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(54) Phase shifter device including MEMS switches and delay lines and portable communication device using the same

(57) A phase shifter device (1) for a portable communication device, said phase shifter device (1) comprising:

a first in-port (22) for an incoming RF signal, and a second out-port (24) for an outgoing RF signal;
a phase switch device (20) including a plurality micro-electro-mechanical (MEM) switches (40) controllable by a control unit (30), said phase switch device (20) being arranged to select one of a plurality of phase shift values corresponding to a switchable time delay line having corresponding different selectable lengths, provided by the phase switch device (20) to the incoming RF signal.

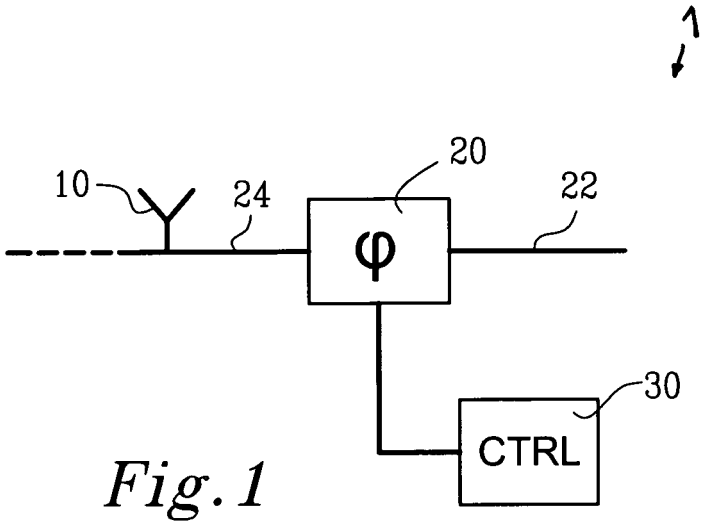

Fig. 1

EP 1 635 418 A1

Description

[0001] This invention relates to phase shifting in RF applications, and in particular to phase shifting in a portable communication device. More particularly, the present invention relates to a phase shifter device and a portable communication device comprising the same.

[0002] In a portable communication device, such as a cellular phone, comprising radiating elements (multiple band antennas etc), different frequencies (separate frequency bands or different frequencies within a band) might need to be phase shifted differently, for instance to optimize performance or to reduce radiation body losses (RF losses).

[0003] A solution to this problem is for instance to provide so-called "delay lines" having different lengths, which requires a larger number of phase shifters. Typically, these phase shifters must be low cost, light in weight, have low power consumption etc. Besides that, a drawback is that phase shifters are normally bulky, which of course implies a problem since the space available on the PCB is limited. For instance, it could be impossible to find space for several delay lines, at least to a reasonable cost. Yet another drawback is that many components have to be measured and approved.

[0004] Phase shifters typically comprise ferrites, PIN diodes and FET switch devices. Such devices are comparatively heavy, have comparatively high power consumption and are typically expensive. Moreover, PIN diodes and FET switches require DC bias voltage, which limits frequency performance and increase RF loss.

[0005] Thus, there is a need to provide a phase shifter device which is capable of phase shifting different frequencies or frequency bands, which device is not bulky, does not have high power consumption, and which is cheap, such that requirements concerning weight, cost and performance are fulfilled.

SUMMARY OF THE INVENTION

[0006] One object of the present invention is thus directed towards providing a phase shifter device, for a portable communication device, that is capable to phase shift different frequencies, such that requirements concerning weight, cost and performance are fulfilled.

[0007] According to a principal aspect of the present invention, this object is achieved by a phase shifter device, in which micro-electro-mechanical switches MEM switches are added along a delay line.

[0008] According to a first aspect of the present invention, there is provided a RF phase shifter device for a portable electronic communication device, said phase shifter device comprising:

> a phase switch device having a first in-port for an incoming RF signal, and a second out-port for an outgoing RF signal;
> including a plurality of micro-electro-mechanical (MEM) switches controllable by a control unit, said phase switch device being arranged to select one of a plurality of phase shift values φ corresponding to a switchable time delay line having corresponding different selectable lengths, provided by the phase switch device to the incoming RF signal.

[0009] According to a second aspect of the present invention, including the first aspect, the control unit is provided by electronics.

[0010] According to a third aspect of the present invention, inclduing the first aspect, the phase switch device is arranged to be controlled by software and electronics providing the control unit. In this way, the length of the phase shift can be set.

