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Takamine

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(54) **MULTIPLEXER, TRANSMISSION DEVICE, AND RECEPTION DEVICE**

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(30) **Foreign Application Priority Data**

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H04B 1/38	(2015.01)
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H01L 25/065	(2006.01)
H01L 41/047	(2006.01)
H01L 41/053	(2006.01)
H03H 7/38	(2006.01)
H03H 9/145	(2006.01)
H04B 1/40	(2015.01)
H03H 9/64	(2006.01)
H01L 27/20	(2006.01)

(52) **U.S. Cl.**
CPC ***H03H 9/72*** (2013.01); ***H01L 25/0655*** (2013.01); ***H01L 41/0475*** (2013.01); ***H01L 41/053*** (2013.01); ***H03H 7/38*** (2013.01); ***H03H 9/14552*** (2013.01); ***H03H 9/6483*** (2013.01); ***H04B 1/40*** (2013.01); *H01L 27/20* (2013.01)

(58) **Field of Classification Search**
CPC H03H 9/72; H01L 25/0655; H01L 41/0475
USPC 455/68, 71, 73
See application file for complete search history.

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(74) *Attorney, Agent, or Firm* — Keating & Bennett, LLP

(57) **ABSTRACT**

A multiplexer includes filters on one principal surface of a mounting substrate and having mutually different frequency bands, and an inductance element which is incorporated in the mounting substrate and one end of which is connected to one end of the filter. The other end of the inductance element and one end of each of the filters, are connected to each other at a common connection point. The inductance element is defined by spiral wiring conductors disposed in first and second wiring layers provided in an inner layer of the mounting substrate. The mounting substrate includes third and fourth wiring layers which are adjacent to the first and second wiring layers, and in which no ground pattern is provided in a portion corresponding to a formation region of the inductance element.

