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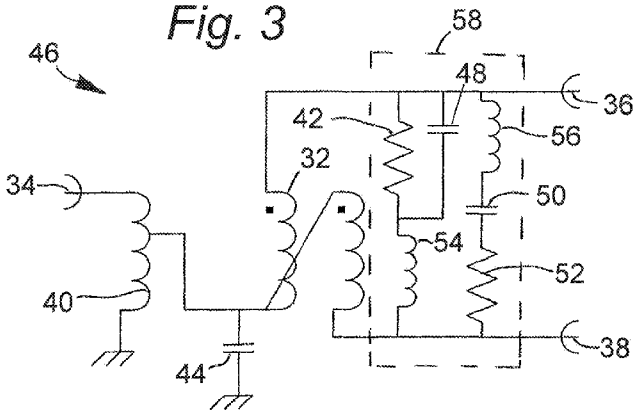
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(54) Title: SIGNAL SPLITTER FOR USE IN MOCA/CATV NETWORKS

Fig. 3



(57) Abstract: There is provided a splitter circuit means for use with a CATV network comprising a signal input (34) in communication with a balun (32) to supply two signal outputs (36, 38), with a resistor (42) connected in parallel between the outputs (36, 38) and wherein additional capacitive, inductive and resistive elements (48, 50, 52, 54, 46) are associated with the resistor (42), thereby to give an insertion loss in to out in the range of 3 to 10 dB and an isolation out to out of <17 dB for signal frequencies in the range 1125 MHz to 1525 MHz. A first capacitive element (48) is connected in parallel with the resistor (42), with the resistor in series with a first inductive element (54), the resistor (42) also in parallel with a second inductive element (56), a second capacitive element (50) and a resistive element (52) connected in series with one another. The splitter circuit means has an insertion loss in to out in the range 3 to 6 d B for signal frequencies in the range 5 MHz to 1000 MHz.

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Title: Signal Splitter for use in MoCA/CATV Networks

Field of the invention

This invention relates to a signal splitter for use in MoCA/CATV networks, the associated circuitry and a cable television network incorporating such signal splitters.

Background to the invention

A signal splitter, also known as a power splitter, for use in networks where CATV (cable television) transmission is combined with MoCA (Multimedia over Coax Alliance) transmission should have good return loss, low insertion loss and high isolation in the CATV frequency range (typically 5 MHz to 1000 MHz) to give excellent RF performance.

However for the MoCA frequency range (typically 1125 MHz to 1525 MHz), the signal splitter should ideally have a low isolation as well as a low insertion loss so as to reduce transmission loss and thus improve or, in some cases, enable MoCA transmission between output ports of a plurality of splitters within an in-home network.

Most homes have an in-home coaxial network installed to distribute TV signals to various locations. This network can also be used to distribute data or other signals to and from these locations.

With the increasing use of IP (Internet Protocol) and the internet, in-home networking is becoming very important and whilst there may be an access point in the home, it can be difficult to distribute data from this access point to and from various locations in the home. There are several technologies available to achieve this, for example PowerLine, MoCA, wireless, fibre optic, and CAT-5. These technologies all have their weaknesses.

The advantages of using the existing in-home coaxial networks are obvious: no new wires are needed and the coaxial cable is a medium with large bandwidth and very

good screening. It is therefore a safe and fast medium and since it is already in place, it is also an economical solution.

However the signal dividers used in existing coaxial networks have a high isolation between output ports making two-way MoCA communication very difficult and in many cases even impossible.

It is an aim of the present invention to provide a signal splitter and associated circuit means to combine suitable RF performance in the CATV frequency range with low isolation in the MoCA frequency range.

Summary of the invention

In accordance with one aspect of the present invention, there is provided a splitter circuit means for use with a CATV network comprising a signal input in communication with a balun to supply two signal outputs, with a resistor connected in parallel between the outputs and wherein additional capacitive, inductive and resistive elements are associated with the resistor, thereby to give an insertion loss in to out in the range of 3 to 10 dB, and preferably an isolation out to out of <17 dB, for signal frequencies in the range 1125 MHz to 1525 MHz. The frequency band of 1125 to 1525 MHz is the preferred MoCA bandwidth and a splitter circuit with a low insertion loss over this frequency range improves MoCA transmission between output ports of associated splitter circuits.

Preferably a first capacitive element is connected in parallel with the resistor, with the resistor in series with a first inductive element, the resistor also in parallel with a second inductive element, a second capacitive element and a resistive element connected in series with one another. A signal splitter incorporating such a circuit will have low isolation, low insertion loss and moderate return loss for signals within the MoCA frequency range.

Desirably the first inductive element has an inductance in the range 10 nH to 40 nH, more preferably 20 nH to 40 nH, with the second inductive element having an inductance in the range 30 nH to 90 nH, more preferably 50 nH to 90 nH.

