pass filter.
10. A radio frequency circuit according to claim 8, wherein the bandpass filter
comprises a low pass filter and a notch filter.
- 15 11. A radio frequency circuit according to any one of the preceding claims,
further comprising an amplifier circuit arranged to amplify a said RF
signal from the transmitting means.
- 20 12. A radio frequency circuit according to any one of the preceding claims,
further comprising a second antenna.
13. A digital cordless telephone having a base station comprising a RF circuit
according to one any of the preceding claims.

14. A digital telephone having a cordless handset comprising a RF circuit according to any one of claims 1 to 12.
15. A digital telephone according to claim 13 or claim 14, wherein the digital
5 telephone uses the DECT standard.
16. A digital telephone according to claim 13 or claim 14, wherein the digital telephone operates in the 2.4Ghz frequency range.

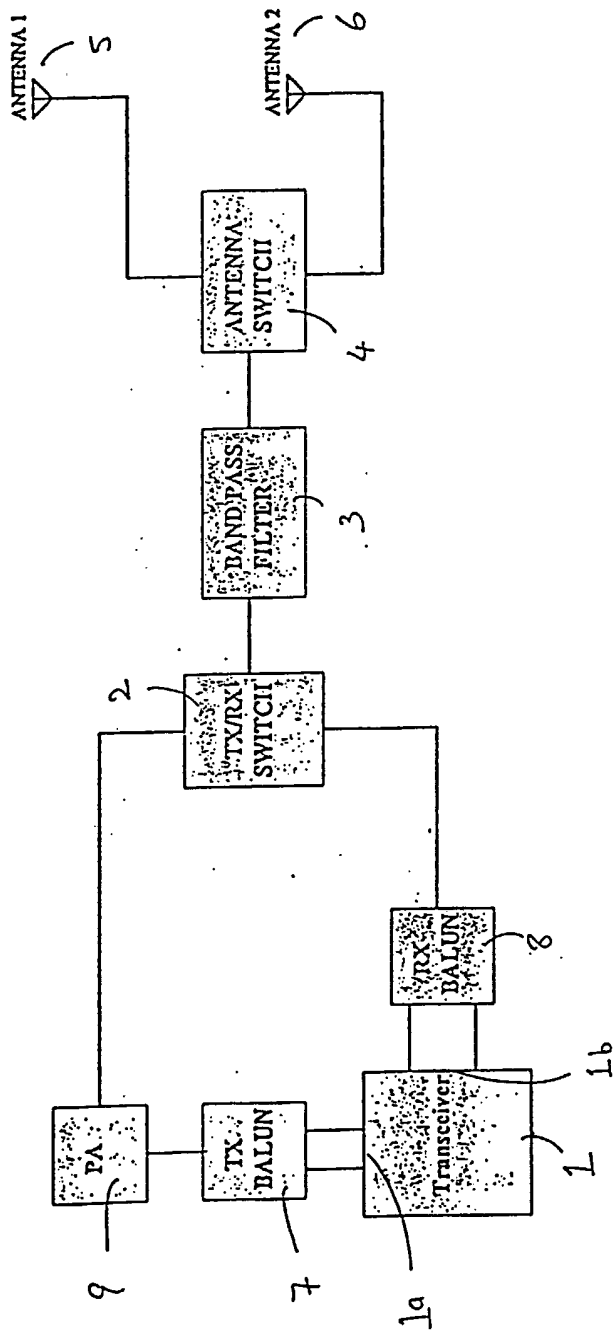


Figure 1

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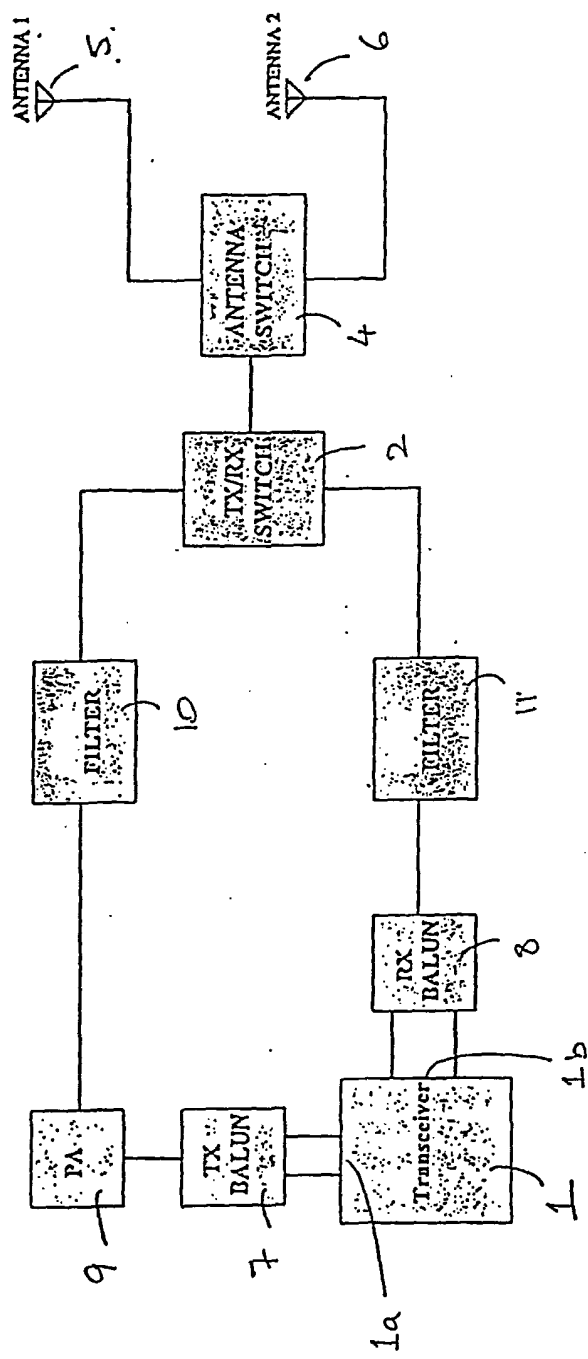
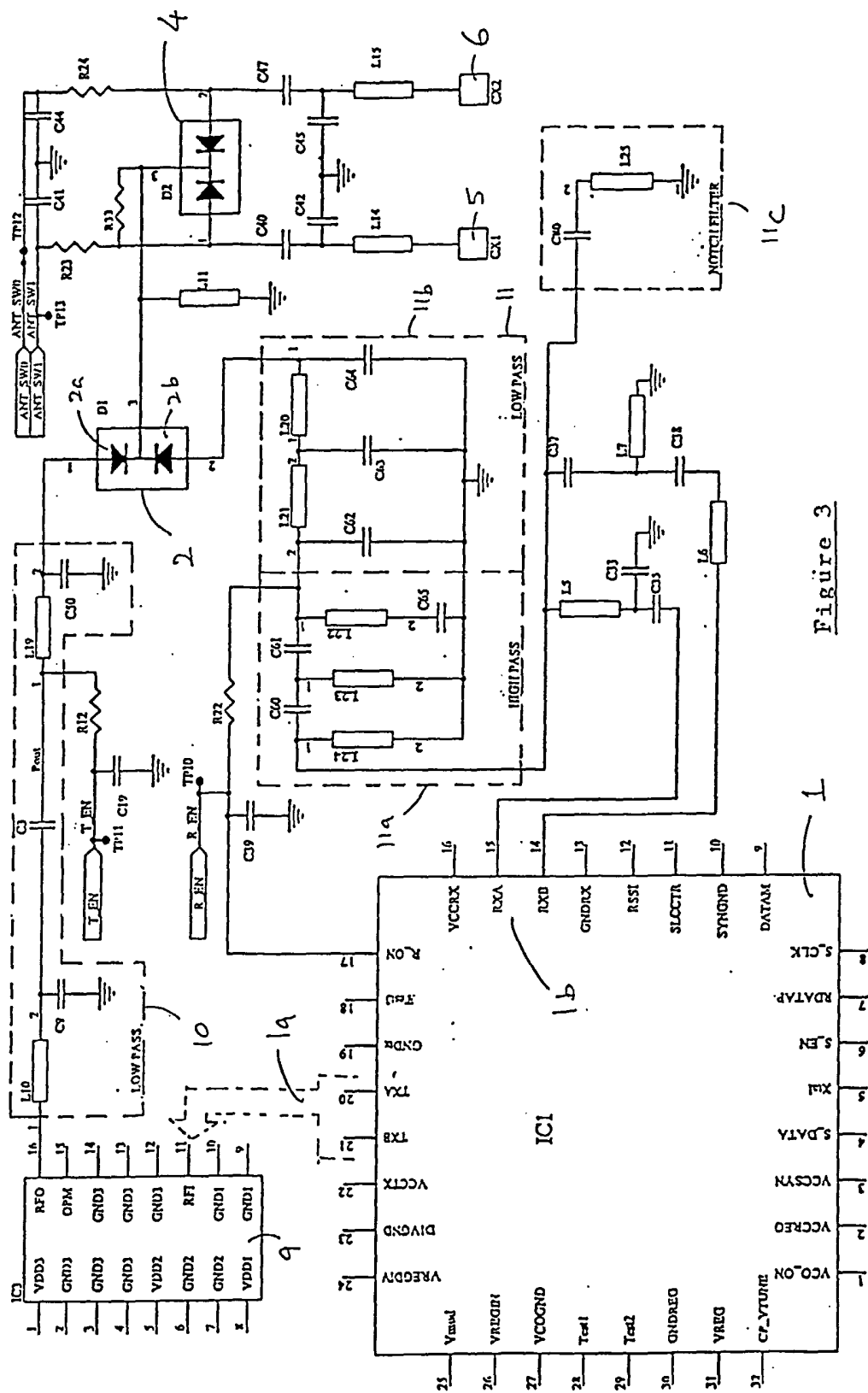