18 Claims, 17 Drawing Sheets

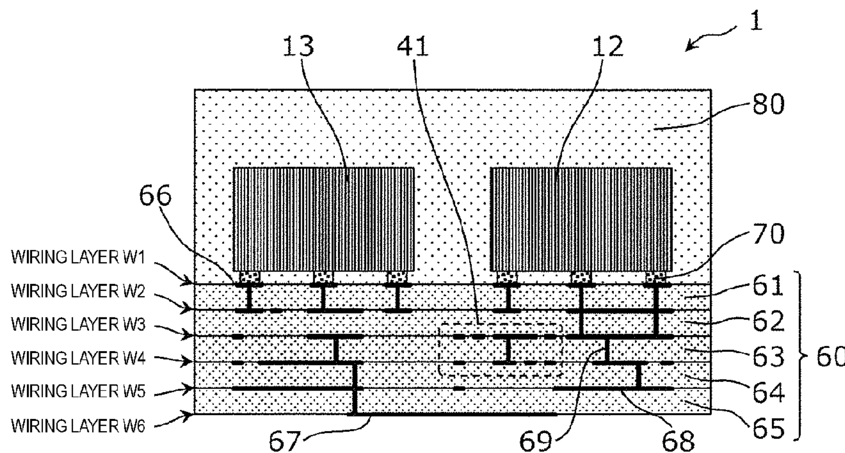

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FIG. 1

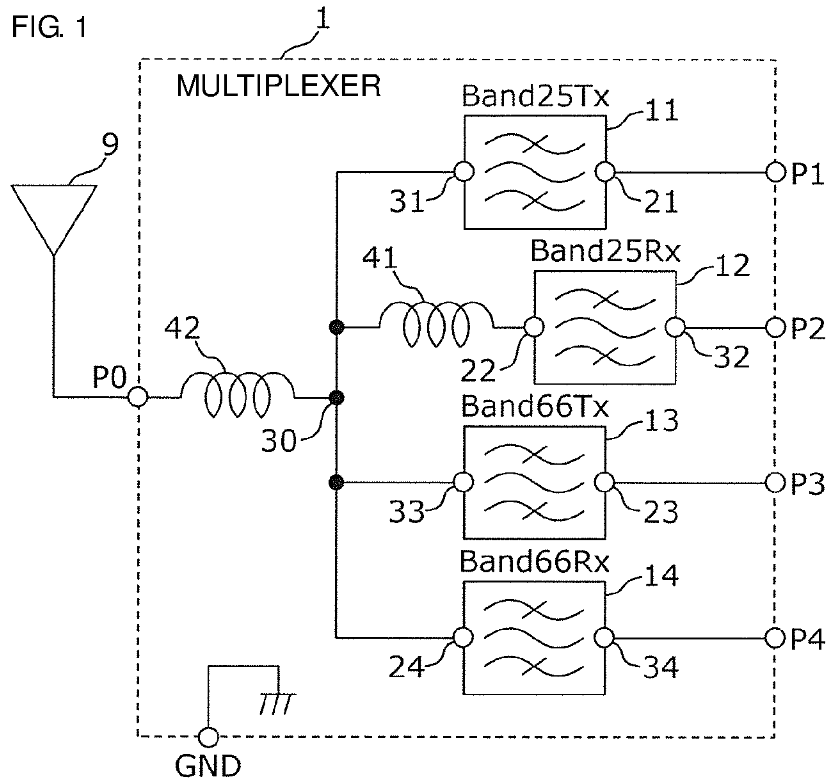


FIG. 2A

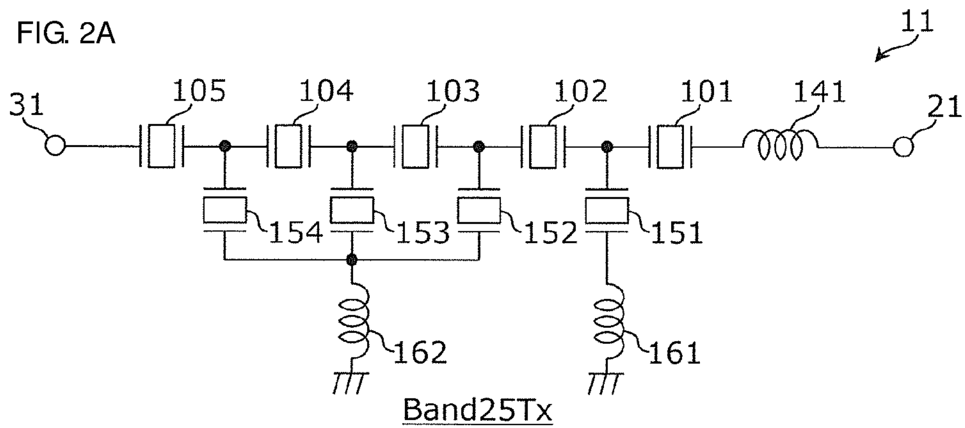


FIG. 2B

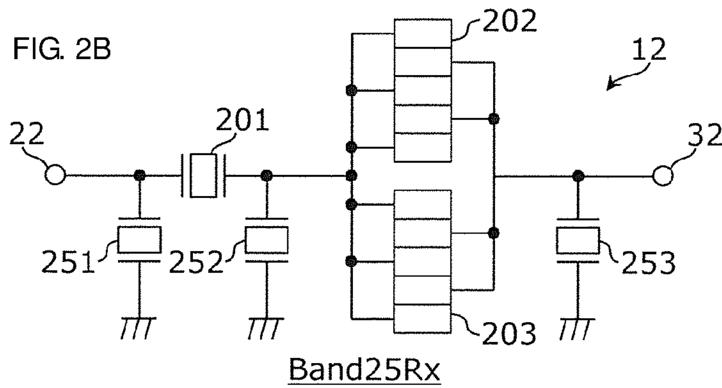


FIG. 2C

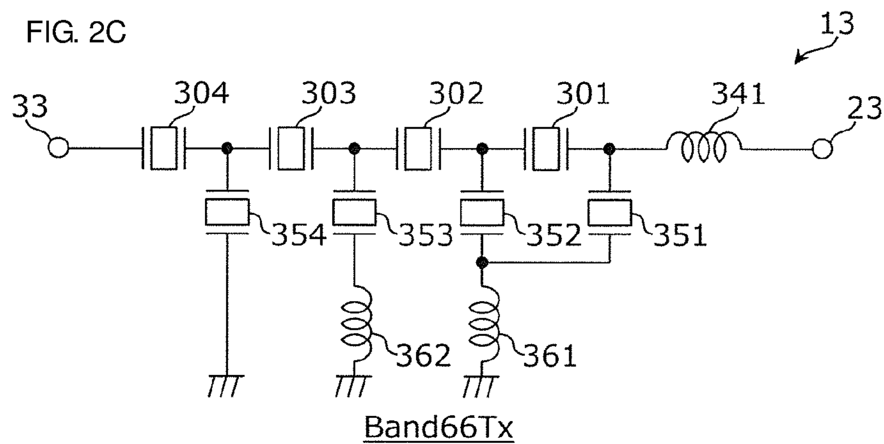


FIG. 2D

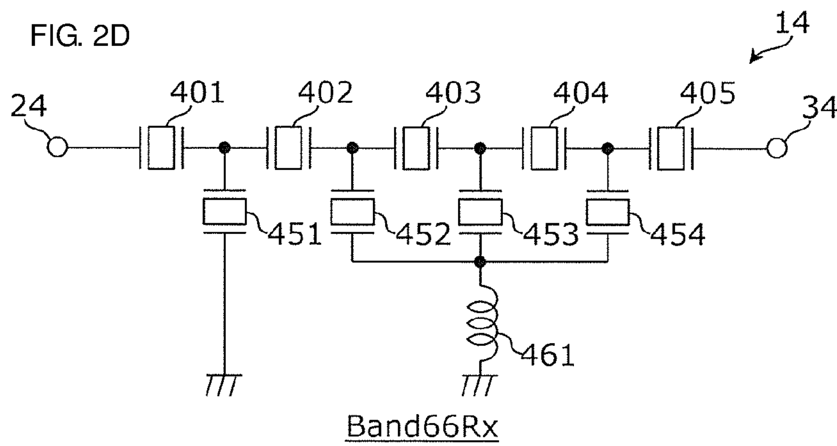


FIG. 3

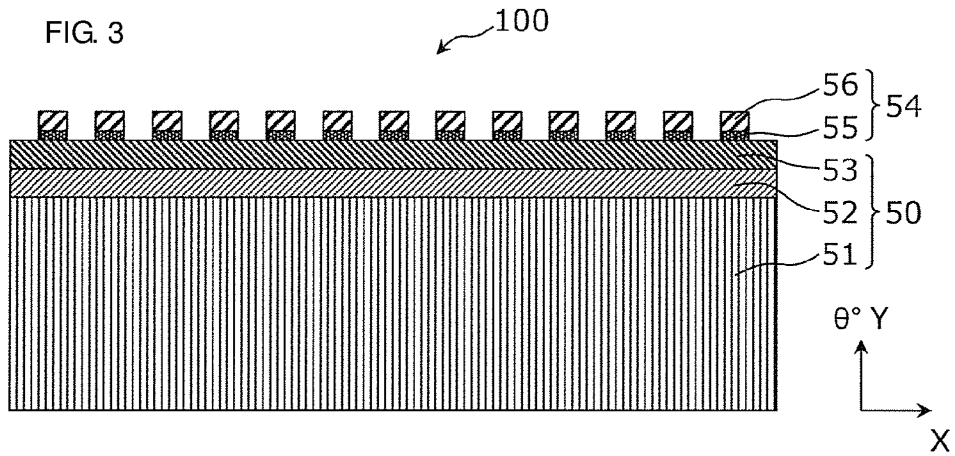


FIG. 4

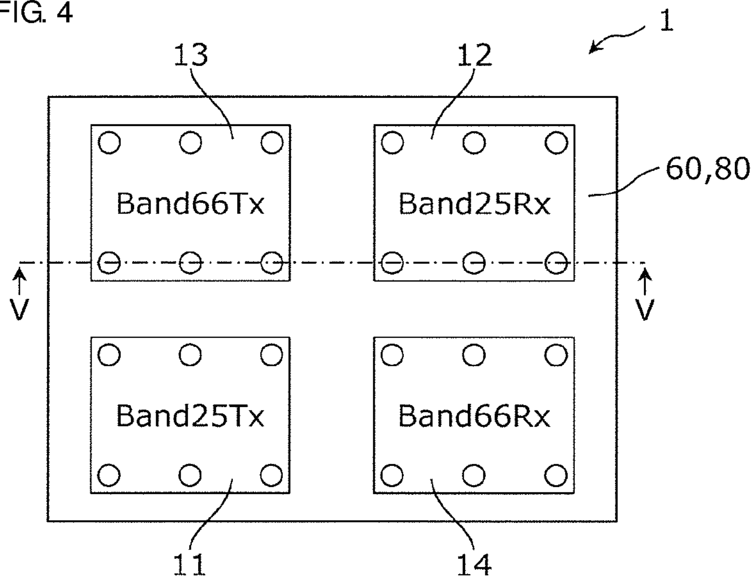


FIG. 5

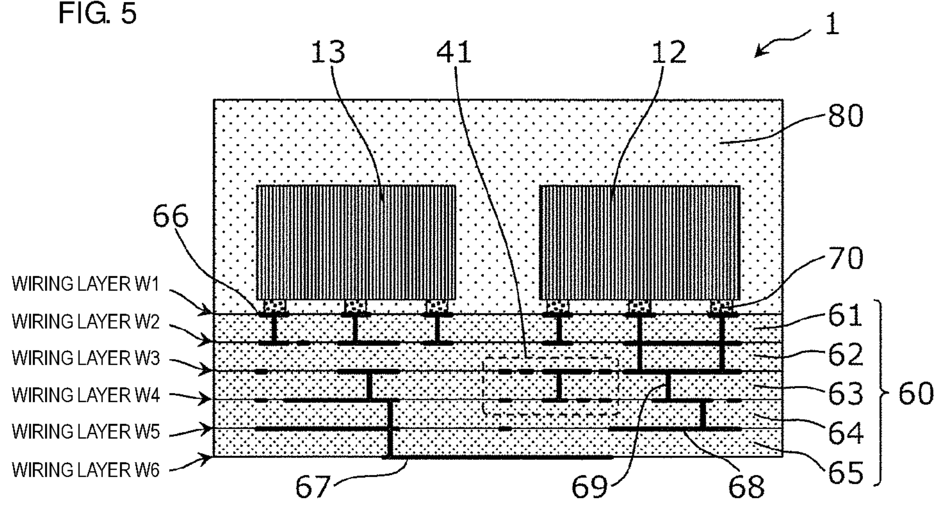


FIG. 6

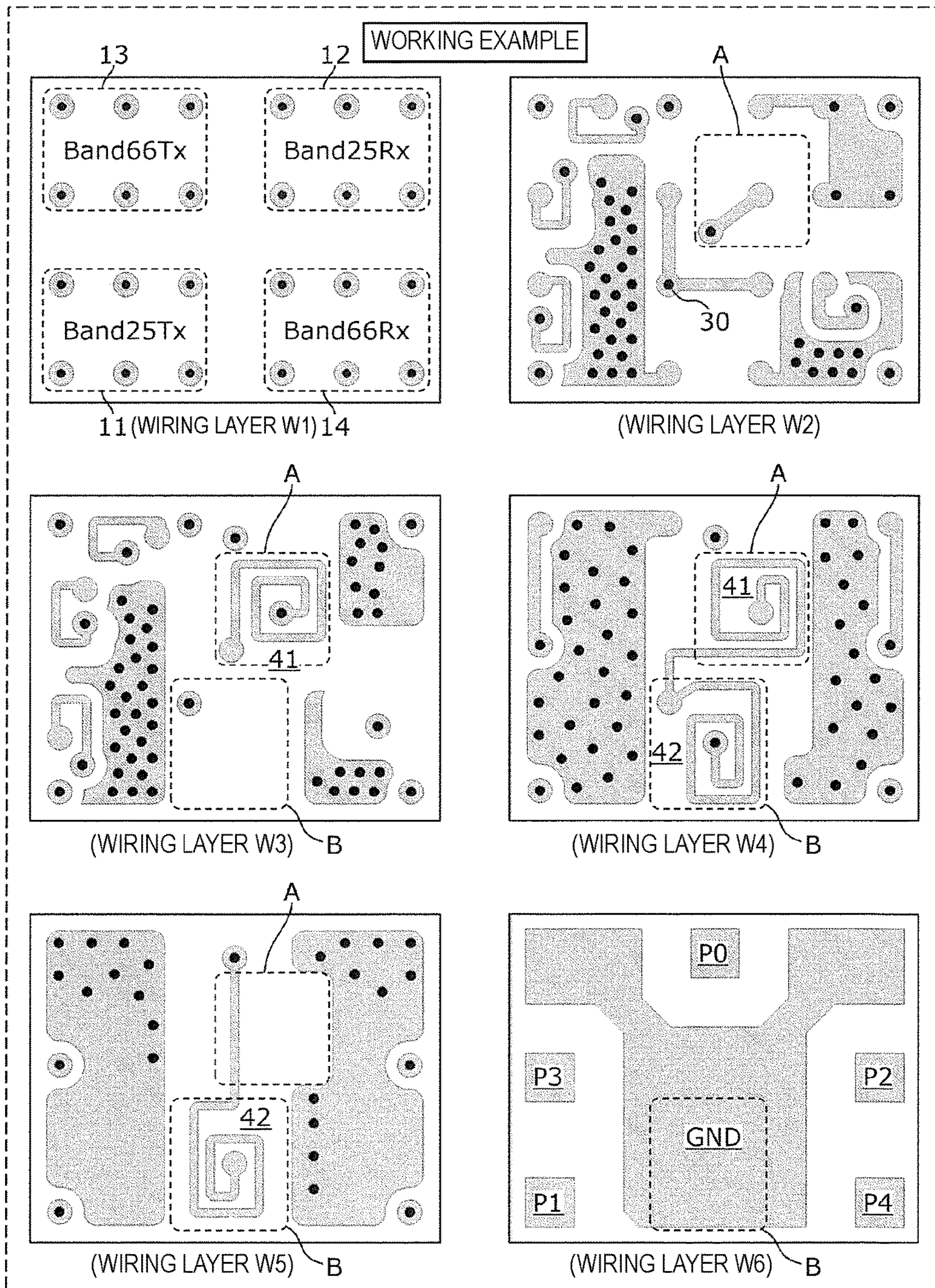


FIG. 7

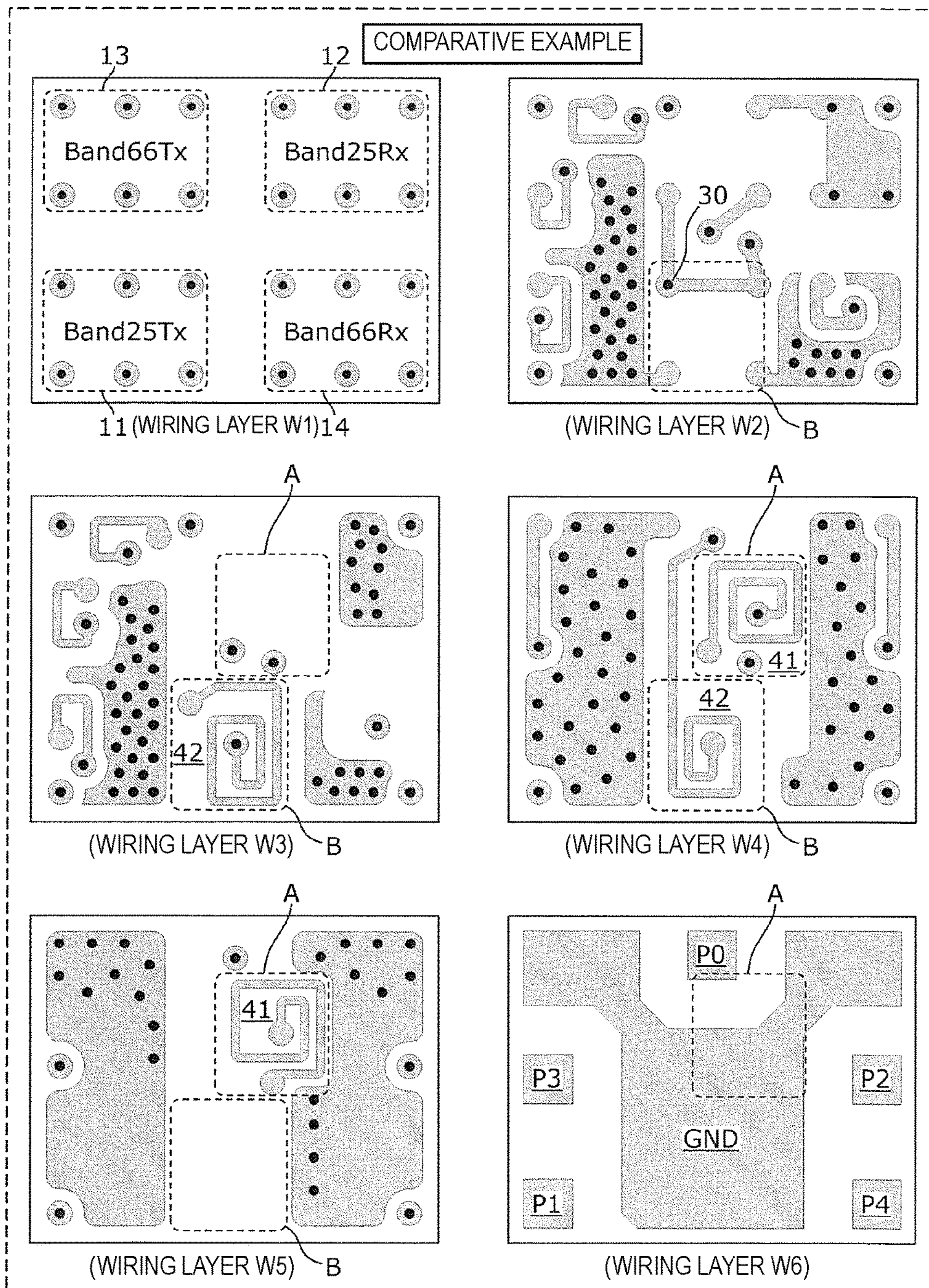
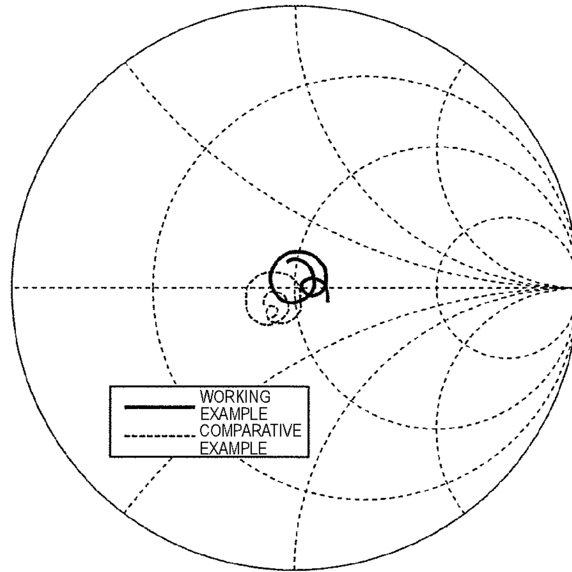
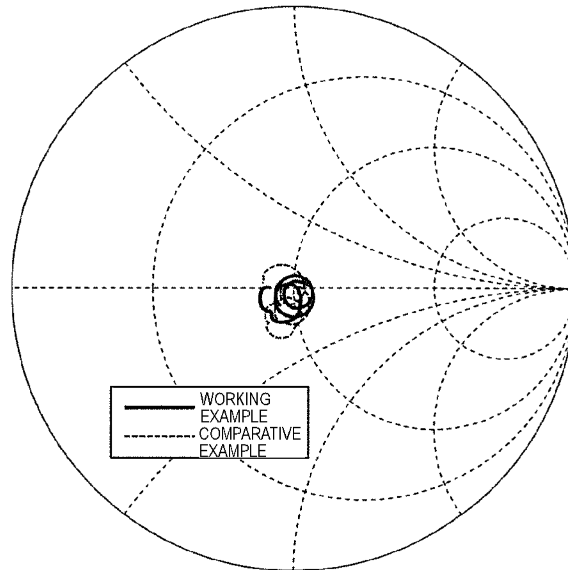


