

FOLDED INTERDIGITAL NOTCH FILTER

Field of the Invention

This invention relates to high frequency filter circuits and, in particular, to a coupled line filter structure and specifically an interdigital notch filter apparatus.

5 Background of the Invention

At high frequencies, resonant circuits such as filter circuits, use distributed components in place of the discrete lumped circuit components used at lower frequencies. Hence, distributed component filter circuitry is used in microwave radio circuits as the band pass and band reject filters in the various stages
10 of the radio circuitry. These filters are typically required, depending on their immediate application, to meet certain size, weight and performance constraints.

Coupled line filter structures having interdigital or comb line structures are frequently used for these applications. These filters include a series of resonant elements arranged in a comb like pattern in an air chamber. These resonant elements
15 are tuned so that the coupled line exhibits some desired frequency characteristic such as frequency band pass. They are easy to manufacture since they do not demand tight tolerances, however for many applications their size and weight may be too great and/or their electrical characteristics such as Q (quality) may not provide the desired electrical performance.

For a given frequency and performance response, a standard resonant cavity filter may have a size exceeding permissible dimensions required by the circuitry package for the intended application. It may have electrical performance requirements that require a high Q value not attainable in the structure under consideration.

25 Summary of the Invention

According to the invention there is provided a microwave interdigital filter as set out in claim 1.

In a particular embodiment shown herein, each chamber includes interdigital resonators that are tuned to enable the folded resonant cavity to produce a
30 band pass filter action. The input to the folded resonant cavity is applied to one chamber through a circulator and the output of the second chamber is terminated in the characteristic impedance of the coupled line or resonant cavity. Output of the

filter is through the circulator thereby causing the overall structure to operate as a high quality notch filter.

Brief Description of the Drawing

In the Drawing:

- 5 FIG. 1 is a block diagram of a cellular radio communication system;
 FIG. 2 is a block diagram of a remote transmitter/receiver of the cellular radio communication system;
 FIG. 3 is a graph of a frequency allocation of the radio communication system;
10 FIG. 4 is a graph of a frequency spectrum of a radio communication system;
 FIG. 5 is a block schematic of a coupled line filter structure used in the remote transmitter/receiver of FIG. 2;
 FIG. 6 is a pictorial view of a coupled line filter embodying the
15 principles of the invention:
 FIGS. 7 - 18 are cross sectional and orthographic projection views of the coupled line filter of FIG. 6 and its component piece parts; and
 FIGS. 19-20 are orthographic projections of another illustrative embodiment of the filter structure.

20 **Detailed Description**

Cellular radiotelephone communications are based on a cell division scheme having specific communication frequencies assigned to specific cells with each cell serving a specific geographical area. The communications are handled through a cell site within the cell having the necessary radiating and receiving
25 antennas and related transmitting and receiving equipment. Often the complete coverage of the cell or geographical area from the cell site is inadequate. In some instances the cell site antenna does not properly radiate the total area of the cell leaving dead areas in which the service to radiotelephones is substandard or non-existent. Splitting the cell into smaller cell areas to improve service is often not
30 desirable due to a lack of suitable cell site locations and/or the expense of providing many new cell sites with its extensive and expensive equipment. One solution to this dilemma is to provide satellite or remote signal radiator and signal receivers at specific locations within the cell where there is poor radio transmission and reception to and from the cell site. These satellite or remote transceivers are connected by land
35 lines to the central cell site and are operative to radiate and receive radio signals. This improves the signal coverage in areas where the cell site radiation and reception

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For a given frequency and performance response, a standard resonant cavity filter may have a size exceeding permissible dimensions required by the circuitry package for the intended application. It may have electrical performance requirements that require a high Q value not attainable in the structure under consideration.

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According to the invention there is provided a microwave interdigital filter as set out in claim 1.

In a particular embodiment shown herein, each chamber includes interdigital resonators that are tuned to enable the folded resonant cavity to produce a band pass filter action. The input to the folded resonant cavity is applied to one chamber through a circulator and the output of the second chamber is terminated in the characteristic impedance of the coupled line or resonant cavity. Output of the

interference and must be blocked. The blocking of these frequencies is performed by a band rejection filter also called a notch filter. At the radio frequencies used for radiotelephone service, coupled line filters with distributed components are used in the remote station equipment. Their use, however, is limited by the size and weight of a coupled line air chamber filter needed to meet the quality requirements of a notch filter for blocking the non-allowable (ie interfering) band of frequencies and the size and weight constraints of the remote transceiver station.