[0011] A fourth aspect of the present invention includes any one of the previous aspects, wherein the MEM switches are metal-metal contact MEM switches.

[0012] A fifth and sixth aspect of the present invention, includes any one of the first to the fourth aspects, wherein a plurality of switching devices are connected in series, or in parallel providing a set of selectable phase shifts to the RF signal(s).

[0013] A seventh aspect of the present invention includes any one of the first to the fourth aspects, wherein a plurality of switching devices are connected in series, and in parallel providing a set of selectable phase shifts to the RF signal(s).

[0014] Yet another aspect of the present invention includes any one of the previous aspects, wherein there is provided a portable electronic communication device comprising:

> a RF phase shifter device for a portable electronic communication device, said phase shifter device comprising:
>
> > a phase switch device having a first in-port for an incoming RF signal, and a second out-port for an outgoing RF signal;
> > including a plurality of micro-electro-mechanical (MEM) switches controllable by a control unit, said phase switch device being arranged to select one of a plurality of phase shift values φ corresponding to a switchable time delay line having corresponding different selectable lengths, provided by the phase switch device to the incoming RF signal.

[0015] The phase shift can be controlled for each part of the frequency range that needs to be adjusted. Since the switching between different channels/bands are quite few compared to Rx/Tx switching, MEM switches would not have any problem handling this.

[0016] The present invention has many advantages, one being that prior art devices are relatively heavier, consume more DC power and more expensive than the device according to the present invention, since the need

of several phase shifters will be eliminated.

[0017] It should be emphasized that the term "comprises/comprising" when used in this specification is taken to specify the presence of stated features, integers, steps or components, but does not preclude the presence or addition of one or more other features, integers, steps, components or groups thereof.

BRIEF DESCRIPTION OF DRAWING FIGURES

[0018] The present invention will now be described in more detail in relation to the enclosed drawings, in which:

Fig. 1 is a schematic and simplified diagram of an antenna element in a portable communication device coupled to a phase shifter device according to an aspect of the invention.

Fig. 2 is a schematic electrical diagram of a MEM switch.

Fig. 3a-3b are schematic side sectional views of an exemplary MEM switch in an open and closed state, respectively.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0019] Referring now to the drawings, a description will be given in detail of embodiments in accordance with the present invention.

[0020] Fig. 1 shows a schematic and simplified diagram of an antenna element 10 in a portable communication device coupled to a phase shifter device 1 according to an aspect of the invention. In this embodiment only one antenna element 10 is shown, but without departing from the inventive idea, several antenna elements 10, arranged in any suitable manner such as a multi-band antenna, comprising several antenna elements, or the like, could also be provided (illustrated by a dashed line). The antenna element 10 is connected to the phase shifter device 1, comprising a phase switch device 20, having a first in-port 22 for an incoming RF signal, and a second out-port 24 for an outgoing RF signal, which phase switch device 20 comprises a plurality of micro-electro-mechanical switches (MEM switches) (not indicated in detail in this figure) added along a delay line, i. e. the MEM switches are integrated in the phase shifter device 1. The MEM switches can be connected in series, in parallel, or in any other suitable configuration. The employment of MEM switches reduces the number of phase shifters required to phase switch different frequencies. A control unit (CTRL) 30 provides control signals to the phase switch device 20, arranged to set a particular phase shift φ depending on the particular control signal, preferably embodied by means of suitable software combined with electronics. The phase shift φ can be controlled for each part of the frequency range that needs to be adjusted.

[0021] Since the switching between different channels/bands are quite few compared to Rx/Tx switching, the MEM switches (in the phase switch device 20) would have no problem handling this. By means of the invention, there will be no need of several bulky, power consuming phase shifters or many space consuming delay lines.

[0022] In the embodiments described herein, the phase switch device 20 comprising MEM switches employ MEM metal-metal switches known per se. Fig. 2 shows a schematic electrical diagram of a MEM switch 40, which is provided with a first RF port 42, and a second RF port 44, forming a RF line, and a switching element 46 that can be closed to complete a path between the first and second port 42, 44. Typically this is performed by means of applying a control voltage (control signal) between line 48 and line 49 (ground), which are connected to so-called "bias electrodes" (not shown in this figure; see Fig. 3).