The first capacitive element may have a capacitance in the range 0.8 pF to 2.2 pF, more preferably in the range 0.8 pF to 1.0 pF, with the second capacitive element preferably having a capacitance in the range 0.3 pF to 1.0 pF, more preferably 0.3 pF to 0.5 pF.

The resistive element may have a resistance in the range 5 to 22 Ohm, where the resistor has a value in the range 56 to 200 Ohm, more preferably 150 to 200 Ohm. Typically the narrower range of values applies where the splitter circuit means is incorporated into a two-way splitter, the broader range applying for four-way splitters.

The splitter circuit means preferably has an insertion loss in to out in the range 3 to 6 dB for frequencies in the range 5 to 1000 MHz and an insertion loss in to out of 3 to 10 dB for frequencies in the range 1125 MHz to 1525 MHz. The splitter circuit means preferably has an isolation port to port of >20 dB for frequencies in the range 5 to 1000 MHz and <17 dB in the frequency range 1125 to 1525 MHz. The splitter circuit means thus is able to have suitable RF performance in the CATV frequency range while at the same time having low insertion loss, low isolation and moderate return loss for signals in the MoCA frequency range.

The invention also lies in a signal splitter incorporating at least one splitter circuit means as aforesaid, so giving two output ports which are typically associated with subscriber equipment. In such a signal splitter, the first inductive element may have an inductance in the range 20 nH to 40 nH, with the second inductive element having an inductance in the range 50 nH to 90 nH, and the first capacitive element may have a capacitance in the range 0.8 pF to 1.0 pF and the second capacitive element may have a capacitance in the range 0.3 pF to 0.5 pF, with the resistive element preferably having a resistance in the range 5 to 22 Ohm.

The signal splitter may incorporate a plurality of splitter circuit means as aforesaid so as to provide additional output ports. Typically one splitter circuit means in accordance with the invention will be connected to two splitters to provide a four-way splitter in accordance with the invention. For such a four-way splitter, the first

inductive element preferably has an inductance in the range 10 nH to 20 nH, with the second inductive element having an inductance in the range 30 nH to 60 nH, and the first capacitive element may have a capacitance in the range 1.0 pF to 2.2 pF with the second capacitive element having a capacitance in the range 0.5 pF to 1.0 pF, with the resistive element having a resistance in the range 5 to 22 Ohm.

For signal splitters in which splitter circuits are combined to give 6, 8, 10 or more ports, the values for the inductive, capacitive and resistive elements will need to be selected to ensure the desired insertion loss in to out of between 3 to 10 dB and an isolation out to out of <17 dB is achieved in the MoCA frequency range.

In accordance with another aspect of the present invention, there is also provided a cable television network incorporating one or more splitter circuit means or signal splitters as aforesaid.

The invention will now be described, by way of example, with reference to the accompanying drawings in which:

Figure 1 shows a schematic diagram of an in-home CATV and MoCA network;

Figure 2 shows a prior art two-way splitter;

Figure 3 shows a signal splitter in accordance with the present invention;

Figure 4 shows a four-way splitter in accordance with the present invention;

Figure 5 is a graph depicting the isolation of the prior art splitter of Figure 2;

Figure 6 is a graph showing the insertion loss of the signal splitter of Figure 3;

Figure 7 is a graph depicting the return loss of the signal splitter of Figure 3; and

Figure 8 is a graph depicting the isolation of the signal splitter shown in Figure 3.

Description

A typical in-home CATV + MoCA network configuration 10 is shown in Figure 1. Within the home of a subscriber are a number of devices 12, such as televisions which receive a signal from a CATV network 14 and are capable of returning modified signals to the network through set-top boxes 16 which are connected via splitters to a modem 18 which receives and transmits signals to and from the CATV network 14. Within the home, there is typically more than one device receiving the signal from the

CATV network and to supply a signal to each item of subscriber equipment, a four-way splitter 20 splits the incoming signal to feed a variety of devices, with if required signals from the four-way splitter being split again, for example by two-way splitter 22. These splitters act to combine the signals returned from the consumer's devices.

The signal or power splitter used in this type of combined CATV/MoCA network should have the normal specification for the CATV frequency range as these channels pass through the modem 18 (from IN to OUT) and are transmitted throughout the in-home network 10.

For transmission in the MoCA frequency range to be achieved, it is necessary to have a lower isolation between the output ports of the power splitters 20, 22 as this will lower the transmission loss. For example: suppose set-top box 16 transmits to set-top box 16'''. The MoCA transmission loss will be:

insertion loss two-way splitter 22 + cable losses + isolation of four-way splitter 20

For MoCA transmission from set-top box 16 to set-top box 16' this would be:

cable loss+ isolation of two-way splitter 22

For MoCA transmission from modem 18 to set-top box 16 the losses will be:

insertion loss four-way splitter 20 + cable losses + insertion loss two-way splitter 22.

