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(54) Resonant assembly

(57) A resonator assembly, comprises: a resonator having a first resonance post coaxially surrounded by a conductive enclosure defining a cavity. The first resonance post is operable to filter a signal at a first frequency. The resonator further comprises a second resonance post located within the cavity. The second resonance post is operable to filter a signal at a second frequency. The resonator comprises a signal coupling configured to couple the signal to a resonator output. Through this approach it is possible to provide an adaptable single device which implements more than one independent resonances within the same cavity volume, allowing to build significantly smaller cavity filters, which avoids the need to provide separate devices, one for each frequency by allowing for independent coupling of each resonant frequency from said cavity. This is particular convenient in resonant assemblies used in RF front ends which will often be required to receive signals at two different frequencies, one for uplink and one for downlink.

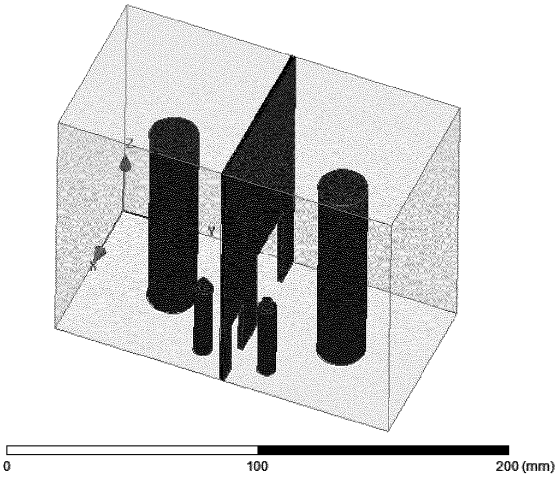

Figure 1d Perspective view

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to a resonant assembly.

BACKGROUND

[0002] Resonant devices are known. In low-frequency electronics, a resonant circuit contains a capacitor and a coil. The capacitor is used to store electrical energy and the coil stores magnetic energy. At resonance, energy stored in the resonant circuit is continuously converted between two states, swapping between capacitor and coil over time. At higher frequencies, transmission lines can resonate. A quarter-wavelength transmission line with one end grounded and the other end open can be seen as a combination of a capacitor and coil. Increasing the permittivity of the transmission line by using, for example, ceramic materials reduces the size of the resonant device. Resonant devices are often used in radio-frequency (RF) front ends. Each resonant device has its own characteristics, including its own resonance frequency. The resonance frequency is dependent on the characteristics of the device and, in particular, on the characteristics of the mixtures of various materials making up the device.

[0003] It is desired to provide an improved resonant device.

SUMMARY

[0004] Accordingly a first aspect provides a resonator assembly, comprising: a resonator having a first resonance post coaxially surrounded by a conductive enclosure defining a cavity, said first resonance post being operable to filter a signal at a first frequency and a second resonance post located within said cavity, said second resonance post being operable to filter a signal at a second frequency; said assembly also comprising: a signal coupling, configured to couple said signal to a resonator output.

[0005] The first aspect recognises that conventional resonators such as, for example, a Transverse ElectroMagnetic (TEM) combline resonator, consists of a metallic cavity enclosure (with a generally circular-shaped or rectangular-shaped cross section) with a cylindrical-shaped metallic post at the centre of the circular/rectangular cavity grounded at one side and open-ended at the opposite side. Each of these resonators is dimensioned to provide a resonance at a particular desired frequency. However, the first aspect recognises that it is possible to reuse the cavity in order provide a resonator which provides a resonance at more than one particular desired frequency. Accordingly a resonator assembly may be provided. The assembly may comprise a resonator which has a first resonance post or element which may be surrounded or enclosed by a conductive enclosure or housing. The conductive enclosure may define a cavity. The first resonance post may resonate or filter a signal at a first frequency. The assembly may comprise a resonator which has a second resonance post or element located within the cavity. The said second resonance post may resonate or filter a signal at a second frequency. Through this approach it is possible to provide a single device which implements more than one independent resonances within the same cavity volume, allowing to build significantly smaller cavity filters, which avoids the need to provide separate devices, one for each frequency. This is particular convenient in resonant assemblies used in RF front ends which will often be required to receive signals at two different frequencies.

[0006] The first aspect recognizes that a dual frequency resonator structure may require provision of suitable coupling mechanisms and filter structures. In particular, the first aspect recognizes that to utilize dual frequency resonators in a filter structure it is required to provide a coupling mechanism to couple individual high-band resonators to each other and individual low-band resonators to each other. Such coupling mechanisms may be arranged such that each band-specific coupling can be adjusted or selected without causing any effect on the coupling or tuning of the other band. Such an arrangement recognizes that it can be advantageous to be able to independently design the filter performance for each band.

[0007] The first aspect may provide a resonator which is configured to offer a means to limit bandwidth of a signal leaving such a resonant cavity structure. The dimensions of the enclosure and resonance posts may be selected to offer a tuned resonance at frequencies of interest. The nature of a coupling to the resonator output may be selected to offer a means to control bandwidth of a signal exiting the resonator. The first aspect recognises that it may be useful to provide a means to couple a signal within a resonator to an output for further use. Such further use may, for example, be further filtering by another resonator, or output to a device or apparatus which is to use a fully filtered signal.

[0008] In one embodiment, the signal coupling is configured to offer independent coupling of the first and second signal at different frequencies to said resonator output. Accordingly, the cavity may support resonance of a signal at least two different frequencies, and those frequencies may be coupled from said resonator independently. That is to say, one frequency may be extracted from the cavity without impinging on extraction of the other frequency.

[0009] In one embodiment, the signal coupling comprises a first signal coupling arranged to couple the signal filtered at a first frequency to a first resonator output and a second signal coupling arranged to couple the signal filtered at a second frequency to a second resonator output. Accordingly, a separate and distinct coupling may be provided in respect of each frequency supported by said cavity.

[0010] In one embodiment, at least one of the first and second signal coupling comprises: an opening provided in said conductive enclosure. Accordingly, that opening may be provided in a side wall of said conductive enclosure.

[0011] In one embodiment, at least one of the first and second signal coupling comprises: an inductive or capacitive wire. Accordingly, that inductive or capacitive wire may pass through a wall of said enclosure.

[0012] In one embodiment, the resonator assembly comprises: an inductive or capacitive wire arranged to couple one of the first and second resonance posts to another of said resonance posts of the same type provided within the cavity. Accordingly coupling between resonance posts of the same type within a cavity may be supported.

[0013] In one embodiment, the opening and/or wire is dimensioned to select a bandwidth of a signal coupled to the resonator output. The cavity and posts may be arranged and configured to tune the resonances offered by the resonator assembly to those frequencies ofparticular interest. The coupling, be it an opening or wire, may be dimensioned in relation to the dimensions of the enclosure and/ or posts to provide an output having a desired bandwidth in relation to each of the resonances of interest.