[0023] There is a physical separation between the bias electrodes and the RF ports 42, 44 provided by insulating layers, such as silicon nitride layers. In this way, the RF line and the control signal (the control voltage) are separated from each other rendering no influence on the RF line.

[0024] Typically, the surface area that the MEM switch 40 requires on a printed circuit board (PCB) is very small (compared to a plurality of delay lines on a PCB), and typically require low DC control power to be operated. The MEM switches can be of any suitable type such as being made of GaAs, provided with metal layers that are conductive. Moreover, the MEM switches do not need bias voltage (and thereto necessary circuits) on the RF line. Fig. 3a-b are diagrammatic side views of a MEM switch in open (signal isolation) and closed state (signal transmission). The drawings are not to scale.

[0025] Fig. 3a-b show the MEM switch 40 in more detail and the function thereof. The switch 40 is typically fabricated on a substrate 41, provided with conductive contact layers 42, 44, the switching element 46, bias electrodes (not shown), conductive pads (not shown). the switching element 46 can for instance be fabricated as a metal layer operating such that when the switch is in its closed state, there is a path between the RF ports 42, 44 (See Fig. 3b). In its open state, the RF ports 42, 44 are separated by a distance, which is typically a few microns or the like. When a voltage is applied across the bias electrodes, the beam 62 is pulled downwards by an electrostatic force, providing contact and closing the switch.

[0026] According to the invention, a plurality of MEM switches are added along a delay line such that different transmission lengths (line paths) can be achieved, thereby realizing different corresponding phase shifts. Preferably, a plurality of MEM switches are connected in close proximity to each other, for instance in series, forming different phase shift transmission path lengths to provide a phase switch device according to the invention, in which different phase shift values can be selected.

[0027] The MEM switches 40 can be arranged in integrated circuits providing the phase switching device 20, or they can be provided directly on conventional PCBs to provide even lower cost.

[0028] It should be realised that cellular phone is just one type of communication device having an antenna element in which the invention can be implemented. It can just as well be provided in other types of portable electronic equipments such as a lap top computer, a palm top computer, an electronic organizer, a smart-phone, a communicator.

[0029] There are more ways in which the invention can be varied. Therefore the invention is only to be limited by the accompanying claims.

Claims

1. A RF phase shifter device for a portable electronic communication device, said phase shifter device (1) comprising:

   a phase switch device (20) having a first in-port (22) for an incoming RF signal, and a second out-port (24) for an outgoing RF signal;
   including a plurality of micro-electro-mechanical (MEM) switches (40) controllable by a control unit (30), said phase switch device (20) being arranged to select one of a plurality of phase shift values φ corresponding to a switchable time delay line having corresponding different selectable lengths, provided by the phase switch device (20) to the incoming RF signal.

2. The RF phase shifter device of claim 1, wherein the control unit (30) is provided by electronics.

3. The RF phase shifter device of claim 1, wherein the control unit (30) is provided by software and electronics.

4. The RF phase shifter device of any one of the previous claims, wherein said MEM switches (40) comprise metal-metal contact MEM switches.

5. The RF phase shifter device of claim 1-4, wherein said MEM switches (40) are connected in series.

6. The RF phase shifter device of claim 1-4, wherein said MEM switches (40) are connected in parallel.

7. The RF phase shifter device of claim 1-4, wherein said MEM switches (40) are connected in series and in parallel.

8. A portable electronic communication device comprising:

   a RF phase shifter device (1) for a portable electronic communication device, said phase shifter device (1) comprising:
   a phase switch device (20) having a first in-port (22) for an incoming RF signal, and a second out-port (24) for an outgoing RF signal;
   including a plurality of micro-electro-mechanical (MEM) switches (40) controllable by a control unit (30), said phase switch device (20) being arranged to select one of a plurality of phase shift values φ corresponding to a switchable time delay line having corresponding different selectable lengths, provided by the phase switch device (20) to the incoming RF signal.