Since the frequency of MoCA is high, the cable losses are significant but cannot be avoided. These high cable losses pose yet another problem: the return loss in the MoCA frequency range at the input of the two-way splitter will be on average:

return loss four-way splitter 22 + 2 times cable loss between two-way 22 and four-way splitter 20

This will increase the isolation between outputs of the two-way splitter 22 and as such increase transmission loss between certain points in the network 10.

A typical prior art two-way signal divider 30 will have a topology as shown in Figure 2. This splitter comprises a transformer in the form of a (typical) 2x2 winding 180 degree balun (balanced to unbalance to converter) 32, also known in the art as a 'fork', which splits the signal from an input 34 to provide separate signals to two customer outputs 36, 38. The impedance at the centrepoint of the balun 32 is half of the input impedance 75 Ohm and the impedances of the outputs 36, 38, each again 75 Ohm, and in the case of a cable TV splitter is 37.5 Ohm. A resistor 42 is connected in parallel with the balun 32 and typically has a value of 150 Ohm. Frequency response compensation of the circuit is achieved by means of capacitor 44 which typically has a capacitance of around 2 pF. A step-up transformer 40 split at (typically) 2 windings and 5 windings is placed in series between the input 34 and the balun 32, transferring the 37.5 Ohm impedance (at the centre tap of balun 32) to 75 Ohm at the input.

This kind of divider has good return loss on all ports and high isolation between output ports. This is not suitable for in-home signal transmission when CATV transmission is combined with MoCA transmission as if the transmission loss of MoCA in the in-home network is to be lowered for the MoCA frequency range the following is required:

- low isolation between output ports
- low insertion loss from in to out
- with a moderate return loss being acceptable.

A standard four-way power splitter is created from three standard two-way splitters as basic building blocks, as is known in the art.

Figure 3 shows a power splitter configuration in accordance with the present invention that does not have the disadvantages of the prior art power splitter shown in Figure 2 when used in an in-home coaxial network in which CATV transmission and

MoCA transmission are combined. In the signal splitter 46 shown in Figure 3, capacitors 48, 50, resistive element, namely resistor 52 and inductors 54, 56 are added to the resistor feedback circuit in the topology shown.

Thus the resistor 42 is connected in parallel with capacitor 48 and in series with inductor 54. Inductor 56, capacitor 50 and resistor 52 are connected in series with each other, but in parallel with resistor 42, capacitor 48 and inductor 54.

The feedback circuit 58 acts as a filter with no or little influence at the CATV frequency range from 5 MHz to 1000 MHz but with low insertion loss in the MoCA frequency range from 1125 MHz to 1525 MHz. This will lower the isolation in the MoCA frequency range while, at the same time, maintaining low insertion loss, moderate return loss and excellent RF performance in the CATV frequency range.

Typical values for the components are:

Resistor 42: 150 to 200 Ohm
Resistor 52: 5 to 22 Ohm
Capacitor 44: depending on the used ferrite and the windings, but typically 1 pF to 3.9 pF
Capacitor 48: 0.8 pF to 1 pF
Capacitor 50: 0.3 pF to 0.5 pF
Inductor 54: 20 nH to 40 nH
Inductor 56: 50 nH to 90 nH

A four-way power splitter is created from three two-way splitters as basic building blocks. This is well known in the art. A possible implementation of the present invention in a four-way splitter is shown in Figure 4 where a first two-way splitter 46 is joined to two-way splitters 47, 49. In this case, the added filter 58 reduces isolation between first 60 and third 64 outputs, first 60 and fourth 66 outputs, second 62 and third 64 outputs and second 62 and fourth 66 outputs while, at the same time, the limited return loss of the filter reduces isolation between the first 60 and second 62 outputs and the third 64 and fourth 66 outputs.

Typical values of the components in the four-way splitter are:

Resistor 42: 56 to 100 Ohm
Resistor 52: 5 to 22 Ohm
Capacitor 44: depending on the used ferrite and the windings, but typically 1 pF to 3.9 pF
Capacitor 48: 1.0 pF to 2.2 pF
Capacitor 50: 0.5 pF to 1.0 pF
Inductor 54: 10 nH to 20 nH
Inductor 56: 30 nH to 60 nH
Resistors 68 and 70: 150 to180 Ohm

The characteristics of a prior art splitter and a splitter according to the invention will now be compared with reference to the graphs shown in Figures 5 to 8.

Figure 5 shows the isolation over the full frequency range of a former art two-way power splitter. It can be seen that the isolation in the MoCA frequency range 72 is > 20 dB.

A two-way power splitter as shown in Figure 3 will have the typical characteristics shown in Figures 6, 7 and 8. Figure 6 illustrates the insertion loss from the input to output (i.e. in to out) with frequency, the CATV transmission frequency range being below point A and the MoCA frequency range being above point B. At point A the insertion loss is 4.1 dB and at point B the insertion loss is 4.3 dB. Figure 7 illustrates the typical return loss with frequency, with the return loss in the CATV transmission frequency range ranging from around 23 dB to around 36 dB and in the MoCA frequency range around 7 to 8 dB. Figure 8 illustrates the typical isolation across the outputs (i.e. out to out) with frequency, with the isolation in the CATV transmission frequency range ranging from around 23 dB to around 37 dB and in the MoCA frequency range around 7 to 8 dB.