FIG. 8A



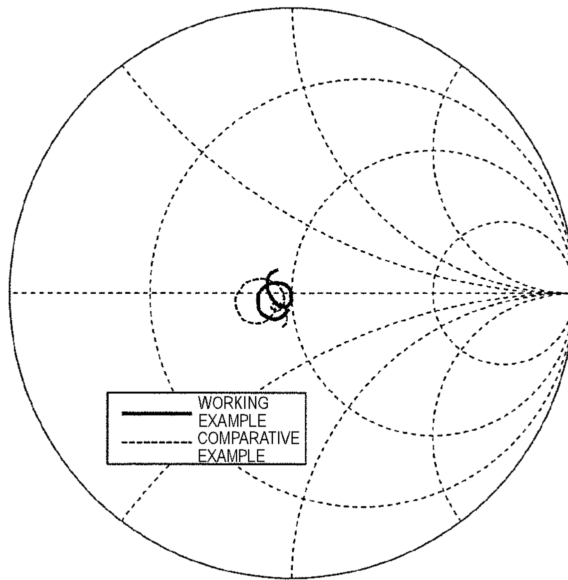
Band25Tx

FIG. 8B



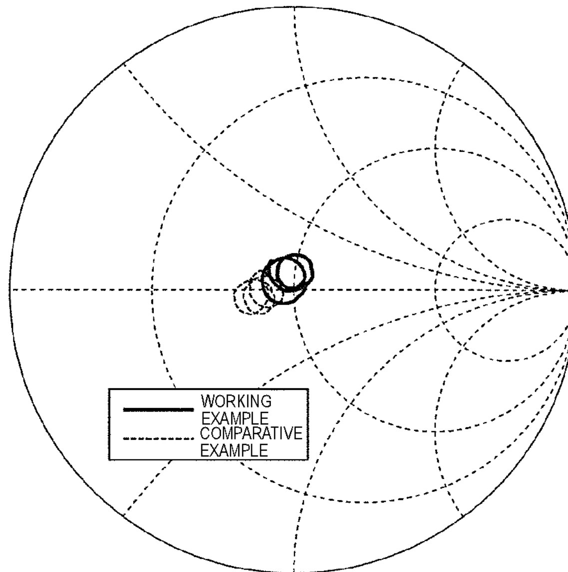
Band25Rx

FIG. 8C



Band66Tx

FIG. 8D



Band66Rx

FIG. 9

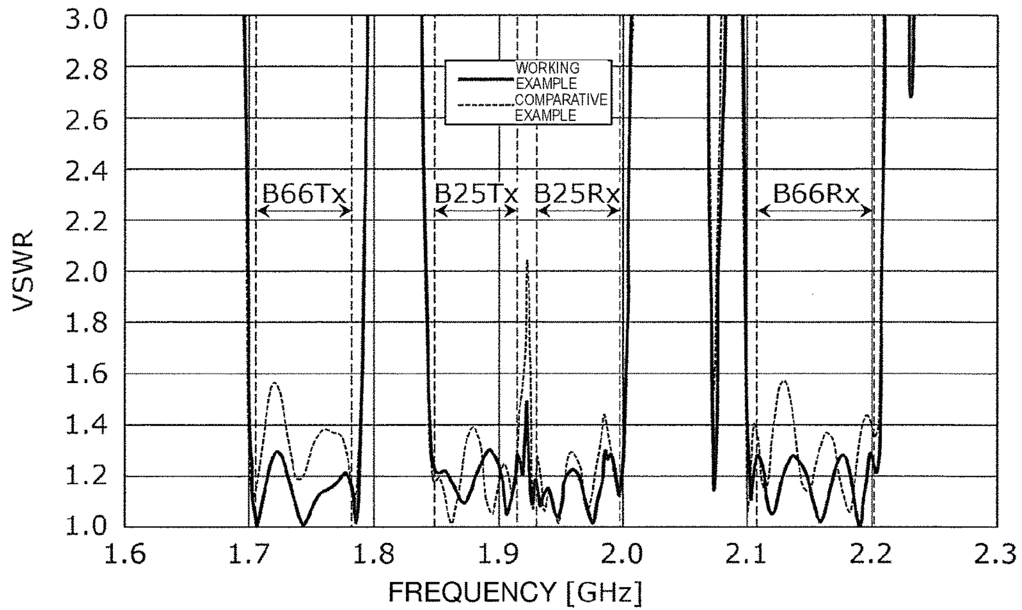


FIG. 10

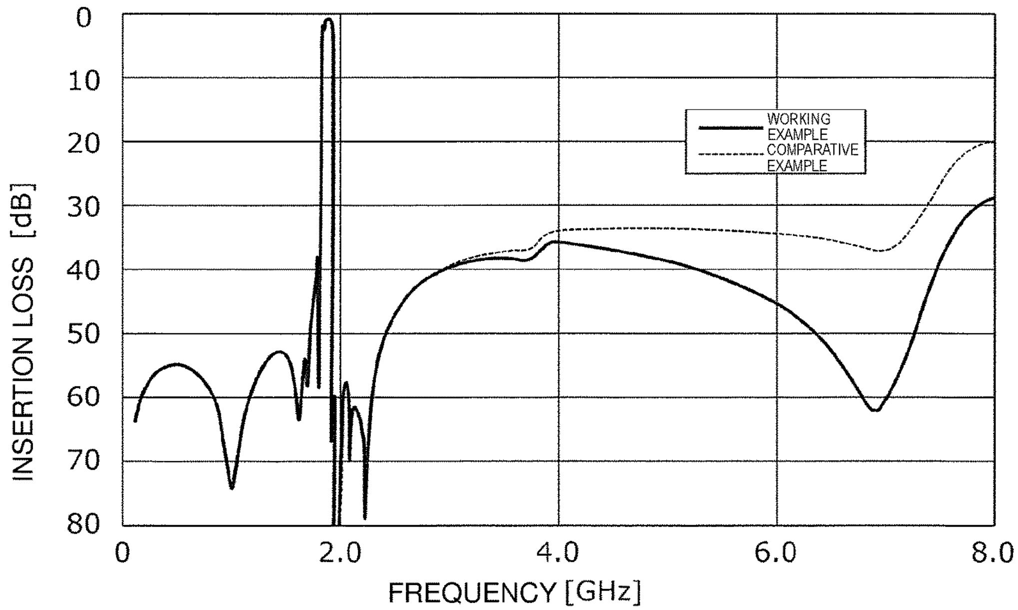


FIG. 11A

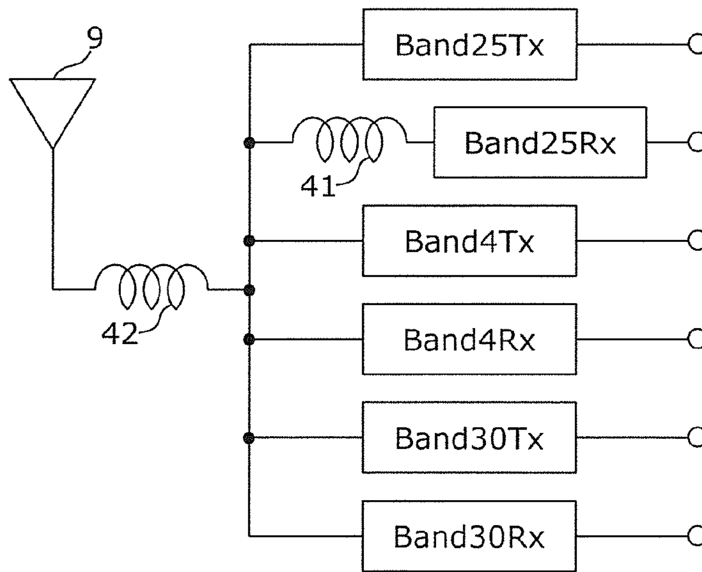


FIG. 11B

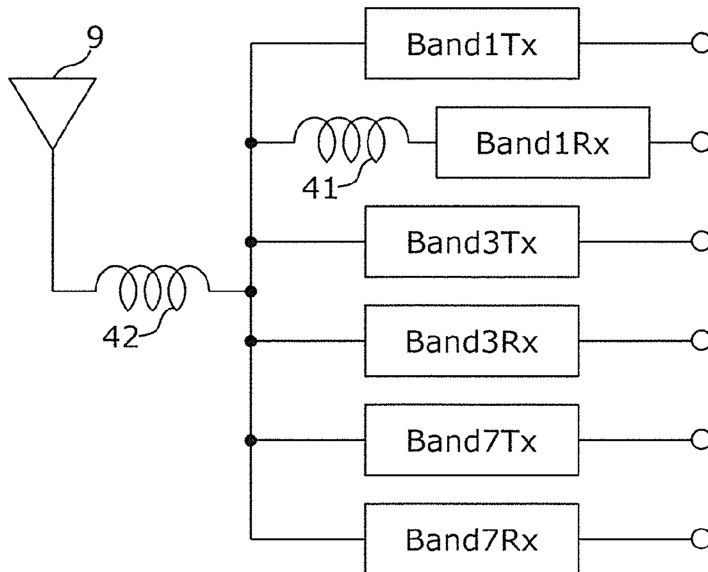


FIG. 12

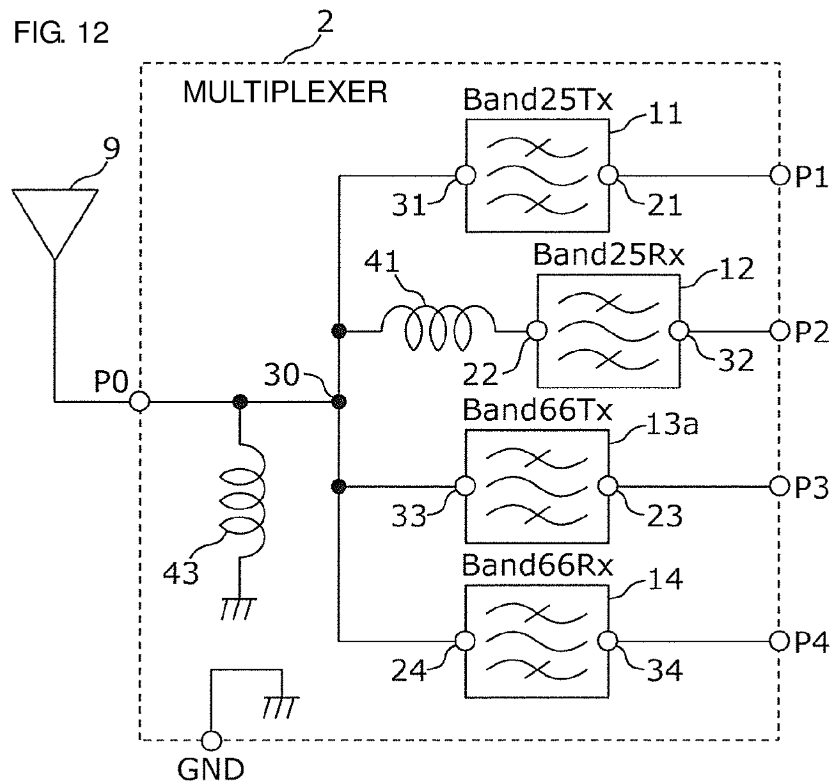


FIG. 13

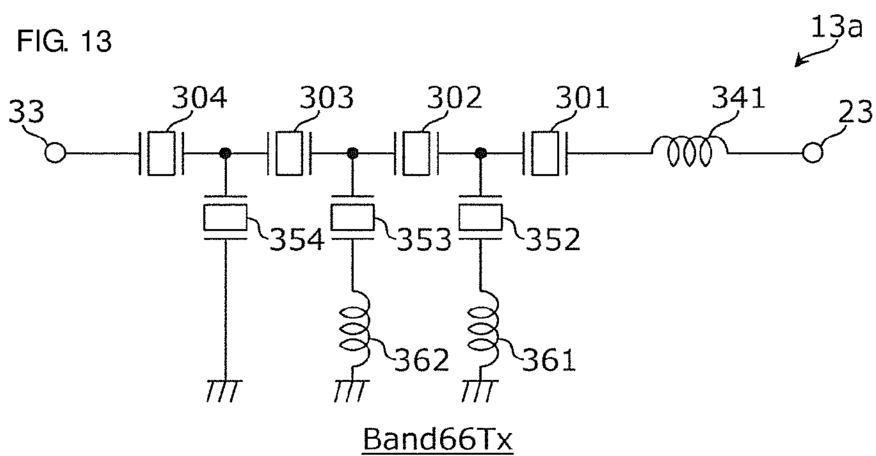


FIG. 14

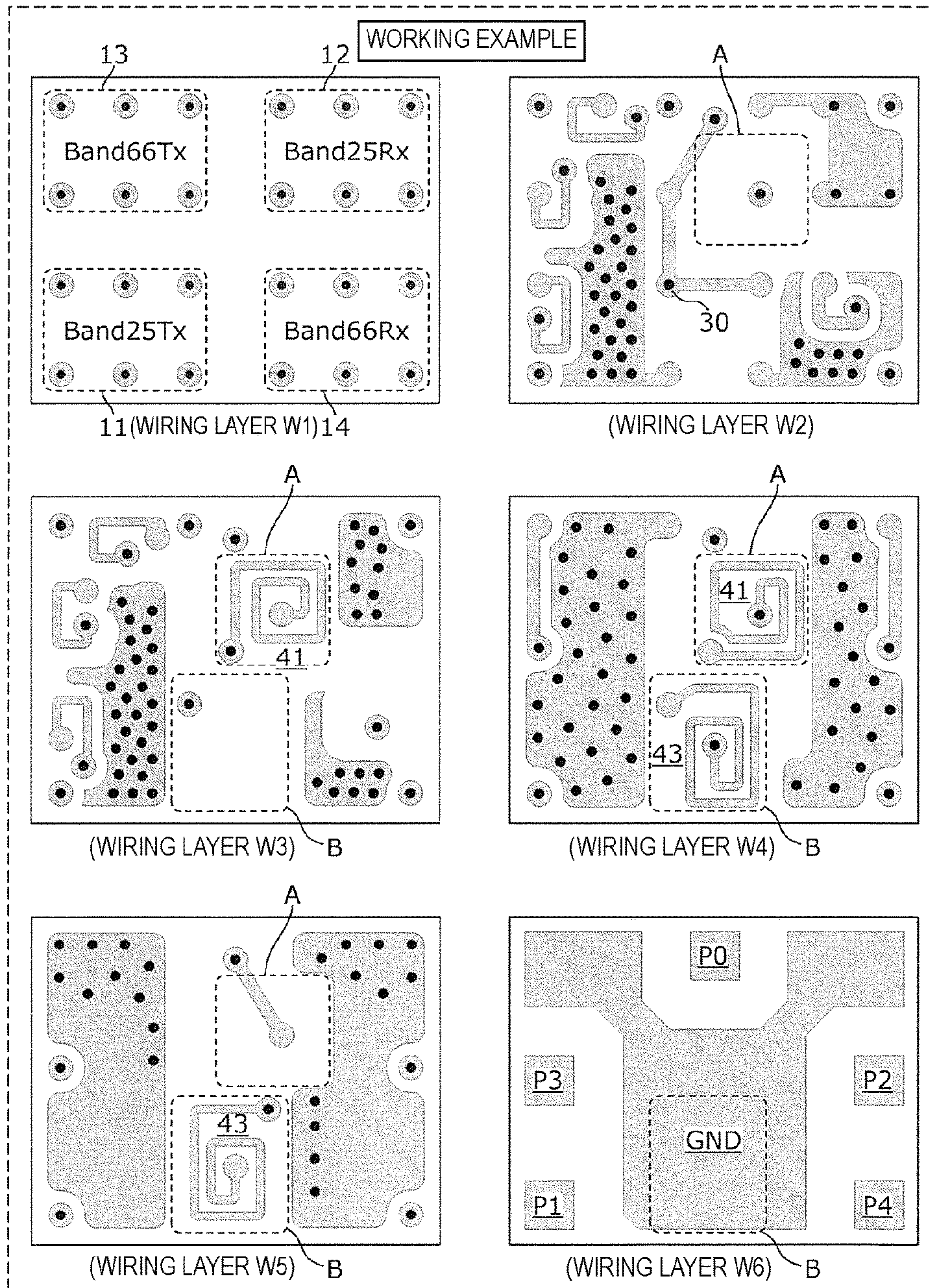


FIG. 15

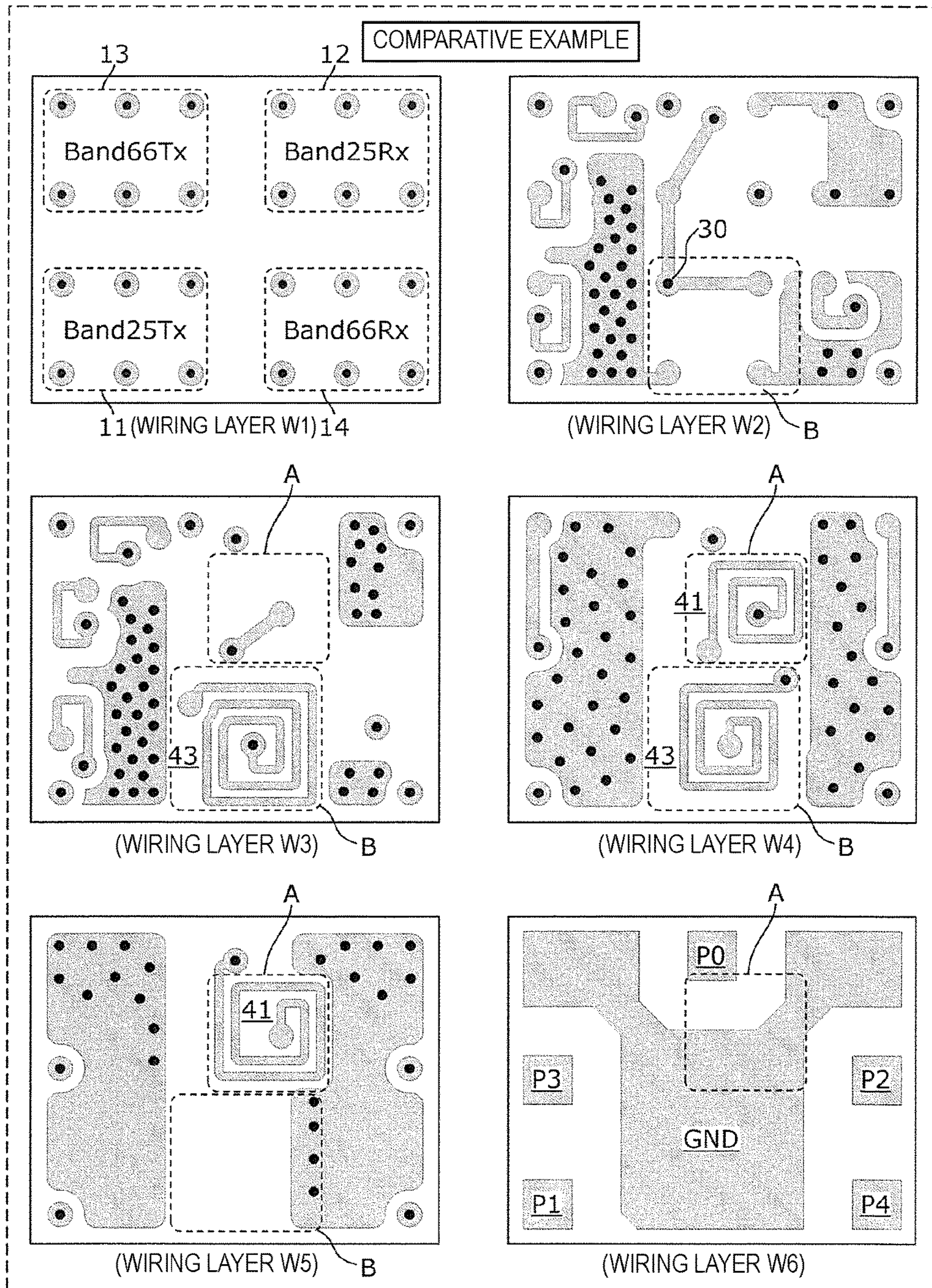
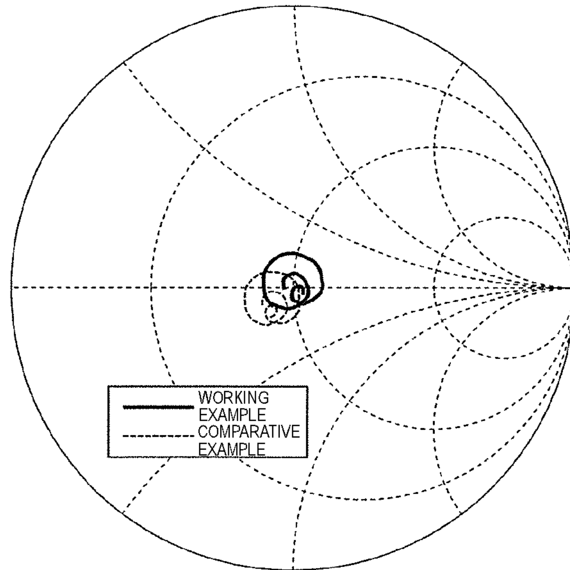
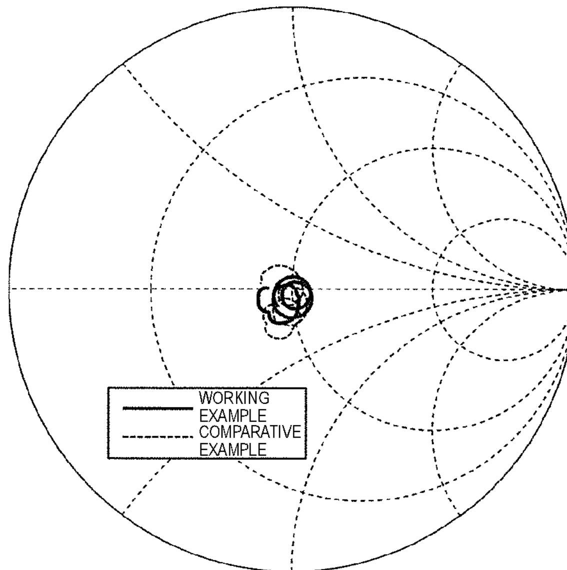


FIG. 16A



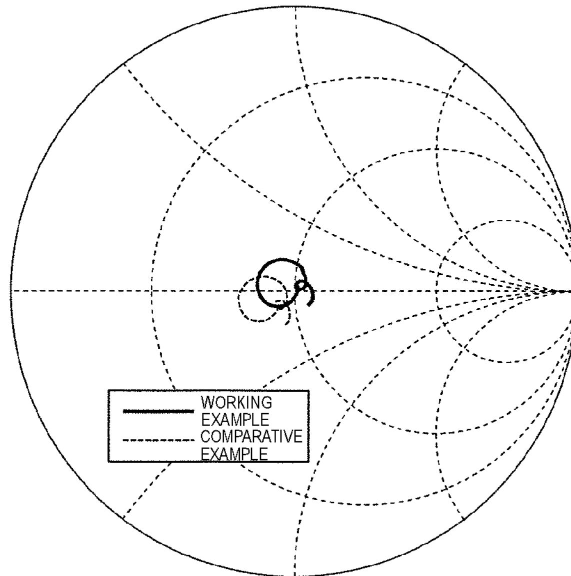
Band25Tx

FIG. 16B



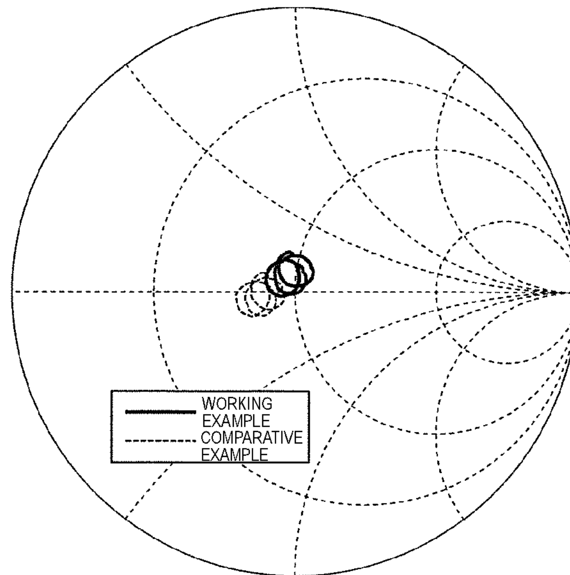
Band25Rx

FIG. 16C



Band66Tx

FIG. 16D



Band66Rx

FIG. 17

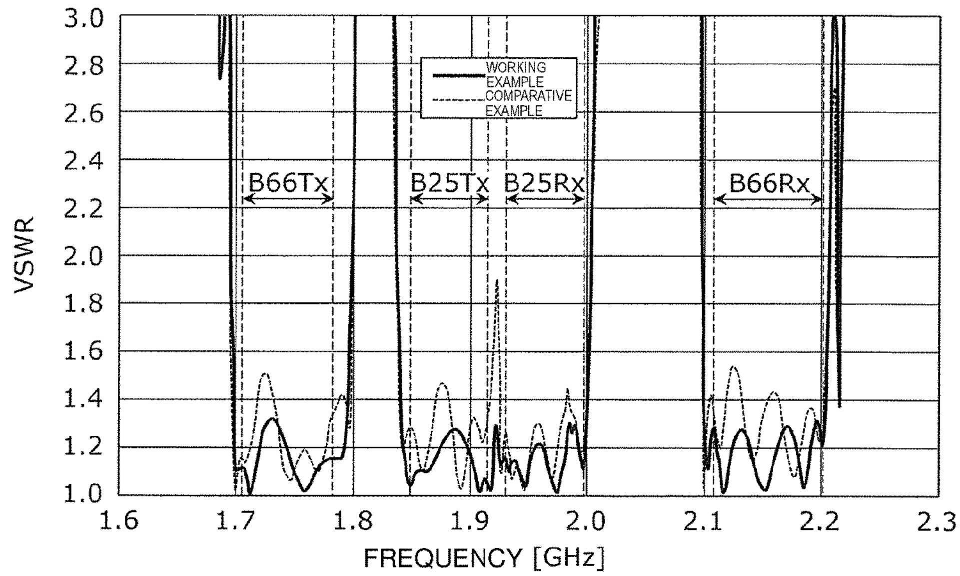


FIG. 18A

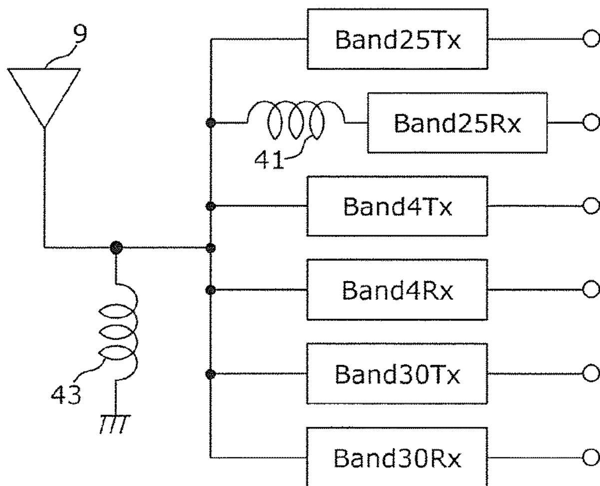
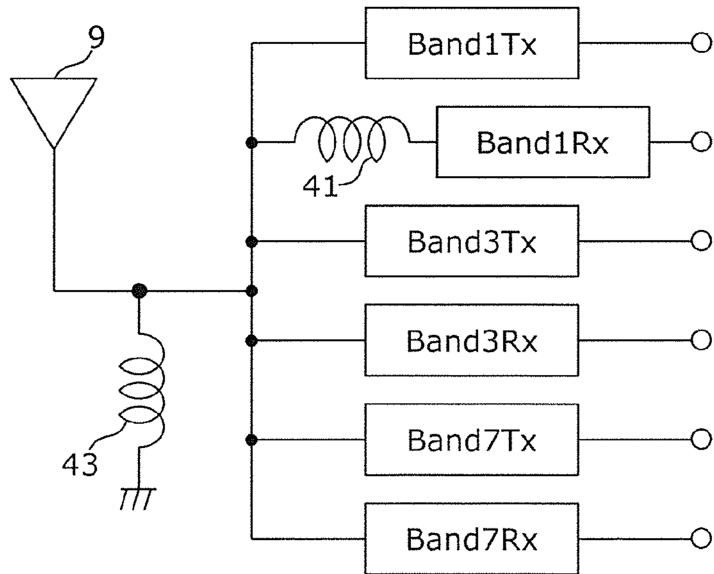


FIG. 18B



MULTIPLEXER, TRANSMISSION DEVICE, AND RECEPTION DEVICE

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of priority to Japanese Patent Application No. 2017-122822 filed on Jun. 23, 2017. The entire contents of this application are hereby incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to multiplexers provided with elastic wave filters, transmission devices, and reception devices.

2. Description of the Related Art

In recent years, cellular phones have been required to support a plurality of frequency bands and a plurality of radio systems, in other words, required to be capable of supporting multiband communication and multimode communication by a single terminal. To meet the above requirement, a multiplexer configured to demultiplex a high frequency signal containing a plurality of radio carrier frequencies is disposed immediately next to a single antenna. As a plurality of band pass filters defining the multiplexer, elastic wave filters exhibiting low loss within the pass band and steepness of the bandpass characteristics in the peripheries of the pass band are used.

International Publication No. 2016/208670 discloses a multiplexer in which a plurality of surface acoustic wave filters are provided and terminals of the filters on an antenna side are connected in common.