[0014] In one embodiment, the signal coupling comprises: a first opening configured to couple the signal at the first frequency to the resonator output and a second opening configured to couple the signal at the second frequency to the resonator output. Accordingly, in some embodiments, it is possible to provide a dual slot decoupling mechanism which is configured to function in dual-frequency fundamental mode combline resonator in filter topologies. Such an arrangement may allow for the resonant signals of interest to be extracted independently from the cavity.

[0015] In one embodiment, the first and second openings are adjacent each other and the enclosure and openings are dimensioned to allow spatial separation of the first and second openings. It will be understood that the dimensions of the enclosure and the frequencies of interest may be selected to support such a dual slot decoupling iris. The dimensions of each slot may be adjusted, in some embodiments, such that the decoupling or coupling offered by each slot is independent to that offered by the other slot.

[0016] In one embodiment, the assembly comprises a plurality of the resonators adjacently located and having shared portions of the conductive enclosure, and wherein the second resonance post in each resonance filter is located towards the shared portions of the conductive enclosure. Accordingly, an appropriate filter, or duplexer may be constructed from a plurality of said resonators.

[0017] In one embodiment, the resonator output of one resonator comprises a signal input to an adjacently located resonator. Accordingly, a signal or signals may be obtained having desired characteristics.

[0018] In one embodiment, said first resonance post and said second resonance post upstand from said conductive enclosure. Accordingly, the posts may project or extend within the cavity.

[0019] In one embodiment, said second frequency is greater than said first frequency.

[0020] In one embodiment, harmonics of said first frequency fail to coincide with harmonics of said second frequency.

[0021] In one embodiment, said second frequency and said first frequency have no common harmonics.

[0022] In one embodiment, said first resonance post and said second resonance post have matching electrical lengths. It will be appreciated that the physical lengths may vary or may be the same depending on the frequency and the permittivity and conductivity of the posts.

[0023] In one embodiment, said first resonance post is located centrally within said conductive enclosure and said second resonance post is located away from said first resonance post and towards said conductive enclosure. Accordingly, the second resonance post may reuse part of the cavity.

[0024] In one embodiment, said first resonance post is operable to convey a signal using a first signal feed and said second resonance post is operable to convey a signal using a second signal feed, at least one of said first signal feed and said second signal feed being provided through a base of said conductive enclosure from which a respective one of said first resonance post and said second resonance post upstands. Hence, the feed may be provided through a part of the enclosure which is other than a side-wall.

[0025] In one embodiment, said first resonance post and said second resonance post convey a signal using a common signal feed positioned between said first resonance post and said second resonance post. Accordingly, a single feed may be provided to convey the signal simultaneously to each post.

[0026] In one embodiment, said common signal feed extends between a base of said conductive enclosure from which said first resonance post and said second resonance post upstands and a face of said conductive enclosure towards which said first resonance post and said second resonance post upstand.

[0027] In one embodiment, at least one of said first resonance post and said second resonance post is configured to have a variable length. In order to tune these two resonances independently, a dedicated tuning mechanism for each resonance is provided. By varying the length, the frequency may be tuned.

[0028] In one embodiment, at least one of said first resonance post and said second resonance post comprises a first portion displaceable with respect to a second portion to vary its length.

[0029] In one embodiment, said first portion is received within said second portion.

[0030] In one embodiment, said second portion comprises a post having a cavity extending therethrough for receiving said first portion therewithin.

[0031] In one embodiment, said first portion comprises a screw received within a screwthread formed within said cavity, said first portion being protrudable from said second portion to vary its length. As mentioned above, conventionally, in order to build filters with two or more resonances, individual physically separated filter cavities for each frequency band are built and these then are tuned independently. Conventionally, these resonances are tuned by tuning screws which protrude through a cavity wall or thorough the cavity cover into the cavity, located close to the region with the highest electrical field of the according resonant mode. However, this approach is often not possible or implies restrictions on the resonator layout, particularly for the resonant mode for the higher frequency which is excited on the shorter resonator post. For example, where the physical distance between the top end of the resonator-post is large, a long tuning screw would have a negative impact on the Q-factor of the resonator or would even result in a complete detuning of the resonator. In some cases it might be feasible to use a tuning screw from the side, but usually in more complex structures, e.g. in a filter-configuration, where several cavities are placed next to each other, this is not possible, since two rows of resonators are placed in parallel, making it impossible to place tuning screws from the side.

[0032] Further particular and preferred aspects are set out in the accompanying independent and dependent claims. Features of the dependent claims may be combined with features of the independent claims as appropriate, and in combinations other than those explicitly set out in the claims.

[0033] Where an apparatus feature is described as being operable to provide a function, it will be appreciated that this includes an apparatus feature which provides that function or which is adapted or configured to provide that function.

BRIEF DESCRIPTION OF THE DRAWINGS

[0034] Embodiments of the present invention will now be described further, with reference to the accompanying drawings, in which:

Figures 1a to 1d illustrate schematically a structural configuration including a dual-slot de-coupling iris according to one embodiment;
Figures. 2a and 2b illustrate schematically a structural configuration of a resonator including an inductive coupling wire according to one embodiment;
Figure 3 illustrates schematically a structural configuration of a resonator including an inductive coupling wire according to one embodiment;
Figure 4 illustrates schematically a cascaded quadruplet filter structure configuration according to one embodiment;
Figures 5a to 5c illustrate schematically performance simulations in relation to an arrangement such as that shown schematically in Figure 4;
Figure 6 illustrates a dual-frequency combline resonator according to one embodiment;
Figures 7 and 8 show the EM field distribution for the two resonant modes;

DESCRIPTION OF THE EMBODIMENTS

[0035] An arrangement is provided where the cavity of a resonator is reused to co-house a further resonator. This provides a device which is able to provide resonance at multiple frequencies without needing to provide multiple devices, each with their own housing. Instead, the resonators are co-located within the same housing. This enables a single device to be provided which operates in same way as a plurality of different resonators, but with a significantly reduced size compared to providing separate resonators. Although the resonator structures can have similar permittivity and and can vary their resonant frequency by varying the length of resonant posts, varying the permittivity of the different resonator structures enables similar-sized structures to resonate at different frequencies. Also, although the embodiments described below provide for a two-frequency resonator, it will be appreciated that by adding additional resonator structures within the housing enables a more than two-frequency resonator to be provided.

[0036] Possible structures and features of a dual frequency resonator and filter assembly are described in detail in relation to Figures 6 to 8 below

Overview

[0037] Before discussing the embodiments in any more detail, first an overview will be provided.