Thus for a CATV transmission frequency range of 5 to 1000 MHz, the splitter of Figure 3 has:

Insertion loss: 4 dB
Return loss : 20 dB
Isolation : 25 dB

and for a MoCA frequency range of 1125 to 1525 MHz, the splitter of Figure 3 has:

Insertion loss : 6 dB
Return loss : 8 dB
Isolation : 8 dB

It can be seen from Figures 5 to 8 that when using the splitter of Figure 3, the transmission characteristics in the CATV frequency range are substantially not affected while, at the same time, the transmission loss in the MoCA frequency range improves. This is also true when more power splitters are cascaded as in a larger network or when two-way power splitters are used as basic building blocks in a four-way splitter.

This power splitter has excellent RF performance in the CATV frequency range while at the same time having low isolation, low insertion loss and moderate return loss for the MoCA frequency range.

Claims

1. A splitter circuit means for use with a CATV network comprising a signal input in communication with a balun to supply two signal outputs, with a resistor connected in parallel between the outputs and wherein additional capacitive, inductive and resistive elements are associated with the resistor, thereby to give an insertion loss in to out in the range of 3 to 10 dB, for signal frequencies in the range 1125 MHz to 1525 MHz.

2. A splitter circuit means according to claim 1, wherein a first capacitive element is connected in parallel with the resistor, with the resistor in series with a first inductive element, the resistor also in parallel with a second inductive element, a second capacitive element and a resistive element connected in series with one another.

3. A splitter circuit means according to claim 2, wherein the first inductive element has an inductance in the range 10 nH to 40 nH, with the second inductive element having an inductance in the range 30 nH to 90 nH.

4. A splitter circuit means according to claims 2 or 3, wherein the first capacitive element has a capacitance in the range 0.8 pF to 2.2 pF with the second capacitive element having a capacitance in the range 0.3 pF to 1.0 pF.

5. A splitter circuit means according to claims 2, 3 or 4, wherein the resistive element has a resistance in the range 5 to 22 Ohm.

6. A splitter circuit means according to any of the preceding claims, wherein the splitter circuit means has an insertion loss in to out in the range 3 to 6 dB for signal frequencies in the range 5 MHz to 1000 MHz.

7. A splitter circuit means according to any of the preceding claims having an isolation out to out of <17 dB for frequencies in the range 1125 MHz to 1525 MHz.

8. A signal splitter incorporating at least one splitter circuit means according to any of claims 1 to 7.

9. A cable television network incorporating one or more splitter circuit means or signal splitters according to claims 1 to 8.