In the multiplexer of International Publication No. 2016/208670, an antenna end of one filter among the plurality of filters is connected to a common connection point with a first inductance element interposed therebetween, and an antenna end of each of the other filters is directly connected to the common connection point.

An impedance of the one filter seen through the first inductance element and a combined impedance of the other filters are designed so as to approach a complex conjugate. With this, impedances of all of the filters seen from the common connection point are adjusted to substantially the same complex impedance.

Further, in the multiplexer, the common connection point and an antenna terminal for connecting an antenna element are connected with a second inductance element interposed therebetween. The second inductance element corrects a shift of the adjusted complex impedance from the characteristic impedance of the antenna element.

As described above, in the multiplexer, the impedance of each of the plurality of filters is adjusted using the first inductance element, and the adjusted impedance is corrected to the characteristic impedance of the antenna element using the second inductance element. Because of this structure, according to the multiplexer of International Publication No. 2016/208670, impedance matching is able to be obtained with high precision using a small number of inductance elements.

The multiplexer of International Publication No. 2016/208670 may be provided using, for example, a mounting substrate in which an inductance element is incorporated.

However, in this case, there arises a problem that the precision of impedance matching is affected by the arrangement of the inductance element inside the mounting substrate.

SUMMARY OF THE INVENTION

Preferred embodiments of the present invention provide multiplexers that each include a mounting substrate including an inductance element therein and that is capable of obtaining excellent impedance matching at an antenna terminal.

A multiplexer according to a preferred embodiment of the present invention includes a mounting substrate, one first elastic wave filter and one or more second elastic wave filters that are provided on one principal surface of the mounting substrate and have different pass bands from each other; and a first inductance element which is included in the mounting substrate, and one end of which is connected to one end of the first elastic wave filter. The other end of the first inductance element and one end of each of the one or more second elastic wave filters are connected to each other. The first elastic wave filter includes one or more first resonators defining a signal path connecting the one end and the other end of the first elastic wave filter, and one or more second resonators connected between the signal path and a reference terminal. At least one of the second resonators is connected between the one end of the first elastic wave filter and the first resonator closest to the one end of the first elastic wave filter in the signal path. Each of the one or more second elastic wave filters includes one or more third resonators defining a signal path connecting the one end and the other end of the second elastic wave filter, and one or more fourth resonators connected between the signal path and a reference terminal. The mounting substrate is a multilayer substrate in which wiring conductors are disposed in or on a plurality of wiring layers that are positioned at the one principal surface, at the other principal surface, and in an inner layer of the mounting substrate. The first inductance element includes a first wiring conductor disposed in or on at least one wiring layer of the plurality of wiring layers. The plurality of wiring layers include a wiring layer which is adjacent to the wiring layer at which the first wiring conductor is disposed, and in which a ground pattern is not provided in a portion overlapping with a formation region of the first inductance element in a plan view.

In this configuration, the impedance of the first elastic wave filter seen through the first inductance element and the combined impedance of all of the second elastic wave filters approach a complex conjugate. As such, the impedances of all of the filters seen from a common connection point of the other end of the first inductance element and the one end of each of the one or more second elastic wave filters, are adjusted to the same or substantially the same complex impedance. At this time, if parasitic capacitance is generated on the first inductance element, the impedance of the first inductance element is decreased and the impedance matching is degraded, thus preventing accurate impedance adjustment.

As such, with the above-described configuration, in the wiring layer adjacent to the wiring layer in which the first inductance element is provided, the ground pattern is not provided in the portion overlapping with the formation region of the first inductance element in a plan view. This prevents an increase in parasitic capacitance generated when a ground pattern is disposed adjacent to the first inductance element, thus reducing or preventing the decrease in imped-

ance of the first inductance element. As a result, the impedance is accurately adjusted at the first elastic wave filter and each of the one or more second elastic wave filters, thus making it possible to obtain a multiplexer with excellent impedance matching.

The plurality of wiring layers may include a wiring layer which is adjacent, on the one principal surface side of the mounting substrate, to the wiring layer at which the first wiring conductor is provided, and in which a ground pattern is not provided in a portion overlapping with the formation region of the first inductance element in a plan view.

With this configuration, the wiring layers in each of which no ground pattern is provided are provided on both sides of the first inductance element, which effectively prevents an increase in parasitic capacitance generated on the first inductance element and makes it possible to reduce or prevent the decrease in impedance of the first inductance element.

A multiplexer according to a preferred embodiment of the present invention further includes a common signal terminal provided in or on the mounting substrate, and a second inductance element included in the mounting substrate and connected between the above common signal terminal and the common connection point of the other end of the first inductance element and the one end of each of the one or more second elastic wave filters. The second inductance element includes a second wiring conductor disposed in or on at least one of the plurality of wiring layers, and at least one of the wiring layers in or on which the second wiring conductor is disposed is positioned closer to the other principal surface of the mounting substrate than any of the wiring layers in or on which the first wiring conductor is disposed.

With this configuration, the impedances adjusted at the first elastic wave filter and the one or more second elastic wave filters is able to be further corrected by the second inductance element collectively. In general, a multiplexer in which filters are disposed on one principal surface of the mounting substrate, is mounted on a mother board, such as a printed circuit board, with the other principal surface of the mounting substrate interposed therebetween. As such, in accordance with the above-described configuration, of the first inductance element and the second inductance element, the second inductance element is disposed closer to the other principal surface of the mounting substrate, while the first inductance element is disposed farther from the other principal surface of the mounting substrate.

With this configuration, even if a ground pattern is provided on the other principal surface of the mounting substrate, the mother board, or other suitable location, the parasitic capacitance between the first inductance element and the ground pattern is reduced and the decrease in impedance of the first inductance element is reduced or prevented, such that a multiplexer having excellent impedance matching is obtained.

Although, conversely, the parasitic capacitance between the second inductance element and the ground pattern becomes large, it does not matter whether the stated parasitic capacitance becomes large or not. This is because the parasitic capacitance generated on the second inductance element has less unfavorable influence on the impedance matching than the parasitic capacitance generated on the first inductance element. To the contrary, by the increase in parasitic capacitance of the second inductance element, a pole due to LC resonance is generated on a higher frequency side outside the pass band, such that improved attenuation outside the pass band is able to be obtained.

A multiplexer according to a preferred embodiment of the present invention further include a common signal terminal provided in or on the mounting substrate, and a second inductance element included in the mounting substrate and connected between a reference terminal and a signal path connecting the common signal terminal and the common connection point of the other end of the first inductance element and the one end of each of the one or more second elastic wave filters. The second inductance element includes a second wiring conductor disposed in or on at least one of the plurality of wiring layers, and at least one of the wiring layers in or on which the second wiring conductor is disposed is located closer to the other principal surface of the mounting substrate than any of the wiring layers in or on which the first wiring conductor is disposed.

With this configuration, the impedances adjusted at the first elastic wave filter and the one or more second elastic wave filters are able to be further corrected by the second inductance element collectively. In general, a multiplexer in which filters are disposed on one principal surface of the mounting substrate, is mounted on a mother board, such as a printed circuit board, with the other principal surface of the mounting substrate interposed therebetween. As such, in accordance with the above-described configuration, of the first inductance element and the second inductance element, the second inductance element is disposed closer to the other principal surface of the mounting substrate, while the first inductance element is disposed farther from the other principal surface of the mounting substrate.

With this configuration, even if a ground pattern is provided on the other principal surface of the mounting substrate, the mother board, or other location, the parasitic capacitance between the first inductance element and the ground pattern is reduced and the decrease in impedance of the first inductance element is reduced or prevented, such that a multiplexer having excellent impedance matching is obtained.

Although, conversely, the parasitic capacitance between the second inductance element and the ground pattern becomes large, it does not matter whether the parasitic capacitance becomes large or not. This is because the parasitic capacitance generated on the second inductance element has less unfavorable influence on the impedance matching than the parasitic capacitance generated on the first inductance element. To the contrary, due to the increase in parasitic capacitance of the second inductance element, an L-value necessary to obtain the impedance matching becomes small, thus reducing the area. Because of this, unnecessary coupling with another inductor is reduced or prevented, so that improved attenuation inside the pass band is obtained.

A multiplexer according to a preferred embodiment of the present invention further includes a ground pattern provided on the other principal surface of the mounting substrate.

With this configuration, the parasitic capacitance between the second inductance element and the ground pattern provided on the other principal surface of the mounting substrate is increased, thus making it possible to improve attenuation outside or inside the pass band.

A transmission device according to a preferred embodiment of the present invention includes a multiplexer according to a preferred embodiment of the present invention, and at least one transmission circuit that is connected to the multiplexer and generate a plurality of transmission signals of mutually different frequency bands, wherein the multiplexer acquires the plurality of transmission signals from the

at least one transmission circuit and combines the acquired transmission signals into a single antenna signal.

A reception device according to a preferred embodiment of the present invention includes a multiplexer according to a preferred embodiment of the present invention, and at least one reception circuit that is connected to the multiplexer and processes a plurality of reception signals of mutually different frequency bands, wherein the multiplexer isolates the plurality of reception signals from a single antenna signal containing the plurality of reception signals and supplies the isolated reception signals to the reception circuit.

As described above, based on the features of preferred embodiments of the multiplexers, transmission devices and reception devices excellent in impedance matching at the antenna terminal are obtained.

With multiplexers, transmission devices, and reception devices according to preferred embodiments of the present invention, excellent impedance matching is able to be obtained at the antenna terminal with a configuration including a mounting substrate in which an inductance element is provided.

The above and other elements, features, steps, characteristics and advantages of the present invention will become more apparent from the following detailed description of the preferred embodiments with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram illustrating an example of a functional configuration of a multiplexer according to a first preferred embodiment of the present invention.

FIG. **2**A is a circuit diagram illustrating an example of a configuration of a transmission-side filter of Band 25 according to the first preferred embodiment of the present invention.

FIG. **2**B is a circuit diagram illustrating an example of a configuration of a reception-side filter of Band 25 according to the first preferred embodiment of the present invention.

FIG. **2**C is a circuit diagram illustrating an example of a configuration of a transmission-side filter of Band 66 according to the first preferred embodiment of the present invention.

FIG. **2**D is a circuit diagram illustrating an example of a configuration of a reception-side filter of Band 66 according to the first preferred embodiment of the present invention.

FIG. **3** is a cross-sectional view illustrating an example of a structure of a resonator according to the first preferred embodiment of the present invention.

FIG. **4** is a plan view illustrating an example of the structure of a multiplexer according to the first preferred embodiment of the present invention.

FIG. **5** is a cross-sectional view illustrating an example of the structure of the multiplexer according to the first preferred embodiment of the present invention.

FIG. **6** is a plan view illustrating a working example of the layout in a mounting substrate according to the first preferred embodiment of the present invention.

FIG. **7** is a plan view illustrating a comparative example of the layout in a mounting substrate according to the first preferred embodiment of the present invention.

FIG. **8**A is a Smith chart showing an example of a complex impedance seen from an antenna end of the transmission-side filter of Band 25 according to the first preferred embodiment of the present invention.

FIG. **8**B is a Smith chart showing an example of a complex impedance seen from an antenna end of the reception-side filter of Band 25 according to the first preferred embodiment of the present invention.

FIG. **8**C is a Smith chart showing an example of a complex impedance seen from an antenna end of the transmission-side filter of Band 66 according to the first preferred embodiment of the present invention.

FIG. **8**D is a Smith chart showing an example of a complex impedance seen from an antenna end of the reception-side filter of Band 66 according to the first preferred embodiment of the present invention.

FIG. **9** is a graph showing an example of a VSWR (Voltage Standing Wave Ratio) of the multiplexer according to the first preferred embodiment of the present invention.

FIG. **10** is a graph showing an example of insertion loss of the multiplexer according to the first preferred embodiment of the present invention.

FIG. **11**A is a block diagram illustrating an example of a functional configuration of a multiplexer according to a variation on the first preferred embodiment of the present invention.

FIG. **11**B is also a block diagram illustrating an example of a functional configuration of a multiplexer according to a variation on the first preferred embodiment of the present invention.

FIG. **12** is a block diagram illustrating an example of a functional configuration of a multiplexer according to a second preferred embodiment of the present invention.

FIG. **13** is a circuit diagram illustrating an example of a circuit configuration of a transmission-side filter of Band 66 configuring the multiplexer according to the second preferred embodiment of the present invention.

FIG. **14** is a plan view illustrating a working example of a wiring layout in a mounting substrate of the multiplexer according to the second preferred embodiment of the present invention.

FIG. **15** is a plan view illustrating a comparative example of a wiring layout in a mounting substrate of the multiplexer according to the second preferred embodiment of the present invention.

FIG. **16**A is a Smith chart showing an example of a complex impedance seen from an antenna end of a transmission-side filter of Band 25 according to the second preferred embodiment of the present invention.

FIG. **16**B is a Smith chart showing an example of a complex impedance seen from an antenna end of a reception-side filter of Band 25 according to the second preferred embodiment of the present invention.

FIG. **16**C is a Smith chart showing an example of a complex impedance seen from an antenna end of a transmission-side filter of Band 66 according to the second preferred embodiment of the present invention.

FIG. **16**D is a Smith chart showing an example of a complex impedance seen from an antenna end of a reception-side filter of Band 66 according to the second preferred embodiment of the present invention.

FIG. **17** is a graph showing an example of a VSWR of the multiplexer according to the second preferred embodiment of the present invention.

FIG. **18**A is a block diagram illustrating an example of a functional configuration of a multiplexer according to a variation on the second preferred embodiment of the present invention.