Figure 2

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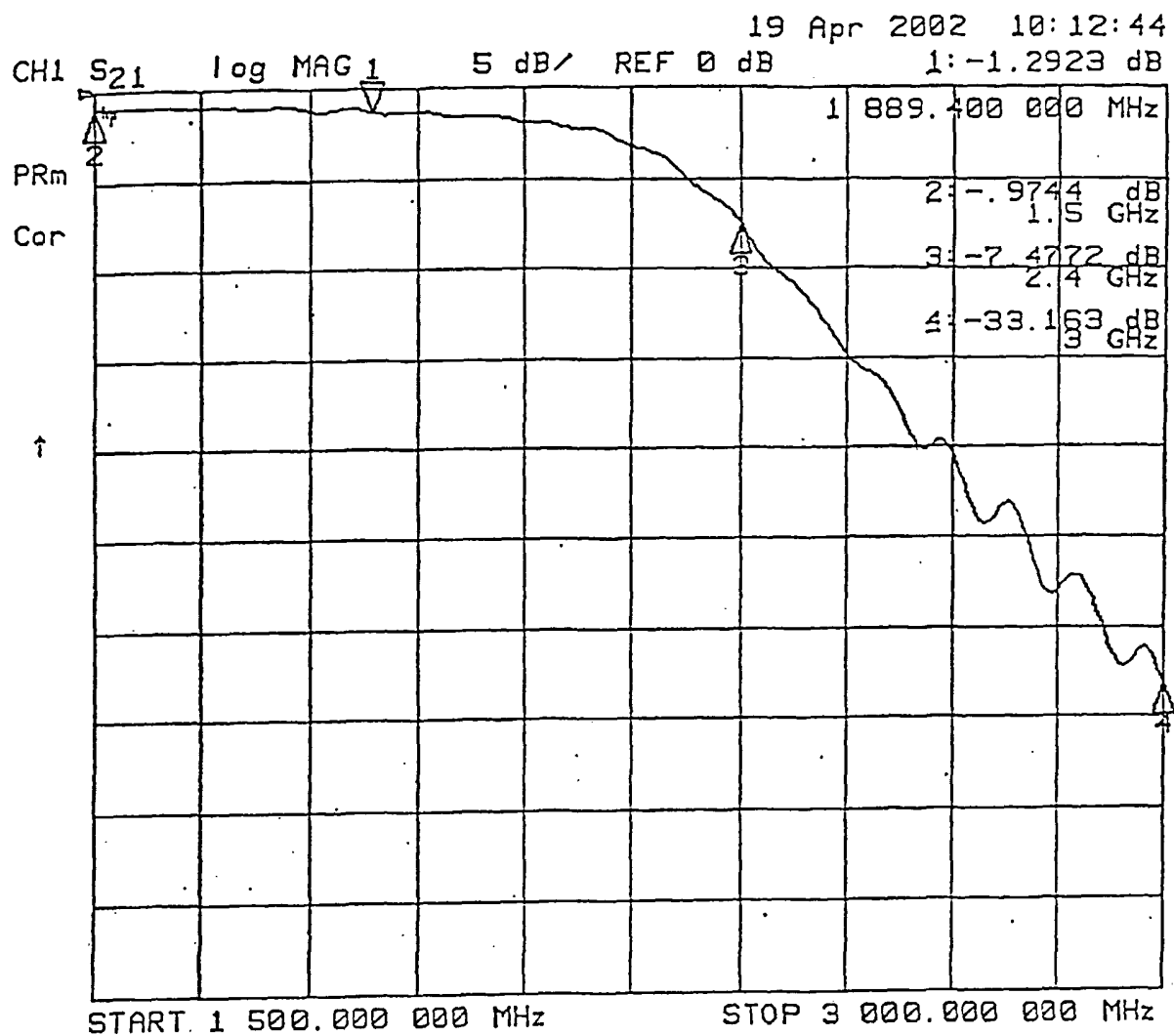