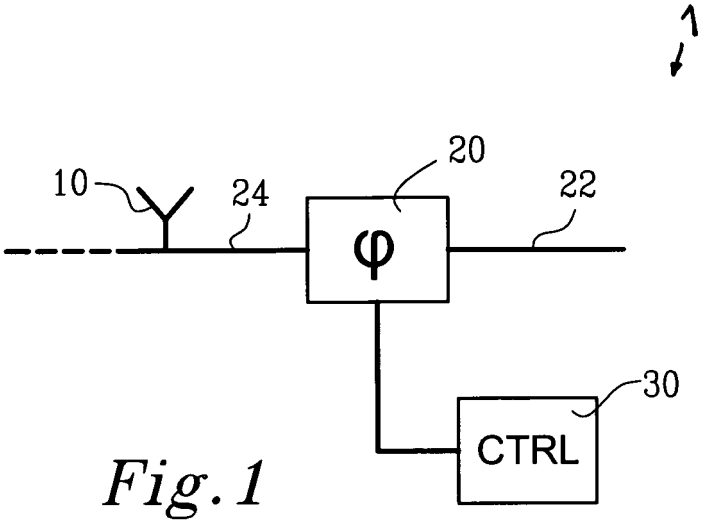

Fig. 1

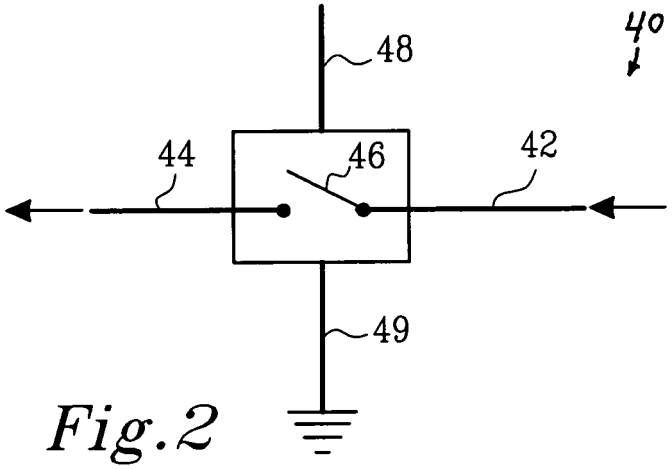

Fig. 2

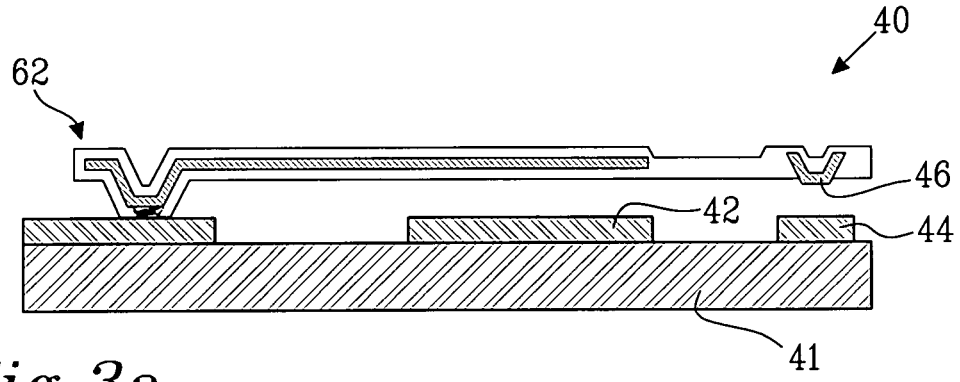

Fig.3a

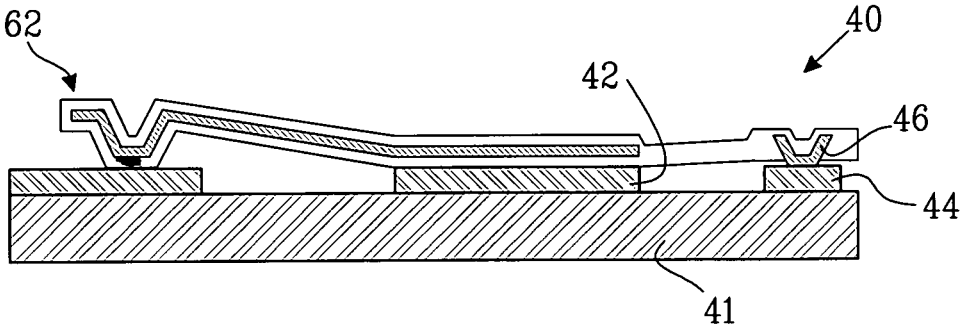

Fig.3b

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EUROPEAN SEARCH REPORT

Application Number
EP 04 02 1432

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	11 February 2005	Cordeiro JP

CATEGORY OF CITED DOCUMENTS

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