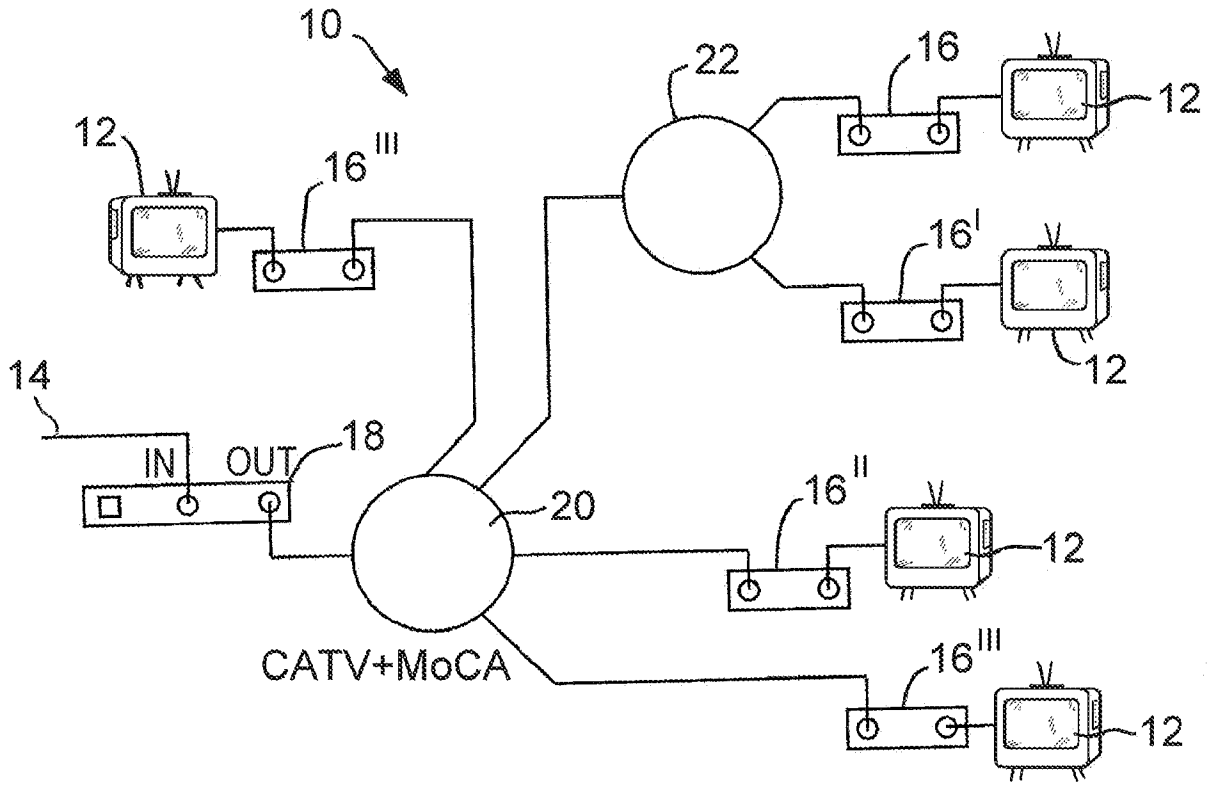

10
22
16
12
12
16III
16I
12
14
IN
OUT
18
20
16II
12
CATV+MoCA
16III
12

Fig. 1

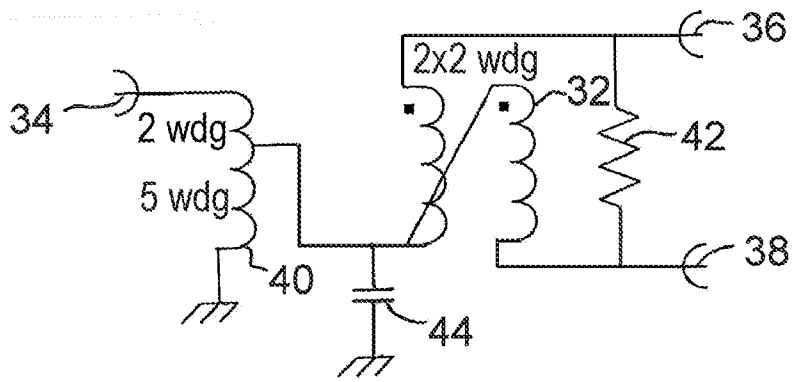

36
2x2 wdg
32
34
2 wdg
42
5 wdg
40
38
44

Fig. 2

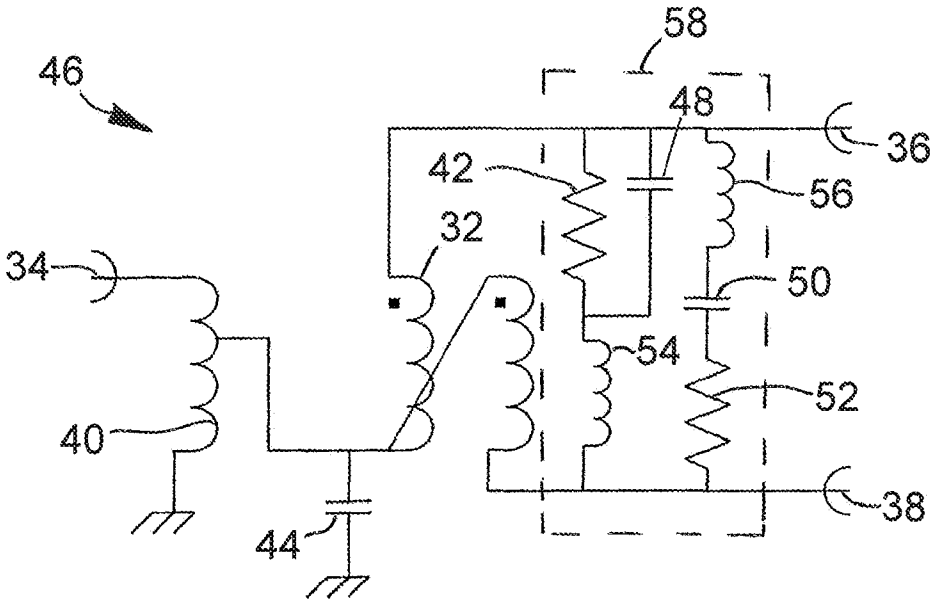

58
46
48
36
42
56
32
34
50
54