[0038] Aspects and embodiments provide a dual slot de-coupling iris mechanism and/or an inductive wire coupling mechanism configured to function in dual-frequency fundamental mode combline resonator in filter topologies. A particular embodiment comprising a cascaded quadruplet configuration is described.

[0039] Coupling devices and arrangements according to aspects and embodiments recognize that it is possible to independently control coupling between adjacent same-frequency-band resonators in a dual frequency arrangement such that individual filtering at distinct frequency bands and bandwidths is achieved. Aspects and embodiments recognize that individual filtering at distinct frequency bands and bandwidth may be achieved in a number of different ways, for example, by configuring a de-coupling iris such that it allows spatial separation of dedicated de-coupling slots as shown in Figure. 2; and/or by configuring an inductive or capacitive wire such that it allows coupling of resonators in an inline topology.

[0040] Aspects and embodiments may provide, for example, a dual-slot de-coupling iris that allows independent control of coupling at distinct frequencies supported by a resonator assembly. Similarly, aspects and embodiments may provide coupling by means of an inductive or capacitive wire mechanism that may allow for the extension of a filter topology to any number of filter poles for two distinct frequency bands by allowing coupling between high frequency resonant structures in isolation.

[0041] One embodiment may provide a cascaded quadruplet structure configuration to support high order filtering functions with the sole use of a plurality of appropriately configured dual-slot de-coupling irises.

[0042] Further aspects and embodiments may provide a four-port device with distinct input/ output coupling to support dual-frequency filtering

[0043] Figures 1a to 1d illustrate schematically a structural configuration including a dual-slot de-coupling iris according to one embodiment. Provision of a dual slot iris may allow for independent coupling of low frequency adjacent resonators and high frequency resonators in adjacent resonator enclosures.

[0044] Figures. 2a and 2b illustrate schematically a structural configuration of a resonator including an inductive coupling wire according to one embodiment. The configuration shown schematically in Figures 2a and 2b allow for coupling of high frequency resonances of two resonators which are located in two separate cavities.

[0045] Figure 3 illustrates schematically a structural configuration of a resonator including an inductive coupling wire according to one embodiment. On particular, Figure 3 shows a coupling wire configuration operable to couple two high-frequency resonators located within the same cavity. Such an arrangement allows independent coupling of high frequency adjacent resonators when the cavities are structured in an inline configuration.

[0046] Combinations of the coupling mechanisms shown in Figures 1 to 3 can allow for various configurations of a dual-resonance cavity structure, for example: linear arrangements, folded, and similar, as required to achieve a desired filter function. By combining an inductive or capacitive wire coupling with an iris coupling it can allow for a filter arrangement having a different number of resonators in each of the two bands of interest, for example, by placing two high-band resonators in each cavity and one low-band, the number ofresonator poles is twice as high for the high band than for the low band.

[0047] Figure 4 illustrates schematically a cascaded quadruplet filter structure configuration according to one embodiment. The filter arrangement shown in Figure 4 includes four cavities that support dual-frequency resonances. The configuration is such that it is possible to couple adjacent resonators for both individual frequency bands by means of utilizing a folded cavity configuration out of the four resonators. De-coupling irises are utilized for controlling the coupling between adjacent resonators for both frequencies. For the high frequency, input/ output ports are realized through SMA coaxial ports at the bottom of the metallic cavity. Similarly, for the low frequency, input/ output ports are realized through SMA coaxial ports at the side walls of the metallic cavity.

[0048] A substantially conventional synthesis approach can be adopted for each individual filter. Design techniques correspond to those used in the conventional design of combline filters. That is to say, parameters calculated to offer individual and independent frequency tuning and bandwidth selection from a cavity and filter involve calculation of resonant frequencies and coupling coefficients in relation to each individual frequency of interest, when considering an entire resonant structure, that is to say, a cavity with at least two posts and combined cavities having at least two resonance posts.

[0049] Figures 5a to 5c illustrate schematically performance simulations in relation to an arrangement such as that shown schematically in Figure 4. In particular an eigenmode solver has been utilized to calculate resonant frequencies and coupling coefficients for a cavity such as that shown in Figure 4. CST microwave studio can be used to simulate an entire filter structure according to Figure 4. Figures 5a and 5b show plots of a simulated performance of a 4-port device such as that shown in Figure 4 when port 3 is excited. Results are computed for the frequency range of 0.5 - 1.2 GHz. Figure 5c shows a plot of simulated performance of a 4-port device such as that shown in Figure 4 when port 1 is excited. Results have been computed for a frequency range of 1.2 -2.0 GHz.

[0050] Figure 5 results are such that it is observable that the decoupling between the low-band and the high-band port is around -20dB, as a result of the specific configuration shown in Figure 4, where the number of low-frequency-resonators is the same as the number of high-band resonators, and can be tolerated for a dual-frequency TX-filter and respectively for a dual-band-RX-filter. For a resonator or filter arrangement to offer a duplexer function the decoupling of an arrangement would need to be increased by adding further poles for the high- or low-frequency band.

Example Resonator Configuration

[0051] Figure 6 illustrates a dual-frequency combline resonator according to one embodiment. This arrangement utilizes the physical space provided by the single, in this example, rectangular, cavity provided in a combline package to include an additional metallic cylindrical post offset from a central location and towards a corner of the rectangular cavity. This is to introduce an additional electromagnetic resonance at a higher frequency. Although a rectangular package is shown, it will be appreciated that any other configuration which provides a coaxial arrangement between the metallic cylindrical post at the central location and a surrounding conductive enclosure could be used. Also, although the posts illustrated are cylindrical, it will be appreciated that non-cylindrical posts may be used.

[0052] In operation, this arrangement creates two electromagnetic (EM) resonances at distinct frequencies, f_1 (a lower frequency due to the centre metallic post) and f_2 (a higher frequency due to the corner metallic post). The centre metallic post within the rectangular metallic cavity with the corner metallic post present resonates at a frequency f_1 (which is slightly different to the frequency at which it would resonate if it were alone within the cavity), whereas the metallic post at the corner within the cavity with the metallic post at the centre present resonates at a higher desired frequency f_2 ($f_2 > f_1$). Due to the distinct and separated in spectrum resonances at f_1 and f_2 for a dual-resonance cavity, the corner metallic post's physical size is a fraction of the centre metallic post's size. This ratio is proportional (within limitations of the frequency ratio f_2/f_1 and specific technology implementation variations) to the ratio of frequencies f_1 and f_2.

[0053] This arrangement enables two electromagnetic resonances at distinct frequencies in a single physical volume within a single metallic enclosure in a combline package. In addition this arrangement provides for dual-posts in a single cavity; a centre post for lower frequency operation and a corner post for higher frequency operation. Furthermore, this arrangement provides for the spatial separation of the resonance field distribution to allow for independent control of input/ output coupling/tuning/inter-resonator coupling.