FIG. **18**B is also a block diagram illustrating an example of a functional configuration of a multiplexer according to a variation on the second preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, preferred embodiments of the present invention will be described in detail using working examples and with reference to the drawings. It is to be noted that all of the preferred embodiments described below represent generic or specific examples. Numerical values, shapes, materials, elements, arrangements of the elements, connection modes, and other features indicated in the following preferred embodiments are merely examples, and are not intended to limit the scope of the present invention. Of the elements included in the following preferred embodiments, those not recited in the independent claims of the present invention are described as arbitrary elements. In addition, sizes of the elements illustrated in the drawings or ratios of the sizes thereof are not necessarily accurate.

First Preferred Embodiment

In a first preferred embodiment of the present invention, a quadplexer is described that is applied to Band 25 (transmission frequency band: about 1850 MHz to about 1915 MHz, reception frequency band: about 1930 MHz to about 1995 MHz) and Band 66 (transmission frequency band: about 1710 MHz to about 1780 MHz, reception frequency band: about 2010 MHz to about 2200 MHz) of the LTE (Long Term Evolution) standard, for example. In the quadplexer, an antenna end of an unbalanced duplexer for Band 25 and an antenna end of a non-equilibrium duplexer for Band 66 connected in common.

FIG. **1** is a block diagram illustrating an example of a functional configuration of a multiplexer according to the first preferred embodiment. As illustrated in FIG. **1**, a multiplexer **1** includes filters **11** to **14**, inductance elements **41** and **42**, a common signal terminal P**0**, selection signal terminals P**1** to P**4**, and a ground terminal GND.

The filters **11** and **12** are preferably a transmission-side filter for Band 25 and a reception-side filter for Band 25, respectively, for example. The filters **13** and **14** are preferably a transmission-side filter for Band 66 and a reception-side filter for Band 66, respectively, for example. An input end **21** of the filter **11**, an output end **32** of the filter **12**, an input end **23** of the filter **13**, and an output end **34** of the filter **14** are connected to the selection signal terminals P**1** to P**4**, respectively. Output ends **31** and **33** of the filters **11** and **13**, and an input end **24** of the filter **14** are connected to a common connection point **30**. An input end **22** of the filter **12** is connected to the common connection point **30** with the inductance element **41** interposed therebetween. The common connection point **30** is connected to the common signal terminal P**0** with the inductance element **42** interposed therebetween. The common signal terminal P**0** is connected to an antenna element **9**.

The inductance element **41** is an example of a first inductance element, and the inductance element **42** is an example of a second inductance element. The common signal terminal P**0** is an example of an antenna terminal.

A transmission signal of Band 25 is supplied to the selection signal terminal P**1** from a transmission circuit (not illustrated). The filter **11** acquires the transmission signal at the input end **21**, performs filtering in a transmission pass band of Band 25 (about 1850 MHz to about 1915 MHz), and outputs the filtered signal from the output end **31**. The transmission signal of Band 25 after the filtering is supplied to the antenna element **9** from the common signal terminal P**0**, through the common connection point **30** and the inductance element **42**.

An antenna signal including a reception signal of Band 25 is supplied to the common signal terminal P**0** from the antenna element **9**. The filter **12** acquires the antenna signal, through the inductance element **42**, the common connection point **30**, and the inductance element **41**, at the input end **22**, performs filtering in a reception pass band of Band 25 (about 1930 MHz to about 1995 MHz), and outputs the filtered signal from the output end **32**. The antenna signal after the filtering is supplied as a reception signal of Band 25 to a reception circuit (not illustrated) from the selection signal terminal P**2**.

A transmission signal of Band 66 is supplied to the selection signal terminal P**3** from a transmission circuit (not illustrated). The filter **13** acquires the transmission signal at the input end **23**, performs filtering in a transmission pass band of Band 66 (about 1710 MHz to about 1780 MHz), and outputs the filtered signal from the output end **33**. The transmission signal of Band 66 after the filtering is supplied to the antenna element **9** from the common signal terminal P**0**, through the common connection point **30** and the inductance element **42**.

An antenna signal including a reception signal of Band 66 is supplied to the common signal terminal P**0** from the antenna element **9**. The filter **14** acquires the antenna signal, through the inductance element **42** and the common connection point **30**, at the input end **24**, performs filtering in a reception pass band of Band 66 (about 2010 MHz to about 2200 MHz), and outputs the filtered signal from the output end **34**. The antenna signal after the filtering is supplied as a reception signal of Band 66 to a reception circuit (not illustrated) from the selection signal terminal P**4**.

Configurations of the filters **11** to **14** will be described below. The configurations described below are merely examples, and are not intended to limit the specific configurations of the filters **11** to **14**. That is, in accordance with the characteristics required for the filters **11** to **14**, a different number of resonators, a different type of filter, e.g., a ladder or longitudinal coupling filter, or other suitable types of filters from that in the following description may be used.

FIG. **2**A is a circuit diagram illustrating an example of a configuration of the filter **11**. As illustrated in FIG. **2**A, the filter **11** is preferably a ladder filter, for example, including a total of nine serial resonators **101** to **105** and parallel resonators **151** to **154**. The filter **11** includes matching inductance elements **141**, **161**, and **162**.

The filter **11** is an example of a second elastic wave filter. The serial resonators **101** to **105** are each an example of a first resonator defining a signal path connecting the output end **31** as one end of the filter **11** and the input end **21** as the other end thereof. The parallel resonators **151** to **154** are each an example of a second resonator connected between the above signal path and the ground terminal GND as a reference terminal.

FIG. **2**B is a circuit diagram illustrating an example of a configuration of the filter **12**. As illustrated in FIG. **2**B, the filter **12** preferably includes a ladder filter including three parallel resonators **251** and **252** and a serial resonator **201**, for example. In a subsequent stage of the ladder filter, longitudinal coupling filters **202** and **203** each including five resonators are connected in parallel, and a parallel resonator **253** is also connected.

The filter **12** is an example of a first elastic wave filter. The serial resonator **201** and the resonators of the longitudinal coupling filters **202** and **203** are each an example of a

resonator defining a signal path connecting the input end **22** as one end of the filter **12** and the output end **32** as the other end thereof. Further, the parallel resonators **251** to **253** are each an example of a resonator connected between the signal path and the ground terminal GND as a reference terminal. In the filter **12**, the parallel resonator **251** is connected between the input end **22** and the serial resonator **201** closest to the input end **22** in the signal path.

FIG. **2**C is a circuit diagram illustrating an example of a configuration of the filter **13**. As illustrated in FIG. **2**C, the filter **13** is preferably a ladder filter, for example, a total of eight serial resonators **301** to **304** and parallel resonators **351** to **354**. The filter **13** includes matching inductance elements **341**, **361**, and **362**.

The filter **13** is an example of a second elastic wave filter. The serial resonators **301** to **304** are each an example of a resonator defining a signal path connecting the output end **33** as one end of the filter **13** and the input end **23** as the other end thereof. The parallel resonators **351** to **354** are each an example of a resonator connected between the signal path and the ground terminal GND as a reference terminal.

FIG. **2**D is a circuit diagram illustrating an example of a configuration of the filter **14**. As illustrated in FIG. **2**D, the filter **14** is preferably a ladder filter, for example, including a total of nine serial resonators **401** to **405** and parallel resonators **451** to **454**. The filter **14** includes a matching inductance element **461**.

The filter **14** is an example of a second elastic wave filter. The serial resonators **401** to **405** are each an example of a resonator defining a signal path connecting the input end **24** as one end of the filter **14** and the output end **34** as the other end thereof. The parallel resonators **451** to **454** are each an example of a resonator connected between the signal path and the ground terminal GND as a reference terminal.

With the above-described configuration, the following impedance matching is obtained in the multiplexer **1**.

A complex impedance of the filters **11**, **13**, and **14** being combined is capacitive when seen from the common connection point **30**. On the other hand, a complex impedance of the filter **12** seen from the common connection point **30** is shifted towards being inductive by the inductance element **41**. By synthesizing these complex impedances, the complex impedances of the filters **11** to **14** seen from the common connection point **30** are adjusted to the same or substantially the same complex impedance remaining slightly capacitive, for example.

The adjusted complex impedance is collectively shifted towards being inductive by the inductance element **42**. As a result, the complex impedances of the filters **11** to **14** seen from the antenna element **9** become equivalent or substantially equivalent to the characteristic impedance of the antenna element **9**, thus obtaining accurate impedance matching.

A structure of a resonator of the filters **11** to **14** will be described. Although a structure of a surface acoustic wave (SAW) resonator is described below, the structure is merely an example and is not intended to limit a specific structure of the resonator of the filters **11** to **14**. That is, in accordance with the characteristics required for the filters **11** to **14**, a different piezoelectric substrate structure from that in the following description, e.g., a FBAR (Film Bulk Acoustic Resonator) structure using bulk elastic waves, or other suitable resonators may be used.

FIG. **3** is a cross-sectional view illustrating an example of the structure of a resonator defining the filters **11** to **14**. The structure illustrated in FIG. **3** is applied to the serial resonators and the parallel resonators of the filters **11** to **14**, and is also applied to the resonators of the longitudinal coupling filters.

As illustrated in FIG. **3**, a resonator **100** includes a substrate **50** and an interdigital transducer (IDT) electrode **54** disposed on the substrate **50**.

The substrate **50** is preferably a multilayer body including a high acoustic velocity film **51**, a low acoustic velocity film **52**, and a piezoelectric film **53**, for example.

The high acoustic velocity film **51** is a film in which an acoustic velocity of a bulk wave propagating therein is larger than those of a surface acoustic wave and a boundary wave propagating in the piezoelectric film **53**. A silicon substrate is an example of the high acoustic velocity film **51** and a thickness thereof is preferably about 200 μm, for example. In FIG. **3**, the high acoustic velocity film **51** also defines and functions as a support substrate to support the low acoustic velocity film **52**, the piezoelectric film **53**, and the IDT electrode **54**. However, not being limited thereto, a support substrate may be provided, other than the high acoustic velocity film **51**, below the high acoustic velocity film **51**.

The low acoustic velocity film **52** is provided on the high acoustic velocity film **51**, and an acoustic velocity of a bulk wave propagating therein is smaller than those of the surface acoustic wave and the boundary wave propagating in the piezoelectric film **53**. A film including silicon dioxide as a main ingredient is an example of the low acoustic wave film **52**, and a thickness thereof is preferably about 670 nm, for example.

The piezoelectric film **53** is provided on the low acoustic velocity film **52**, the surface acoustic wave propagates therein. Lithium tantalate single crystal of θ-rotated Y-cut X-propagation or ceramic material may preferably be used for the piezoelectric film **53**, and a thickness thereof is preferably about 600 nm, for example. Here, "lithium tantalate single crystal of θ-rotated Y-cut X-propagation or ceramic material" refers to lithium tantalate single crystal that is cut along a surface taking, as a normal line, an axis rotated around an X-axis by an angle of θ from a Y-axis where a propagation direction of the surface acoustic wave is the X-axis direction, or a ceramic material. The value of θ is preferably, for example, about 50 degrees.

The IDT electrode **54** includes a pair of comb-shaped electrodes provided on the piezoelectric film **53**, and excites the piezoelectric film **53** in response to an applied electric signal. The IDT electrode **54** is preferably, for example, a multilayer film including a main electrode layer **56** made of aluminum including about 1% of copper and having a thickness of about 162 nm that is provided on a close contact layer **55** with a thickness of about 12 nm including a main ingredient of titanium. On the main electrode layer **56**, a protection layer with a thickness of about 25 nm whose main ingredient is silicon dioxide may further be provided (not illustrated).

According to the above-described structure, by providing the low acoustic velocity film **52**, energy of the elastic wave is effectively confined inside the piezoelectric film **53** and the low acoustic velocity film **52** based on elastic wave properties that concentrate the energy thereof in a medium of a small acoustic velocity. In addition, the high acoustic velocity film **51** reduces or prevents leakage of the elastic wave from the high acoustic velocity film **51** towards a structure on a lower side (not illustrated). As a result, the resonator **100** with small loss and a high Q-value is obtained.

In a filter provided with matching elements, such as an inductance element and a capacitance element, it is difficult to prevent an increase in loss and a decrease in a Q-value due

to the matching elements. However, the resonator **100** compensates, with small loss and a high Q-value of the resonator **100**, for the increase in loss and the decrease in the Q-value due to the matching elements, thus making it possible to obtain a filter having excellent characteristics.

The IDT electrodes **54** defining a plurality of resonators **100** may be provided on the substrate **50**. Further, by providing, on the substrate **50**, wiring conductors (not illustrated) connected with the IDT electrodes **54**, the resonators **100** may be wired to each other. For example, the filters **11** to **14** may be defined as chip components by providing the plurality of resonators included in the filters **11** to **14** and the substrate **50** in which the resonators are wired to each other. The matching inductance elements, e.g., the inductance element **141** of the filter **11** and the inductance element **341** of the filter **13**, included in the filters **11** to **14** may not be incorporated in the chip components, but may be provided as external components.

A structure of the multiplexer **1** will be described below. In the following, as an example, a structure of a multiplexer as a module component in which filters as chip components are mounted on a mounting substrate or a portion of the module component is described and illustrated.

FIGS. **4** and **5** are respectively a plan view and a cross-sectional view illustrating an example of the structure of the multiplexer **1**. FIG. **5** corresponds to a cross section taken along a V-V cutting line and viewed in a direction of the arrows in FIG. **4**.

As illustrated in FIGS. **4** and **5**, the multiplexer **1** includes a mounting substrate **60**, a conductive bonding material **70**, the filters **11** to **14**, and a sealing layer **80**.