52
40
38
44

Fig. 3

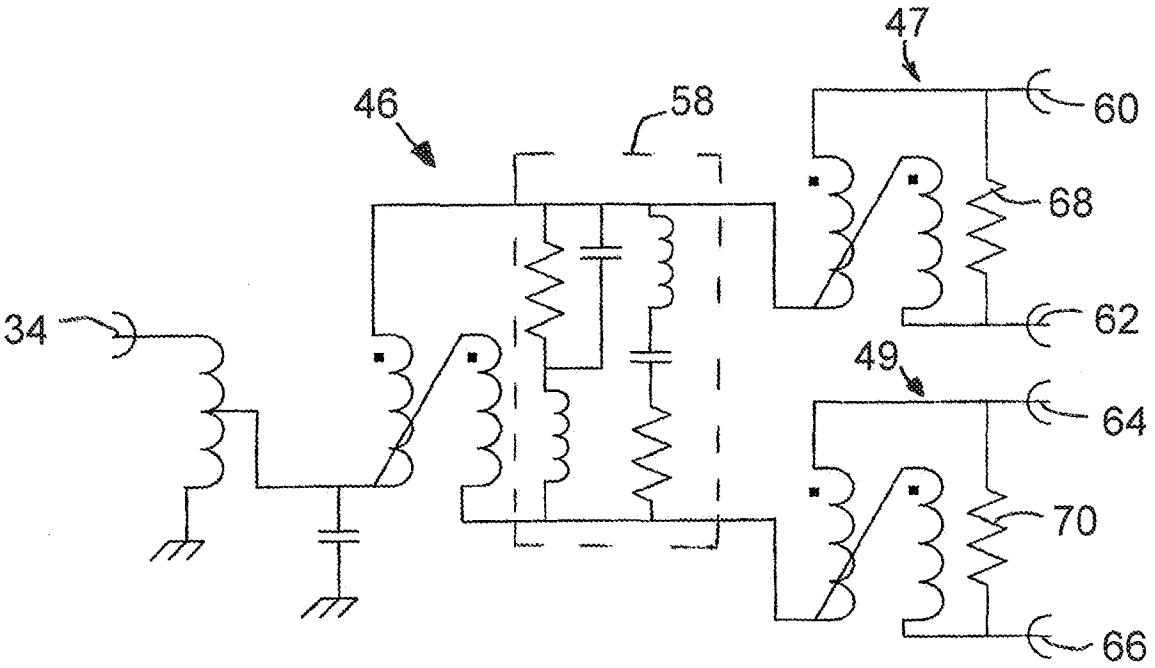

47
46
58
60
68
34
62
49
64
70
66

Fig. 4

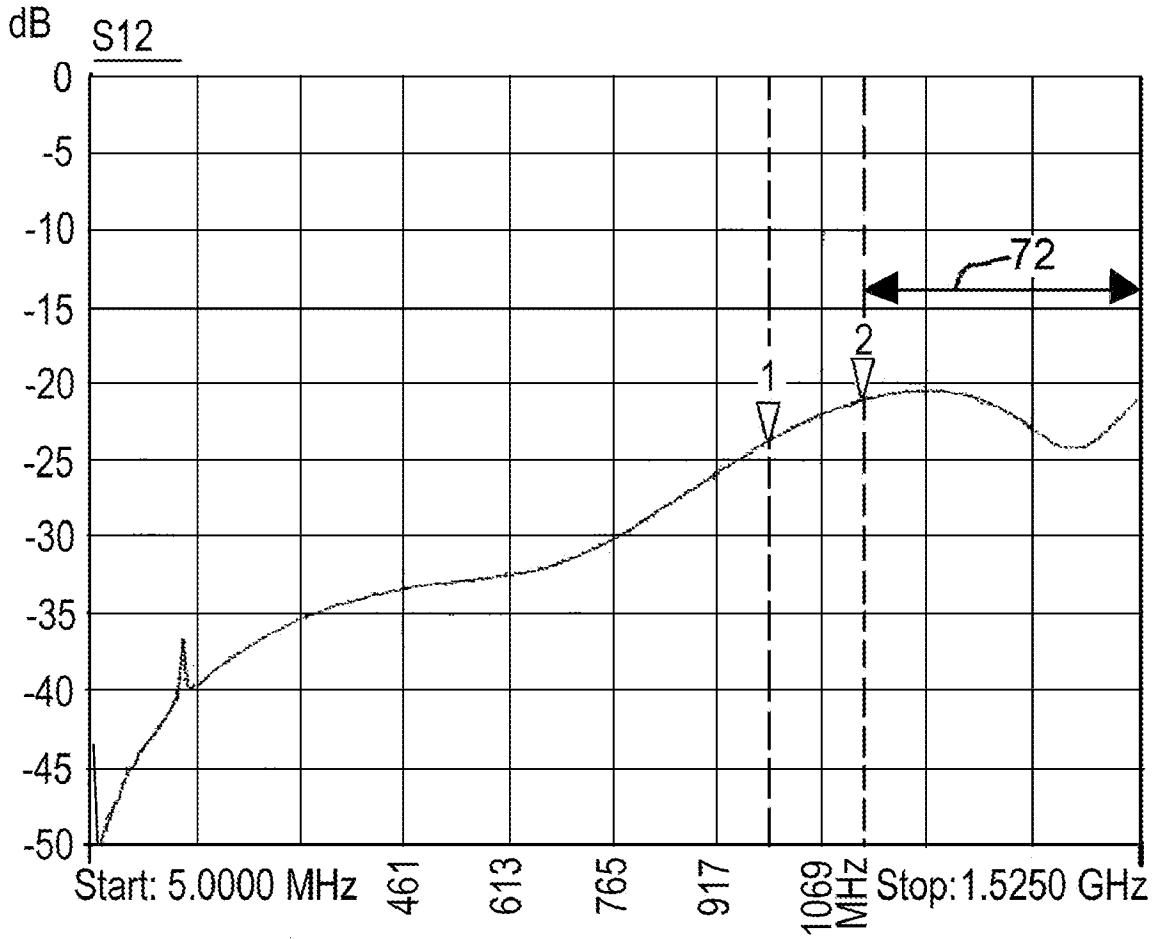

dB
S12
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
72
1
2
Start: 5.0000 MHz
461
613
765
917
1069 MHz
Stop:1.5250 GHz

Fig. 5