A coupled line notch filter, suitable for this application, is shown in the block schematic of FIG. 5. The block 501 depicts a folded coupled line interdigital filter device with a folded air chamber serving as a resonant cavity. Two coaxial connectors 502 and 503 electrically couple the electrical signals of the cavity to the external circuitry outside of the cavity. A grounded terminating impedance 505 with an impedance value equaling the characteristic impedance of the cavity resonator is connected to the connector 503. A circulator device 506 has its central port 509 connected to the connector 502. The circulator device also includes an input port 507 and an output port 508. The circulator device 506 is a radio frequency unidirectional signal transmission device and is operative to unidirectionally permute power signals from one port to the next port of the circulator device. Input signals having a broad band of frequency extending from f_1 to f_4 , with the frequencies from f_2 to f_3 , to be rejected are applied to the input port 507 and are circulated to the central port 507 where they are input, via the coaxial connector 502, to the chamber of the coupled line filter, 501. The coupled line filter operates as a band pass filter transmitting the signal frequencies between f_2 to f_3 to the terminating impedance 505. All other frequency signals are reflected back to the port 509 of the circulator device 506 and these signals exclusive of the band from f_2 to f_3 are permuted to the output port 508. This particular arrangement produces a notch filter having an operative quality Q significantly higher than that of the coupled line band pass filter.

The overall filter apparatus is shown in pictorial form in the FIG. 6.

Two conductive members 601 and 602 having substantially a channel shape are joined to a central or common planar member 606 (substantially internal to the apparatus) which divides the apparatus into substantially two chambers. In a preferred arrangement, these components are joined by welding at the junction located along the two longitudinal edges of the channel of the conductive channel shaped members 601 and 602 and the common planar member 606.

is substandard.

A cellular telephone system including remote transceivers (e.g. radiators and receivers) is shown in the FIG. 1. A mobile switching center 101 interconnects a land telephone system 102 to the various base sites 103, 104 and 105. Each of the base sites includes radio equipment connected to communicate to the mobile radiotelephones and each has a cell site antenna 113, 114 and 115, respectively, to transmit and receive radio signals. It also includes the necessary stored program controls to control channel assignments, handoffs and registrations. The base site 105 does not properly radiate all of its intended area to provide the desired service level and, hence, various locations of its cell 120 are poorly radiated. Remote transceiver stations 106, 107 and 108, each having an antenna 116, 117 and 118 respectively, have been installed at various locations within the cell 120 to radiate these otherwise poorly radiated locations of the cell. These stations, connected to the mobile switching control 101 by land lines, are all located within the cell in order to provide substantially uniform illumination of the cell. Each remote transceiver station includes transmission and switching equipment to couple it to the base site 105 which has all the stored program controls of the cell.

Each remote transceiver station includes the necessary circuitry for providing line communication between the satellite station and the cell site. Since the remote transceiver station is designed to eliminate the expense of cell splitting into a plurality of cells it is of necessity small and light in weight so it may be mounted on external building walls, inside buildings and other similar mounting locations to obviate the need for new cell sites. A block diagram of a portion of the processing circuitry of a remote transceiver station is shown in FIG. 2. A transmitting and receiving antenna 201 is connected to a band pass filter 202. The bandpass filter 202 is connected to a band rejection filter 203. It in turn is connected to transceiver equipment 204 to process received signals and signals intended for transmission. A cellular frequency allocation, in which the cell site and its remote transceiver stations operate, is shown in the graph of FIG. 3. The frequencies assigned to system A includes the portions 301 and 302 of the spectrum. The frequencies assigned to system B includes the portions 305 and 306 of the spectrum. Each system has a discontinuous assigned frequency spectrum and, hence, has a band with a portion of frequencies that must be blocked out. This blocking is performed with a band rejection filter. The allowable spectrum for system B, for example is shown by the waveform of FIG. 4. As is shown, the frequencies from f_1 to f_2 and from f_3 to f_4 are permissible and the frequencies from f_2 to f_3 are

the endplates are connected to the conductive outer boundaries by screw type fastening devices .

6. A microwave interdigital filter structure as claimed in claim 1,
wherein:

5 the endplates are connected to the conductive outer boundaries by weld connections.