Figure 4

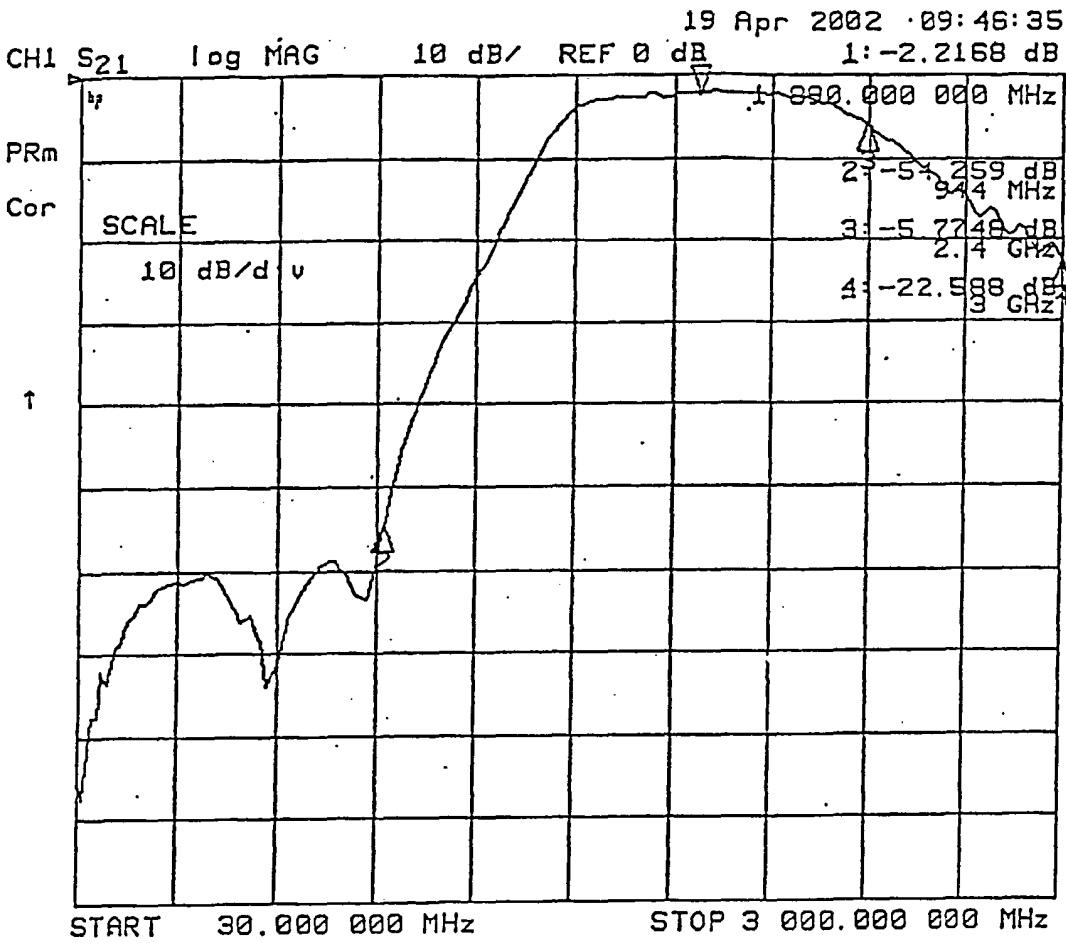


Figure 5