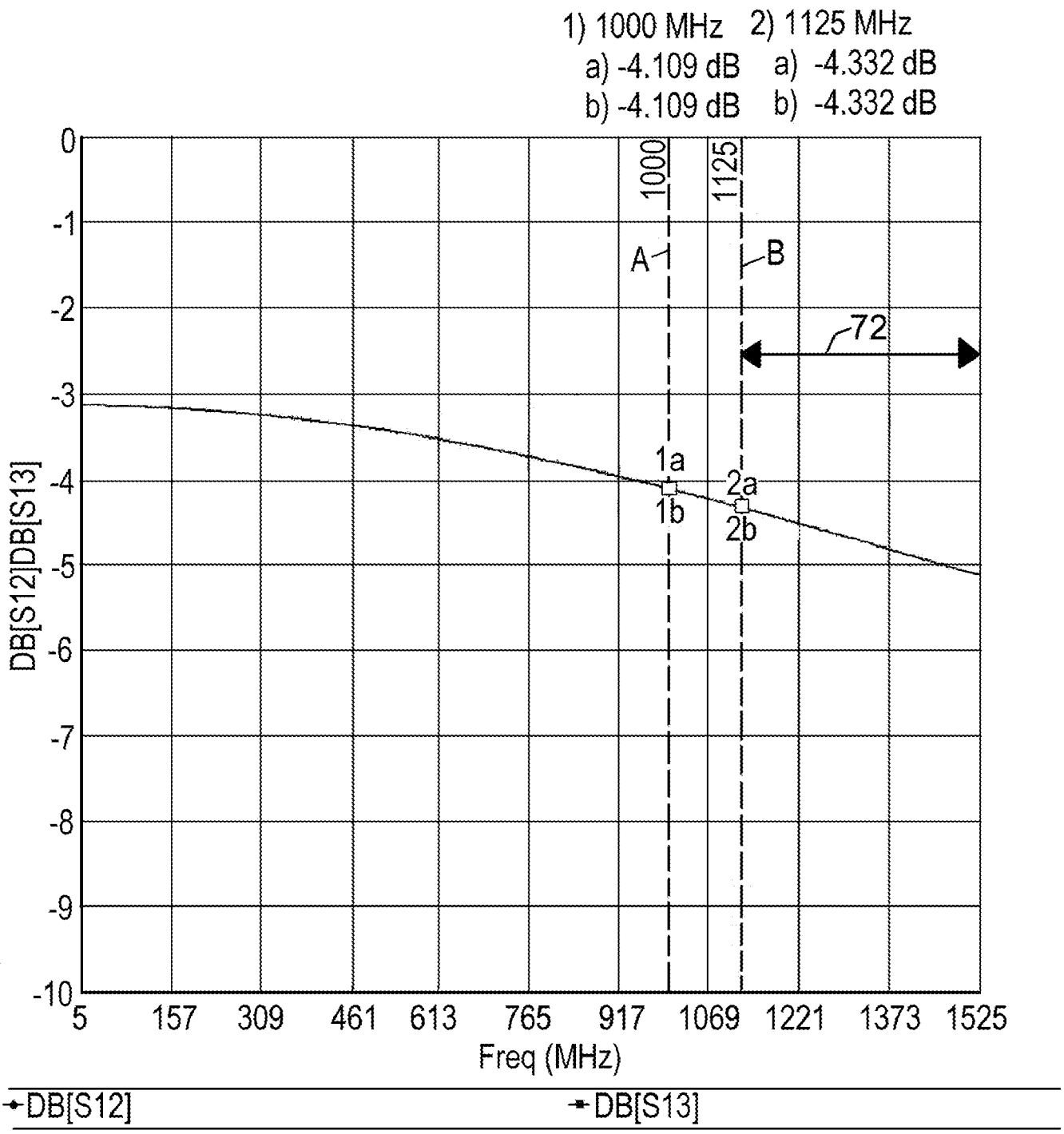

1) 1000 MHz 2) 1125 MHz
a) -4.109 dB a) -4.332 dB
b) -4.109 dB b) -4.332 dB
1000
1125
A
B
72
1a
1b
2a
2b
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
DB[S12]DB[S13]
5
157
309
461
613
765
917
1069
1221
1373
1525
Freq (MHz)
DB[S12]
DB[S13]