[0054] For optimal operation, the ratio of the frequencies (f_2/f_1) for the dual-resonance cavity should be selected so that the ratio (f_2/f_1) cannot be close to unity (i.e., the two frequencies cannot be very similar), since the two resonances cannot then be uncoupled as required for two distinct filtering functions to be realized. Also, for a combline package, the ratio between the frequencies cannot be close to 3, since the first higher order resonance $n{*}f_1$ ($n=3$) of the low frequency resonance (f_1) will coincide with the second, high frequency fundamental mode resonance, (f_2). However, it will be appreciated that this is not a substantial problem for a number of dual-frequency applications (e.g., operating at 700 MHz and 1800 MHz).

[0055] An eigenmode analysis tool has been utilized to calculate the resonant frequency and Q-factor of the resonant structures considered. Ohmic losses are included in the simulations; silver has been considered for the cavity walls and copper for the posts (although other materials could be used). The results demonstrate that two resonant modes can be supported with this configuration and that these resonant modes closely correspond to the resonant modes of the individual standalone resonator modes of the low-band and high-band resonators.

[0056] Figures 7 and 8 show the EM field distribution for the two resonant modes.

[0057] Table 1 summarizes the resonant frequency and Q-factor of the first 3 eigenmodes of the standalone low-band combline resonator, standalone high-band resonator and combined resonator of Figure 2.

Table 1: Resonant frequency and Q-factor for the first 3 eigenmodes of the standalone low-band cavity, standalone high-band cavity, and combined low+high-band cavity

	Mode 1			Mode 2			Mode 3		
	f_0 (MHz)	Q_0		f_0 (MHz)	Q_0		f_0 (MHz)	Q_0	
Low	695.792	6407		2061.33	11389		2223.42	13850	
High	1792.12	4004		5237.13	7026		5722.69	8652	
Low + High	696.044	6186	f_0 (%) 0.04 U Q_0 (%) 3.45 D	1769.86	4449	f_0 (%) 1.24 D Q_0 (%) 11.1 U	2065.57	11243	f_0 (%) 0.26

[0058] The low frequency resonance of the combined cavity resonator is not affected as compared to the standalone low frequency cavity resonator. The Q-factor is slightly decreased (3.45 %). Similarly, the high-frequency resonance is not affected, whereas the Q-factor has been increased significantly (11.1 %). This is due to the greater electrical size of the host cavity. It is to be noted that the first harmonic resonance frequency of the standalone low-band resonator is not significantly affected by the inclusion of the high-band metallic post, thus does not create problems for the high-band resonance of the combined cavity.

[0059] Accordingly, it can be seen that embodiments provide an arrangement having a reduced physical size but enabling two distinct resonant frequencies to coexist at the expense of slightly higher manufacturing and design complexity. Through this approach, no additional physical space is required for the high band resonant structure (f_2). Instead this is incorporated into the low band resonant structure (at f_1) without any additional physical space requirement. This provides an arrangement which offers high Q-factor (at f_2) with no additional physical space requirements. The additional physical space of the combined resonant structure allows for increase in the quality factor at the high frequency regime (f_2). This can allow for high performance filtering; required for narrow-band filter wireless telecommunication applications. The quality factors of the high frequency resonant structures are higher (represent lower ohmic loses) as compared with the standalone high filtering quality factors in the conventional filtering approaches. Also, due to the fact that additional physical space is inherent to the resonant structure for the high frequency, increase in the high power handling capabilities for terrestrial communication systems can be pursued. Furthermore, although there are additional cost of fabrication for a resonant structure at the high frequency there is an overall cost reduction due to the fact that only one resonant cavity needs to be fabricated instead of two.

[0060] A person of skill in the art would readily recognize that steps of various above-described methods can be performed by programmed computers. Herein, some embodiments are also intended to cover program storage devices, e.g., digital data storage media, which are machine or computer readable and encode machine-executable or computer-executable programs of instructions, wherein said instructions perform some or all of the steps of said above-described methods. The program storage devices may be, e.g., digital memories, magnetic storage media such as a magnetic disks and magnetic tapes, hard drives, or optically readable digital data storage media. The embodiments are also intended to cover computers programmed to perform said steps of the above-described methods.

[0061] The functions of the various elements shown in the Figures, including any functional blocks labelled as "processors" or "logic", may be provided through the use of dedicated hardware as well as hardware capable of executing software in association with appropriate software. When provided by a processor, the functions may be provided by a single dedicated processor, by a single shared processor, or by a plurality of individual processors, some of which may be shared. Moreover, explicit use of the term "processor" or "controller" or "logic" should not be construed to refer exclusively to hardware capable of executing software, and may implicitly include, without limitation, digital signal processor (DSP) hardware, network processor, application specific integrated circuit (ASIC), field programmable gate array (FPGA), read only memory (ROM) for storing software, random access memory (RAM), and non volatile storage. Other hardware, conventional and/ or custom, may also be included. Similarly, any switches shown in the Figures are conceptual only. Their function may be carried out through the operation of program logic, through dedicated logic, through the interaction of program control and dedicated logic, or even manually, the particular technique being selectable by the implementer as more specifically understood from the context.

[0062] It should be appreciated by those skilled in the art that any block diagrams herein represent conceptual views of illustrative circuitry embodying the principles of the invention. Similarly, it will be appreciated that any flow charts, flow diagrams, state transition diagrams, pseudo code, and the like represent various processes which may be substantially represented in computer readable medium and so executed by a computer or processor, whether or not such computer or processor is explicitly shown.

[0063] The description and drawings merely illustrate the principles of the invention. It will thus be appreciated that those skilled in the art will be able to devise various arrangements that, although not explicitly described or shown herein, embody the principles of the invention and are included within its spirit and scope. Furthermore, all examples recited herein are principally intended expressly to be only for pedagogical purposes to aid the reader in understanding the principles of the invention and the concepts contributed by the inventor(s) to furthering the art, and are to be construed as being without limitation to such specifically recited examples and conditions. Moreover, all statements herein reciting principles, aspects, and embodiments of the invention, as well as specific examples thereof, are intended to encompass equivalents thereof.

Claims

1. A resonator assembly, comprising:

a resonator having a first resonance post coaxially surrounded by a conductive enclosure defining a cavity, said first resonance post being operable to filter a signal at a first frequency and a second resonance post located within said cavity, said second resonance post being operable to filter a signal at a second frequency; and
a signal coupling, configured to couple said signal to a resonator output.

2. An assembly according to claim 1, wherein said signal coupling is configured to offer independent coupling of said first and second signal to said resonator output.

3. An assembly according to claim 1 or claim 2, wherein said signal coupling comprises a first signal coupling arranged to couple at said signal filtered at a first frequency to a first resonator output and a second signal coupling arranged to couple said signal filtered at a second frequency to a second resonator output.