The mounting substrate **60** is preferably a multilayer substrate including base material layers **61** to **65** that are laminated, and the base material layers **61** to **65** are made of resin, such as phenol or epoxy, for example. Connection electrodes **66** and **67** are provided on one principal surface and the other principal surface of the mounting substrate **60** respectively, an in-plane conductor **68** (wiring pattern) is provided on an interface between the base material layers adjacent to each other, and an interlayer conductor **69** (via) is provided passing through the base material layer.

The connection electrode **66** connects the filters **11** to **14**. The chip filters **11** to **14** are each attached to the connection electrode **66** using the conductive bonding material **70**, such as solder, for example. The connection electrode **67** defines the common signal terminal P**0**, the selection signal terminals P**1** to P**4**, and the ground terminal GND. The multiplexer **1** is mounted on a mother board, such as a printed circuit board (not illustrated), for example, via the connection electrode **67**. The connection electrodes **66** and **67** are preferably made of a copper alloy foil, and metal plating, such as gold plating is performed thereupon, for example.

The in-plane conductor **68** and the interlayer conductor **69** define the circuit (including the inductance elements **41** and **42**) of the multiplexer **1** as illustrated in FIG. **1**. The in-plane conductor **68** is preferably made of, for example, a copper alloy foil disposed on surfaces of the base material layers **61** to **65**. The interlayer conductor **69** is preferably made of, for example, copper alloy plated on an inner wall of a through-hole provided in each of the base material layers **61** to **65**.

The sealing layer **80** seals an upper surface of the mounting substrate **60** and the filters **11** to **14**. The sealing layer **80** is preferably made of, for example, thermosetting resin or ultraviolet curing resin.

The arrangement of the inductance elements **41** and **42** in the mounting substrate **60** will be described below. Note that the arrangement described below is merely an example, and is not intended to limit the specific arrangement of the inductance elements **41** and **42**. That is, arrangements different from the arrangement described below may be used in accordance with a design for the arrangement of the inductance elements **41** and **42** to be explained later.

Hereinafter, for the sake of convenience in explanation, exposure surfaces and bonding surfaces of the base material layers **61** to **65** in the mounting substrate **60** are represented as wiring layers W**1** to W**6** respectively in the order of distance to the filters **11** to **14** from closest to farthest. The wiring layers W**1** and W**6** are provided on the one principal surface and the other principal surface of the mounting substrate **60** respectively, and the wiring layers W**2** to W**5** are provided in an inner layer of the mounting substrate **60**. In the case in which relative positions of the wiring layers W**1** to W**6** are described using the terms "upper" and "lower", the wiring layer W**1** is positioned on an upper side while the wiring layer W**6** is positioned on a lower side.

FIG. **6** is a plan view illustrating an example of the layout in the mounting substrate **60**. In the FIG. **6**, an example of the layout of the connection electrodes **66** and **67**, the in-plane conductor **68**, and the interlayer conductor **69** that are arranged in the wiring layers W**1** to W**6** is illustrated.

In FIG. **6**, gray regions indicate the connection electrodes **66** and **67** and the in-plane conductor **68**, and a black circle indicates the interlayer conductor **69** provided between the wiring layer and the wiring layer positioned on a lower side by one layer. Broken-line frames indicate regions at which the filters **11** to **14** and the inductance elements **41** and **42** are provided.

Spiral in-plane conductors provided in a region A of the wiring layers W**3** and W**4** are connected with the interlayer conductor, thus defining the inductance element **41**. The spiral in-plane conductors provided in the region A of the wiring layers W**3** and W**4** and the interlayer conductor connecting the stated in-plane conductors are an example of a first wiring conductor. No ground pattern is provided in a region A of the wiring layers W**2** and W**5**.

The ground pattern refers to a sheet-shaped wiring conductor connected to the ground electrode as a reference terminal. The expression "no ground pattern is provided in a portion overlapping with the region A" means that a ground pattern having a substantial size is not present in the portion. For example, a ground pattern may be present with an area ratio of less than about 10% in the portion. With this, the following case is included in the case of no ground pattern being provided: a case in which linear ground wiring that connects two points enters the portion, the ground pattern enters the portion due to an alignment shift, or other deviations.

As described above, the mounting substrate **60** includes the wiring layer W**5** in which no ground pattern is provided in a portion overlapping with the region A in which the inductance element **41** is provided in a plan view, adjacent to the wiring layer W**4**, in which the first wiring conductor is disposed, on the other principal surface side of the mounting substrate **60**.

Further, the mounting substrate **60** includes the wiring layer W**2** in which no ground pattern is provided in a portion overlapping with the region A in which the inductance element **41** is provided in a plan view, adjacent to the wiring layer W**3**, in which the first wiring conductor is disposed, on the one principal surface side of the mounting substrate **60**.

Spiral in-plane conductors provided in a region B of the wiring layers W**4** and W**5** are connected with the interlayer conductor, thus defining the inductance element **42**. The spiral in-plane conductors provided in the region B of the

wiring layers **W4** and **W5** and the interlayer conductor connecting the in-plane conductors are an example of a second wiring conductor.

As described above, of the wiring layers in which the second wiring conductor is disposed, at least the wiring layer **W5** is positioned closer to the other principal surface of the mounting substrate **60** than any of the wiring layers **W3** and **W4**, in which the first wiring conductor is disposed.

In a case in which parasitic capacitance is generated on the inductance element **41**, the impedance of the inductance element **41** decreases, so that impedance matching at the common signal terminal **P0** is degraded. As such, in accordance with the layout illustrated in FIG. **6**, a ground pattern is not provided in the portion overlapping with the region A in which the inductance element **41** is provided, in the wiring layers **W2** and **W5** respectively adjacent to the wiring layers **W3** and **W4**, in which the inductance element **41** is provided.

This prevents an increase in parasitic capacitance generated when a ground pattern is disposed adjacent to the inductance element **41** and reduces or prevents the decrease in impedance of the inductance element **41**, thus obtaining a multiplexer having excellent impedance matching at the common signal terminal **P0**.

Further, according to the layout illustrated in FIG. **6**, of the inductance elements **41** and **42**, the inductance element **41** is disposed farther from the other principal surface of the mounting substrate, while the inductance element **42** is disposed closer to the other principal surface of the mounting substrate.

This reduces parasitic capacitance between the inductance element **41** and a ground pattern included in the mother board (not illustrated), and reduces or prevents the decrease in impedance of the inductance element **41**, thus obtaining a multiplexer having excellent impedance matching at the common signal terminal **P0** (antenna terminal).

In the layout illustrated in FIG. **6**, although parasitic capacitance between the inductance element **42** and a ground pattern included in the mother board (not illustrated) is likely to increase, parasitic capacitance generated on the inductance element **42** imparts less unfavorable influence to the impedance matching than that generated on the inductance element **41**. To the contrary, the increase in parasitic capacitance of the inductance element **42** causes a pole due to the LC resonance to be generated on a higher frequency side outside the pass band, thus effectively improving the attenuation outside the pass band.

A ground pattern is provided as the connection electrode **67** in the wiring layer **W6** in the layout in FIG. **6**. This increases the parasitic capacitance between the inductance element **42** and the ground pattern provided in the wiring layer **W6**, thus improving the attenuation outside the pass band with more certainty.

In order to confirm the above-described effects, a comparative example of the layout in the mounting substrate **60** was prepared, and simulation was performed based on the layouts of the working example and the comparative example to calculate signal propagation characteristics of the multiplexer.

FIG. **7** is a plan view illustrating the comparative example of the layout in the mounting substrate **60**. In the FIG. **7**, an example of the layout of the connection electrodes **66** and **67**, the in-plane conductor **68**, and the interlayer conductor **69** that are disposed in the wiring layers **W1** to **W6** is illustrated. Because the notations in FIG. **7** is the same as that in FIG. **6**, description thereof is not repeated.

The layout of the comparative example in FIG. **7** is different from the layout of the working example in FIG. **6** in the following points. The inductance element **41** is provided in the wiring layers **W4** and **W5**, and the inductance element **42** is provided in the wiring layers **W3** and **W4**. Further, a ground pattern is provided in a portion of the wiring layer **W6**, which is adjacent to the wiring layer **W5**, overlapping with a region A in which the inductance element **41** is provided in a plan view. The multiplexer configured in accordance with the layout of the comparative example cannot sufficiently exhibit the above-described advantageous effects due to these differences.

FIGS. **8**A to **8**D are Smith charts showing complex impedances of the filters **11** to **14** seen from the common signal terminal **P0**, where a solid line represents the working example and a dotted line represents the comparative example. As shown in FIGS. **8**A to **8**D, of the complex impedances of the filters, the complex impedances in the working example preferably agree with the characteristic impedance. However, variations are seen in the comparative example.

FIG. **9** is a graph showing VSWRs of the filters **11** to **14** seen from the common signal terminal **P0**, where a solid line represents the working example and a dotted line represents the comparative example. As shown in FIG. **9**, the VSWRs of the filters **11** to **14** seen from the common signal terminal **P0** are no more than about 1.30 in all of the frequency bands in the working example. However, a maximum value of about 1.40 to about 1.55 is observed in each frequency band in the comparative example.

FIG. **10** is a graph showing insertion loss of the filter **11** seen from the common signal terminal **P0**, where a solid line represents the working example and a dotted line represents the comparative example. As shown in FIG. **10**, a pole is generated near about 7 GHz in the working example, thus improving the attenuation on a high frequency side outside the pass band in comparison with the comparative example.

From the results of the simulation, it has been confirmed that the signal propagation characteristics are improved in the working example based on the impedance matching with high precision in comparison with the comparative example.

The structure and advantageous effects according to a preferred embodiment of the multiplexer have been described using an example of the quadplexer applied to Band 25 and Band 66. However, the same or substantially the same advantageous effects are also able to be obtained by a quadplexer of another combination, such as a combination of Bands 1 and 3 or a combination of Bands 3 and 7, for example. Moreover, not being limited to the quadplexer, a multiplexer that achieves more accurate impedance matching is able to be obtained as a hexaplexer combining three bands as illustrated in FIGS. **11**A and **11**B, or other suitable multiplexers.

Second Preferred Embodiment

FIG. **12** is a block diagram illustrating an example of a functional configuration of a multiplexer according to a second preferred embodiment of the present invention. As illustrated in FIG. **12**, a multiplexer **2** includes filters **11** to **14**, inductance elements **41** and **43**, a common signal terminal **P0**, selection signal terminals **P1** to **P4**, and a ground terminal GND.

In the multiplexer **2**, compared to the multiplexer **1** in FIG. **1**, a filter **13***a* as the transmission-side filter for Band 66 and the inductance element **43** are changed. The inductance element **43** is connected between a reference terminal and a

signal path connecting a common connection point **30** and the common signal terminal P**0**.

FIG. **13** is a circuit diagram illustrating an example of a configuration of the filter **13***a*. As illustrated in FIG. **13**, in the filter **13***a*, the parallel resonator **351** is removed from the filter **13** illustrated in FIG. **2**C.

With the above-described configuration, impedance matching is obtained as described below in the multiplexer **2**.

A complex impedance, seen from the common connection point **30**, of the filters **11**, **13***a*, and **14** being combined is capacitive. On the other hand, the complex impedance of the filter **12** seen from the common connection point **30** is shifted towards being inductive by the inductance element **41**. By combining these complex impedances, complex impedances of the filters **11** to **14** seen from the common connection point **30** are adjusted to the same or substantially the same complex impedance remaining slightly capacitive, for example.

The adjusted complex impedance is further shifted towards being inductive by the inductance element **43**. As a result, the complex impedances of the filters **11** to **14** seen from an antenna element **9** become equivalent or substantially equivalent to the characteristic impedance of the antenna element **9**, thus obtaining accurate impedance matching.

FIG. **14** is a plan view illustrating a working example of a layout in the mounting substrate **60**. In the FIG. **14**, an example is illustrated of a layout of connection electrodes **66** and **67**, an in-plane conductor **68**, and an interlayer conductor **69** that are arranged in wiring layers W**1** to W**6**.

In the layout in FIG. **14**, similar to the layout in FIG. **6**, the inductance element **41** is defined by connecting, with the interlayer conductor, spiral in-plane conductors provided in a region A of the wiring layers W**3** and W**4**. The spiral in-plane conductors provided in the region A of the wiring layers W**3** and W**4** and the interlayer conductor connecting the in-plane conductors are an example of the first wiring conductor. No ground pattern is provided in a region A of the wiring layers W**2** and W**5**.

As discussed above, the mounting substrate **60** includes the wiring layer W**5** in which no ground pattern is provided in a portion overlapping with the region A in which the inductance element **41** is provided in a plan view, adjacent to the wiring layer W**4**, in which the first wiring conductor is disposed, on the other principal surface side of the mounting substrate **60**.

Further, the mounting substrate **60** includes the wiring layer W**2** in which no ground pattern is provided in a portion overlapping with the region A in which the inductance element **41** is provided in a plan view, adjacent to the wiring layer W**3**, in which the first wiring conductor is disposed, on the one principal surface side of the mounting substrate **60**.

Spiral in-plane conductors provided in a region B of the wiring layers W**4** and W**5** are connected with the interlayer conductor, thus defining the inductance element **43**. The spiral in-plane conductors provided in the region B of the wiring layers W**4** and W**5** and the interlayer conductor connecting the in-plane conductors are an example of the second wiring conductor.

As described above, of the wiring layers in which the second wiring conductor is disposed, at least the wiring layer W**5** is positioned closer to the other principal surface of the mounting substrate **60** than any of the wiring layers W**3** and W**4**, in which the first wiring conductor is disposed.