4. An assembly according to claim 3, wherein at least one of said first and second signal coupling comprises: an opening provided in said conductive enclosure.

5. An assembly according to claim 3 or claim 4, wherein at least one of said first and second signal coupling comprises: an inductive or capacitive wire.

6. An assembly according to any preceding claim, wherein said resonator assembly comprises: an inductive or capacitive wire arranged to couple one of said first and second resonance posts to another of said resonance posts of the same type provided within said cavity.

7. An assembly according to any one of claims 4 to 6, wherein said opening or said wire is dimensioned to select a bandwidth of a signal coupled to said resonator output.

8. An assembly according to any preceding claim, wherein said signal coupling comprises: a first opening configured to couple said signal at said first frequency to said resonator output and a second opening configured to couple said signal at said second frequency to said resonator output.

9. An assembly according to claim 8, wherein said first and second openings are adjacent each other and said conductive enclosure and said openings are dimensioned to allow spatial separation of said first and second openings.

10. An assembly according to any preceding claim, comprising a plurality of said resonators adjacently located and having shared portions of said conductive enclosure, and wherein said second resonance post in each resonance filter is located towards said shared portions of said conductive enclosure.

11. An assembly according to claim 10, wherein said resonator output of one resonator comprises a signal input to an adjacently located resonator.

12. An assembly according to any preceding claim, wherein said first resonance post and said second resonance post upstand from said conductive enclosure.

13. An assembly according to any preceding claim, wherein said second frequency is greater than said first frequency.

14. An assembly according to any preceding claim, wherein harmonics of said first frequency fail to coincide with harmonics of said second frequency.

15. An assembly according to any preceding claim, wherein said first resonance post is located centrally within said conductive enclosure and said second resonance post is located away from said first resonance post and towards said conductive enclosure.

Amended claims in accordance with Rule 137(2) EPC.

1. A resonator assembly, comprising:

a resonator having a first resonance post coaxially surrounded by a conductive enclosure defining a cavity, said first resonance post being operable to filter a signal at a first frequency and a second resonance post located within said cavity, said second resonance post being operable to filter a signal at a second frequency; and
a signal coupling, configured to couple said signal to a resonator output; wherein
said first and second resonance posts are configured such that harmonics of said first frequency fail to coincide with harmonics of said second frequency and a ratio of said first and second frequency are not close to unity allowing said first and second frequency signals to be uncoupled; and
said first resonance post is located centrally within said conductive enclosure and said second resonance post

is located away from said first resonance post and towards said conductive enclosure.

2. An assembly according to claim 1, wherein said signal coupling is configured to offer independent coupling of said first and second signal to said resonator output.

3. An assembly according to claim 1 or claim 2, wherein said signal coupling comprises a first signal coupling arranged to couple at said signal filtered at a first frequency to a first resonator output and a second signal coupling arranged to couple said signal filtered at a second frequency to a second resonator output.

4. An assembly according to claim 3, wherein at least one of said first and second signal coupling comprises: an opening provided in said conductive enclosure.

5. An assembly according to claim 3 or claim 4, wherein at least one of said first and second signal coupling comprises: an inductive or capacitive wire.

6. An assembly according to any preceding claim, wherein said resonator assembly comprises: an inductive or capacitive wire arranged to couple one of said first and second resonance posts to another of said resonance posts of the same type provided within said cavity.

7. An assembly according to any one of claims 4 to 6, wherein said opening or said wire is dimensioned to select a bandwidth of a signal coupled to said resonator output.

8. An assembly according to any preceding claim, wherein said signal coupling comprises: a first opening configured to couple said signal at said first frequency to said resonator output and a second opening configured to couple said signal at said second frequency to said resonator output.

9. An assembly according to claim 8, wherein said first and second openings are adjacent each other and said conductive enclosure and said openings are dimensioned to allow spatial separation of said first and second openings.

10. An assembly according to any preceding claim, comprising a plurality of said resonators adjacently located and having shared portions of said conductive enclosure, and wherein said second resonance post in each resonance filter is located towards said shared portions of said conductive enclosure.

11. An assembly according to claim 10, wherein said resonator output of one resonator comprises a signal input to an adjacently located resonator.

12. An assembly according to any preceding claim, wherein said first resonance post and said second resonance post upstand from said conductive enclosure.

13. An assembly according to any preceding claim, wherein said second frequency is greater than said first frequency.

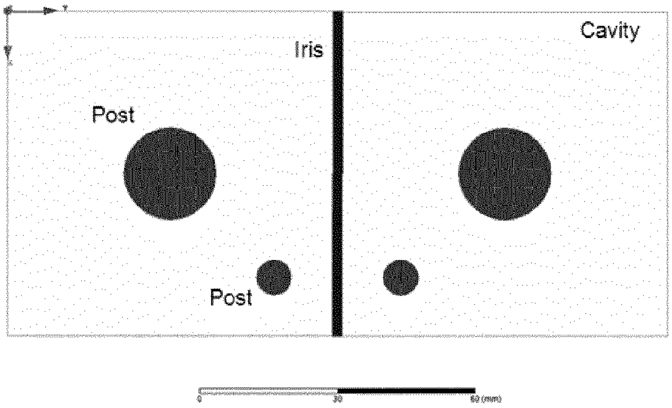


Figure 1a - Top view

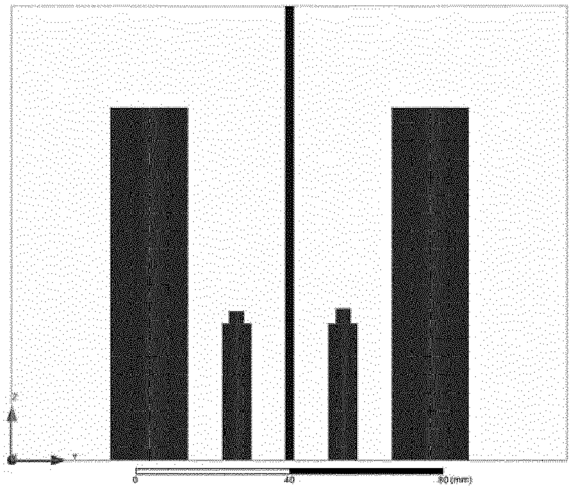


Figure 1b Front view

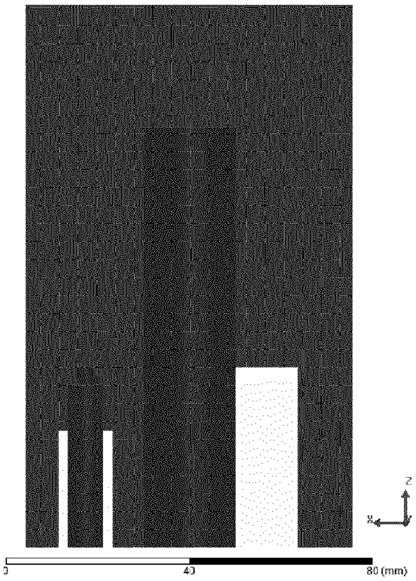


Figure 1c Side view

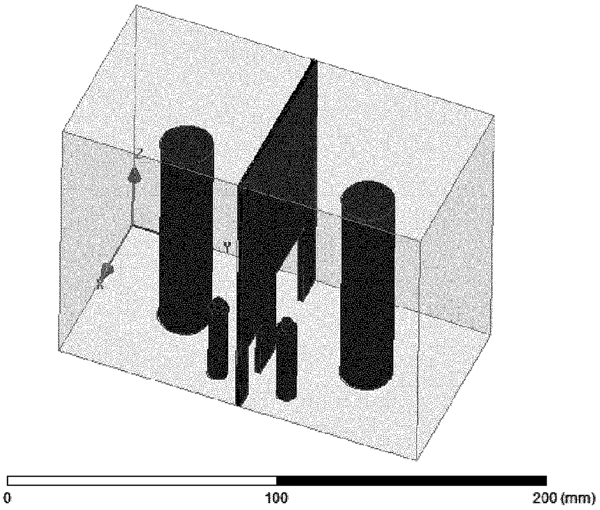


Figure 1d Perspective view

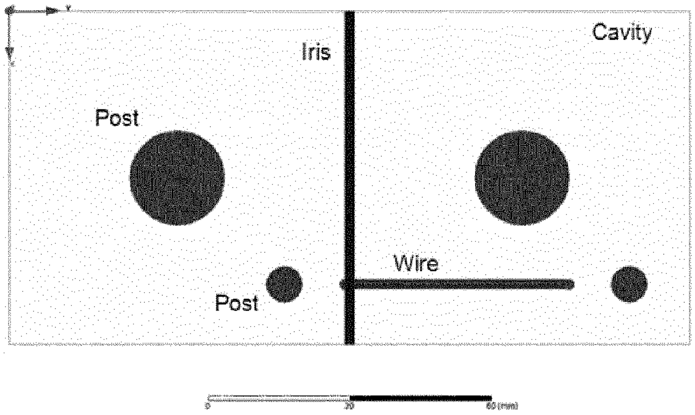


Figure 2a Top view

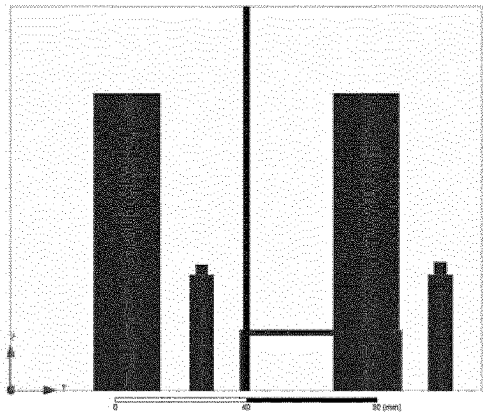
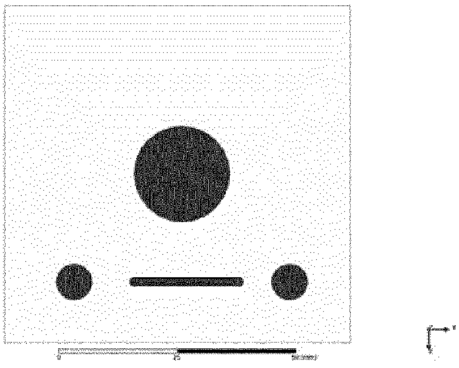


Figure 2b Front view



Top view

Figure 3: Configuration of proposed inductive wire coupling mechanism utilized for coupling high frequency resonators in an inline topology.

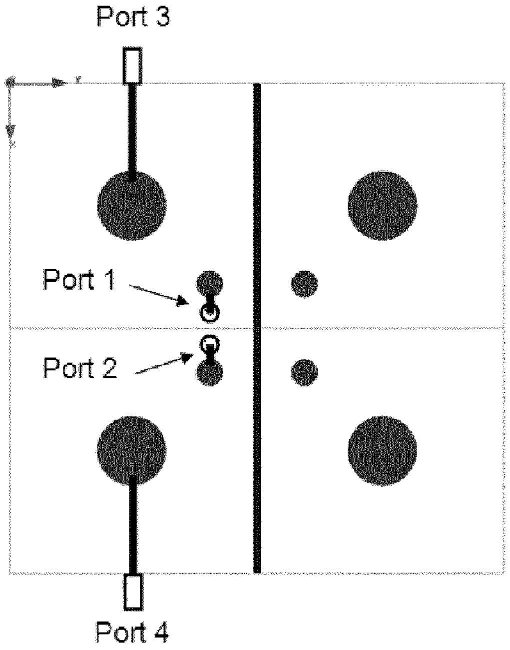


Figure 4: Configuration of proposed cascaded quadruplet structure configuration to support high order filter functions in a folded form/Configuration of the 4-port device.