Further, of the inductance elements **41** and **43**, the inductance element **41** is disposed farther from the other principal surface of the mounting substrate, while the inductance element **43** is disposed closer to the other principal surface of the mounting substrate.

With the layout in FIG. **14**, because parasitic capacitance generated on the inductance element **41** is reduced or prevented due to the same or substantially the same structure as that of the layout in FIG. **6** and the decrease in impedance of the inductance element **41** is reduced or prevented, a multiplexer having excellent impedance matching at the common signal terminal P**0** is obtained.

In the layout illustrated in FIG. **14**, although parasitic capacitance between the inductance element **43** and a ground pattern included in the mother board (not illustrated) is likely to increase, parasitic capacitance generated on the inductance element **43** imparts less unfavorable influence to the impedance matching than that generated on the inductance element **41**. Moreover, the increase in parasitic capacitance of the inductance element **43** allows an L-value necessary to obtain the impedance matching to be small, and consequently makes the area small. Because of this, unnecessary coupling with another inductor is reduced or prevented, thus effectively improving the attenuation inside the pass band.

A ground pattern is provided as the connection electrode **67** in the wiring layer W**6** in the layout of FIG. **14**. This increases the parasitic capacitance between the inductance element **43** and the ground pattern provided in the wiring layer W**6**, thus improving the attenuation inside the pass band with more certainty.

In order to confirm the above-described advantageous effects, a comparative example of the layout in the mounting substrate **60** was prepared, and simulation was performed based on the layouts of the working example and the comparative example to calculate signal propagation characteristics of the multiplexer.

FIG. **15** is a plan view illustrating the comparative example of the layout in the mounting substrate **60**. In FIG. **15**, an example of a layout of the connection electrodes **66** and **67**, the in-plane conductor **68**, and the interlayer conductor **69** that are disposed in the wiring layers W**1** to W**6** is illustrated.

The layout of the comparative example in FIG. **15** is different from the layout of the working example in FIG. **14** in the following points. The inductance element **41** is provided in the wiring layers W**4** and W**5**, and the inductance element **43** is provided in the wiring layers W**3** and W**4**. Further, a ground pattern is provided in a portion of the wiring layer W**6**, which is adjacent to the wiring layer W**5**, overlapping with a region A in which the inductance element **41** is provided in a plan view. The multiplexer configured in accordance with the layout of the comparative example cannot sufficiently exhibit the above-described advantageous effects due to these differences.

FIGS. **16**A to **16**D are Smith charts showing complex impedances of the filters **11** to **14** seen from the common signal terminal P**0**, where a solid line represents the working example and a dotted line represents the comparative example. As shown in FIGS. **16**A to **16**D, of the complex impedances of the filters, the complex impedances in the working example preferably agree with the characteristic impedance. However, variations are observed in the comparative example.

FIG. **17** is a graph showing VSWRs of the filters **11** to **14** seen from the common signal terminal P**0**, where a solid line represents the working example and a dotted line represents the comparative example. As shown in FIG. **17**, the VSWRs of the filters **11** to **14** seen from the common signal terminal

P0 are no more than about 1.30 in all if the frequency bands in the working example. However, a maximum value of around 1.47 to 1.53 is observed in each frequency band in the comparative example.

From the results of the simulation, it has been confirmed that the signal propagation characteristics are able to be improved in the working example based on the impedance matching with high precision in comparison with the case of the comparative example.

The structure and advantageous effects according to a preferred embodiment of the multiplexer have been described using an example of the quadplexer applied to Band 25 and Band 66. However, the same or substantially the same advantageous effects are also able to be obtained by a quadplexer of another combination, such as a combination of Bands 1 and 3 or a combination of Bands 3 and 7, for example. Moreover, not being limited to the quadplexer, a multiplexer that achieves more accurate impedance matching is able to be obtained as a hexaplexer combining three bands as illustrated in FIGS. **18**A and **18**B, or other suitable multiplexers, for example.

Although the multiplexers, the transmission devices, and the reception devices according to preferred embodiments of the present invention have been described above with reference to the preferred embodiments, the present invention is not limited to the individual preferred embodiments. Various modifications and variations conceived by those skilled in the art may be performed on the preferred embodiments of the present invention, preferred embodiments defined by combining elements of different preferred embodiments, and other configurations may be included in the scope the present invention without departing from the spirit of the aspects of the present invention.

The features and aspects of the present invention may be widely used, as an elastic wave filter device that is small in size and has excellent insertion loss characteristics including a plurality of elastic wave filters, in a communication apparatus, such as a cellular phone, for example.

While preferred embodiments of the present invention have been described above, it is to be understood that variations and modifications will be apparent to those skilled in the art without departing from the scope and spirit of the present invention. The scope of the present invention, therefore, is to be determined solely by the following claims.

What is claimed is:

1. A multiplexer comprising:

a mounting substrate;

one first elastic wave filter and one or more second elastic wave filters that are provided on one principal surface of the mounting substrate and have different pass bands from each other; and

a first inductance element provided in the mounting substrate, and one end of which is connected to one end of the first elastic wave filter; wherein

another end of the first inductance element and one end of each of the one or more second elastic wave filters are connected to each other;

the first elastic wave filter includes one or more first resonators defining a signal path connecting the one end and the another end of the first elastic wave filter and one or more second resonators connected between the signal path and a reference terminal, and at least one of the second resonators is connected between the one end of the first elastic wave filter and the first resonator closest to the one end of the first elastic wave filter in the signal path;

each of the one or more second elastic wave filters includes one or more third resonators defining a signal path connecting the one end and the another end of the second elastic wave filter, and one or more fourth resonators connected between the signal path and a reference terminal;

the mounting substrate is a multilayer substrate including wiring conductors that are disposed in or on a plurality of wiring layers that are provided at the one principal surface, at another principal surface, and in an inner layer of the mounting substrate;

the first inductance element includes a first wiring conductor disposed in or on at least one of the plurality of wiring layers; and

the plurality of wiring layers include a wiring layer which is adjacent, on the another principal surface side of the mounting substrate, to the wiring layer on which the first wiring conductor is disposed, and in which a ground pattern is not provided in a portion overlapping with a formation region of the first inductance element in a plan view.

2. The multiplexer according to claim **1**, wherein the plurality of wiring layers include a wiring layer which is adjacent, on the one principal surface side of the mounting substrate, to the wiring layer on which the first wiring conductor is disposed, and in which a ground pattern is not provided in a portion overlapping with the formation region of the first inductance element in a plan view.

3. The multiplexer according to claim **1**, further comprising:

a common signal terminal provided in or on the mounting substrate; and

a second inductance element provided in the mounting substrate and connected between the common signal terminal and a common connection point of the another end of the first inductance element and the one end of each of the one or more second elastic wave filters; wherein

the second inductance element includes a second wiring conductor disposed in or on at least one of the plurality of wiring layers; and

at least one of the wiring layers in or on which the second wiring conductor is disposed is closer to the another principal surface of the mounting substrate than any of the plurality of wiring layers in or on which the first wiring conductor is disposed.

4. The multiplexer according to claim **1**, further comprising:

a common signal terminal provided in or on the mounting substrate; and

a second inductance element provided in the mounting substrate and connected between a reference terminal and a signal path connecting the common signal terminal and a common connection point of the another end of the first inductance element and the one end of each of the one or more second elastic wave filters; wherein

the second inductance element includes a second wiring conductor disposed in or on at least one of the plurality of wiring layers; and

at least one of the wiring layers in or on which the second wiring conductor is disposed is closer to the another principal surface of the mounting substrate than any of the plurality of wiring layers in or on which the first wiring conductor is disposed.

5. The multiplexer according to claim **3**, further comprising:

a ground pattern provided on the another principal surface of the mounting substrate.

6. The multiplexer according to claim **1**, wherein

each of the first, second, third, and fourth resonators includes a substrate and an interdigital transducer electrode disposed on the substrate;

the substrate is a multilayer body including a high acoustic velocity film, a low acoustic velocity film, and a piezoelectric film;

the high acoustic velocity film has an acoustic velocity of a bulk wave propagating therein that is larger than acoustic velocities of a surface acoustic wave and a boundary wave propagating in the piezoelectric film;

the low acoustic velocity film is provided on the high acoustic velocity film, and an acoustic velocity of a bulk wave propagating therein is smaller than the acoustic velocities of the surface acoustic wave and the boundary wave propagating in the piezoelectric film; and

the piezoelectric film is provided on the low acoustic velocity film.

7. A transmission device comprising:

the multiplexer according to claim **1**; and

at least one transmission circuit connected to the multiplexer and generating a plurality of transmission signals having mutually different frequency bands; wherein

the multiplexer acquires the plurality of transmission signals from the at least one transmission circuit and combines the acquired transmission signals into a single antenna signal.

8. The transmission device according to claim **7**, wherein the plurality of wiring layers include a wiring layer which is adjacent, on the one principal surface side of the mounting substrate, to the wiring layer on which the first wiring conductor is disposed, and in which a ground pattern is not provided in a portion overlapping with the formation region of the first inductance element in a plan view.

9. The transmission device according to claim **7**, further comprising:

a common signal terminal provided in or on the mounting substrate; and

a second inductance element provided in the mounting substrate and connected between the common signal terminal and a common connection point of the another end of the first inductance element and the one end of each of the one or more second elastic wave filters; wherein

the second inductance element includes a second wiring conductor disposed in or on at least one of the plurality of wiring layers; and

at least one of the wiring layers in or on which the second wiring conductor is disposed is closer to the another principal surface of the mounting substrate than any of the plurality of wiring layers in or on which the first wiring conductor is disposed.

10. The transmission device according to claim **7**, further comprising:

a common signal terminal provided in or on the mounting substrate; and

a second inductance element provided in the mounting substrate and connected between a reference terminal and a signal path connecting the common signal terminal and a common connection point of the another end of the first inductance element and the one end of each of the one or more second elastic wave filters; wherein

the second inductance element includes a second wiring conductor disposed in or on at least one of the plurality of wiring layers; and

at least one of the wiring layers in or on which the second wiring conductor is disposed is closer to the another principal surface of the mounting substrate than any of the plurality of wiring layers in or on which the first wiring conductor is disposed.

11. The transmission device according to claim **9**, further comprising:

a ground pattern provided on the another principal surface of the mounting substrate.

12. The transmission device according to claim **7**, wherein

each of the first, second, third, and fourth resonators includes a substrate and an interdigital transducer electrode disposed on the substrate;

the substrate is a multilayer body including a high acoustic velocity film, a low acoustic velocity film, and a piezoelectric film;

the high acoustic velocity film has an acoustic velocity of a bulk wave propagating therein that is larger than acoustic velocities of a surface acoustic wave and a boundary wave propagating in the piezoelectric film;

the low acoustic velocity film is provided on the high acoustic velocity film, and an acoustic velocity of a bulk wave propagating therein is smaller than the acoustic velocities of the surface acoustic wave and the boundary wave propagating in the piezoelectric film; and

the piezoelectric film is provided on the low acoustic velocity film.

13. A reception device comprising:

the multiplexer according to claim **1**; and

at least one reception circuit connected to the multiplexer and processing a plurality of reception signals having mutually different frequency bands; wherein

the multiplexer isolates the plurality of reception signals from a single antenna signal including the plurality of reception signals and supplies the isolated reception signals to the reception circuit or reception circuits.

14. The reception device according to claim **13**, wherein the plurality of wiring layers include a wiring layer which is adjacent, on the one principal surface side of the mounting substrate, to the wiring layer on which the first wiring conductor is disposed, and in which a ground pattern is not provided in a portion overlapping with the formation region of the first inductance element in a plan view.

15. The reception device according to claim **13**, further comprising:

a common signal terminal provided in or on the mounting substrate; and

a second inductance element provided in the mounting substrate and connected between the common signal terminal and a common connection point of the another end of the first inductance element and the one end of each of the one or more second elastic wave filters; wherein

the second inductance element includes a second wiring conductor disposed in or on at least one of the plurality of wiring layers; and

at least one of the wiring layers in or on which the second wiring conductor is disposed is closer to the another principal surface of the mounting substrate than any of the plurality of wiring layers in or on which the first wiring conductor is disposed.

16. The reception device according to claim **13**, further comprising:

a common signal terminal provided in or on the mounting substrate; and

a second inductance element provided in the mounting substrate and connected between a reference terminal and a signal path connecting the common signal terminal and a common connection point of the another end of the first inductance element and the one end of each of the one or more second elastic wave filters; wherein

the second inductance element includes a second wiring conductor disposed in or on at least one of the plurality of wiring layers; and

at least one of the wiring layers in or on which the second wiring conductor is disposed is closer to the another principal surface of the mounting substrate than any of the plurality of wiring layers in or on which the first wiring conductor is disposed.

17. The reception device according to claim **15**, further comprising:

a ground pattern provided on the another principal surface of the mounting substrate.

18. The reception device according to claim **13**, wherein each of the first, second, third, and fourth resonators includes a substrate and an interdigital transducer electrode disposed on the substrate;

the substrate is a multilayer body including a high acoustic velocity film, a low acoustic velocity film, and a piezoelectric film;

the high acoustic velocity film has an acoustic velocity of a bulk wave propagating therein that is larger than acoustic velocities of a surface acoustic wave and a boundary wave propagating in the piezoelectric film;

the low acoustic velocity film is provided on the high acoustic velocity film, and an acoustic velocity of a bulk wave propagating therein is smaller than the acoustic velocities of the surface acoustic wave and the boundary wave propagating in the piezoelectric film; and

the piezoelectric film is provided on the low acoustic velocity film.

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