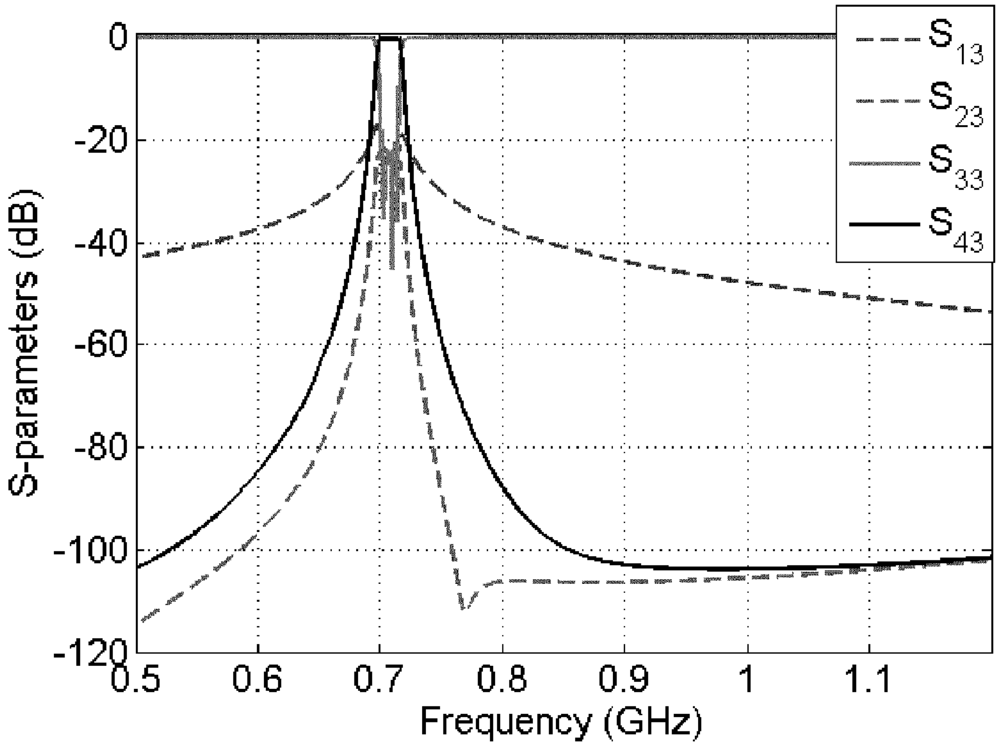


Figure 5a
Excitation at port 3 – Frequency range between 0.5 – 1.2 GHz

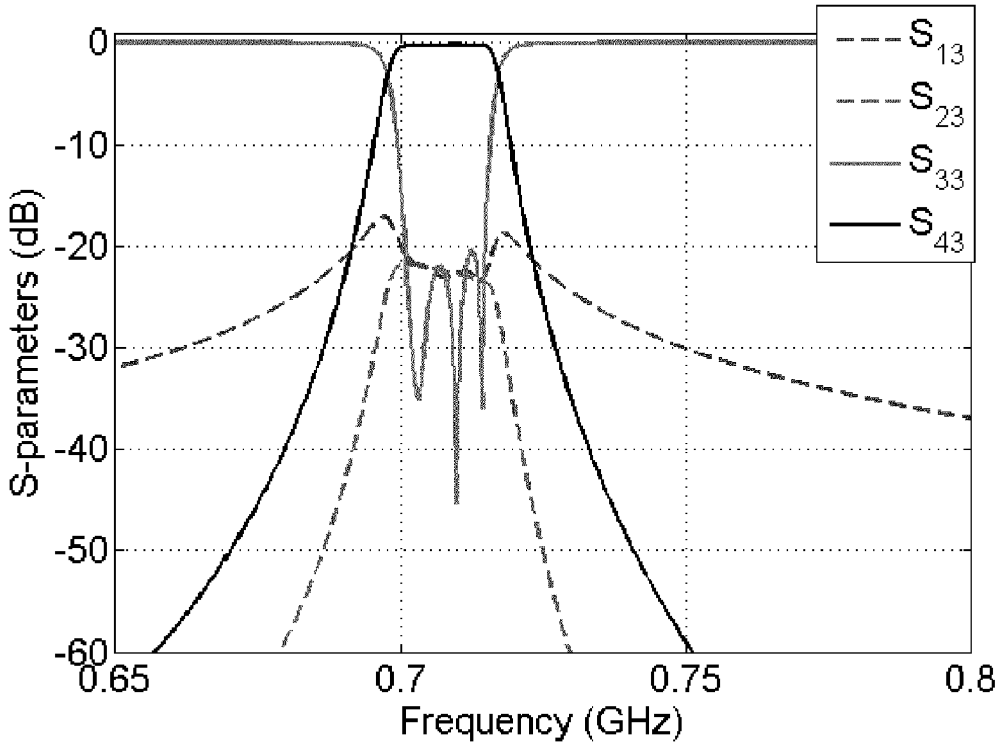


Figure 5b
Excitation at port 3 – Frequency range between 0.65 – 0.80 GHz (Zoomed view)

Figure 5 (a) Simulated performance of the 4-port device when port 3 is excited within the frequency range of 0.5 – 1.2 GHz. (b) Zoomed view of Fig. 5a. Simulations include ohmic losses (Al).

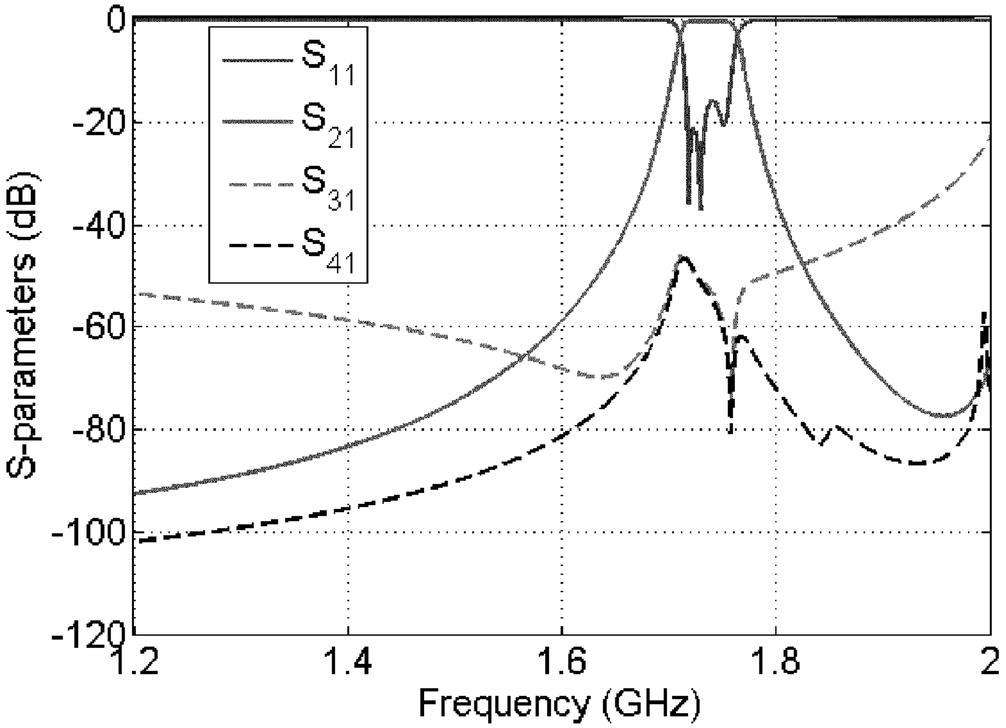
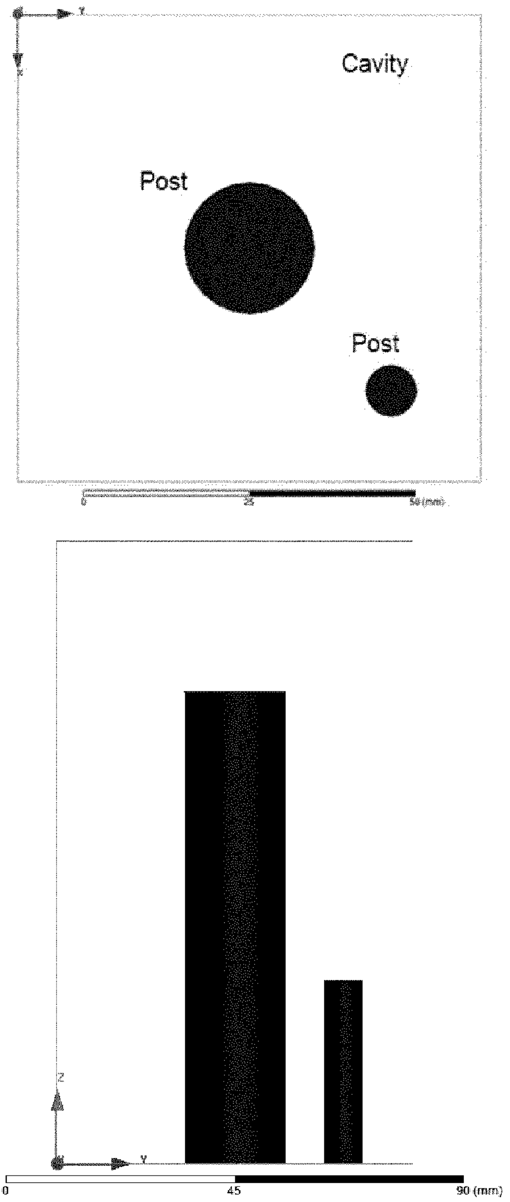


Figure 5c

Excitation at port 1 – Frequency range between 1.20 – 2.00 GHz

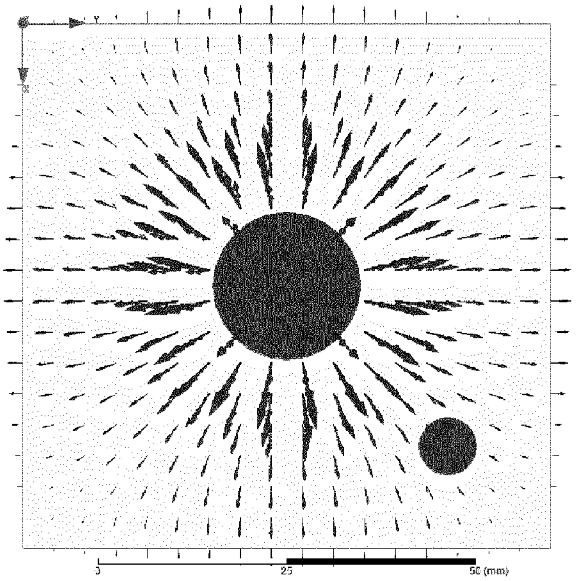
Figure 5c Simulated performance of the 4-port device when port 1 is excited within the frequency range of 1.2 – 2.0 GHz.



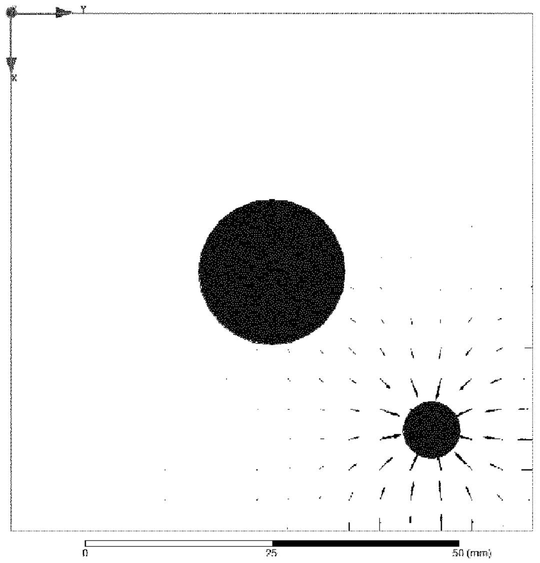
Top view

Side view

Figure 6: Configuration of proposed dual-frequency combline resonator



Low frequency



High frequency

Figure 7: Electric field distribution at resonance at the low frequency and Electric field distribution at reonance at the high frequency

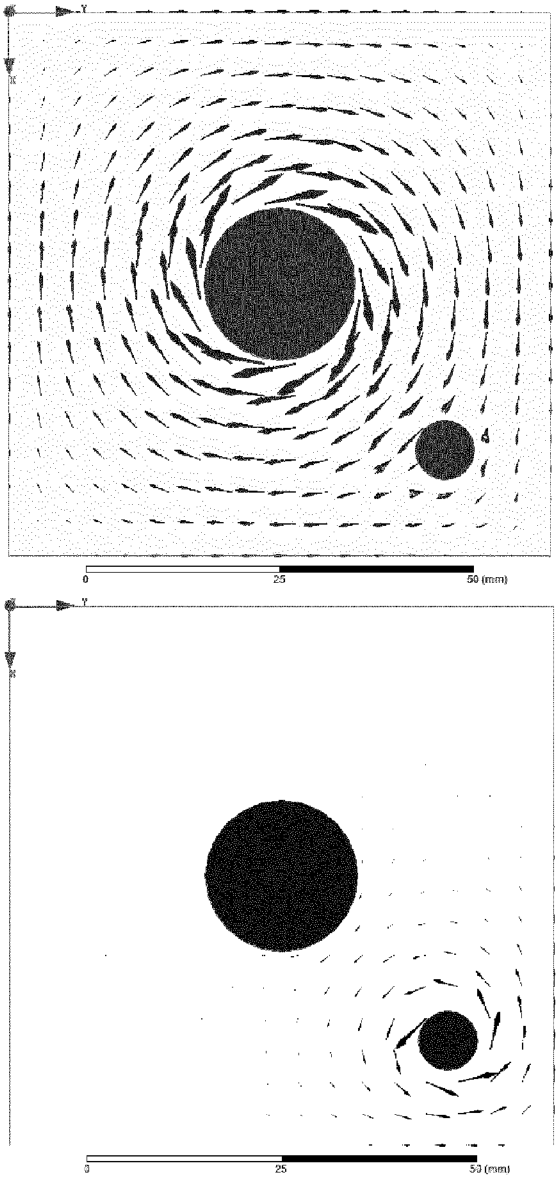


Figure 8:
(top)Magnetic field distribution at resonance at the low frequency.
(bottom) Magnetic field distribution at resonance at the high frequency

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EUROPEAN SEARCH REPORT

Application Number
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Y	* paragraph [0041] - paragraph [0055] * * paragraph [0063] - paragraph [0065] * * figures 2-8 * -----	5-7
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CLASSIFICATION OF THE APPLICATION (IPC)

INV.
H01P1/213
H01P7/04
H01P1/205

TECHNICAL FIELDS SEARCHED (IPC)

H01P

The present search report has been drawn up for all claims

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Place of search	Date of completion of the search	Examiner
Munich	18 October 2013	Köppe, Maro

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DOCUMENTS CONSIDERED TO BE RELEVANT

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The present search report has been drawn up for all claims

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Place of search	Date of completion of the search	Examiner
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