Fig. 6

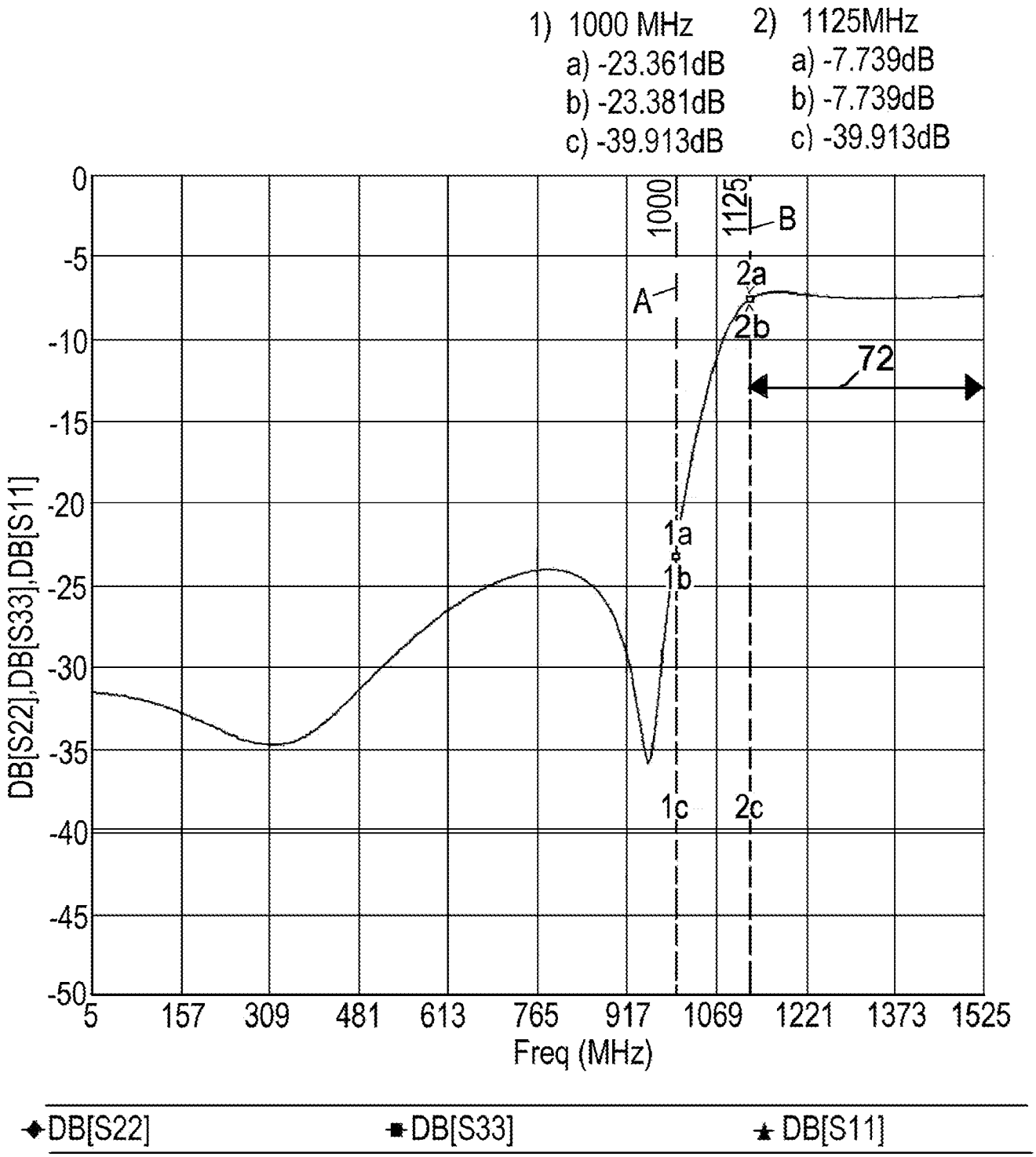

1) 1000 MHz
a) -23.361dB
b) -23.381dB
c) -39.913dB
2) 1125MHz
a) -7.739dB
b) -7.739dB
c) -39.913dB
1000
1125
A
B
1a
1b
1c
2a
2b
2c
72
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
DB[S22],DB[S33],DB[S11]
5
157
309
481
613
765
917
1069
1221
1373
1525
Freq (MHz)
DB[S22]
DB[S33]
DB[S11]

Fig. 7

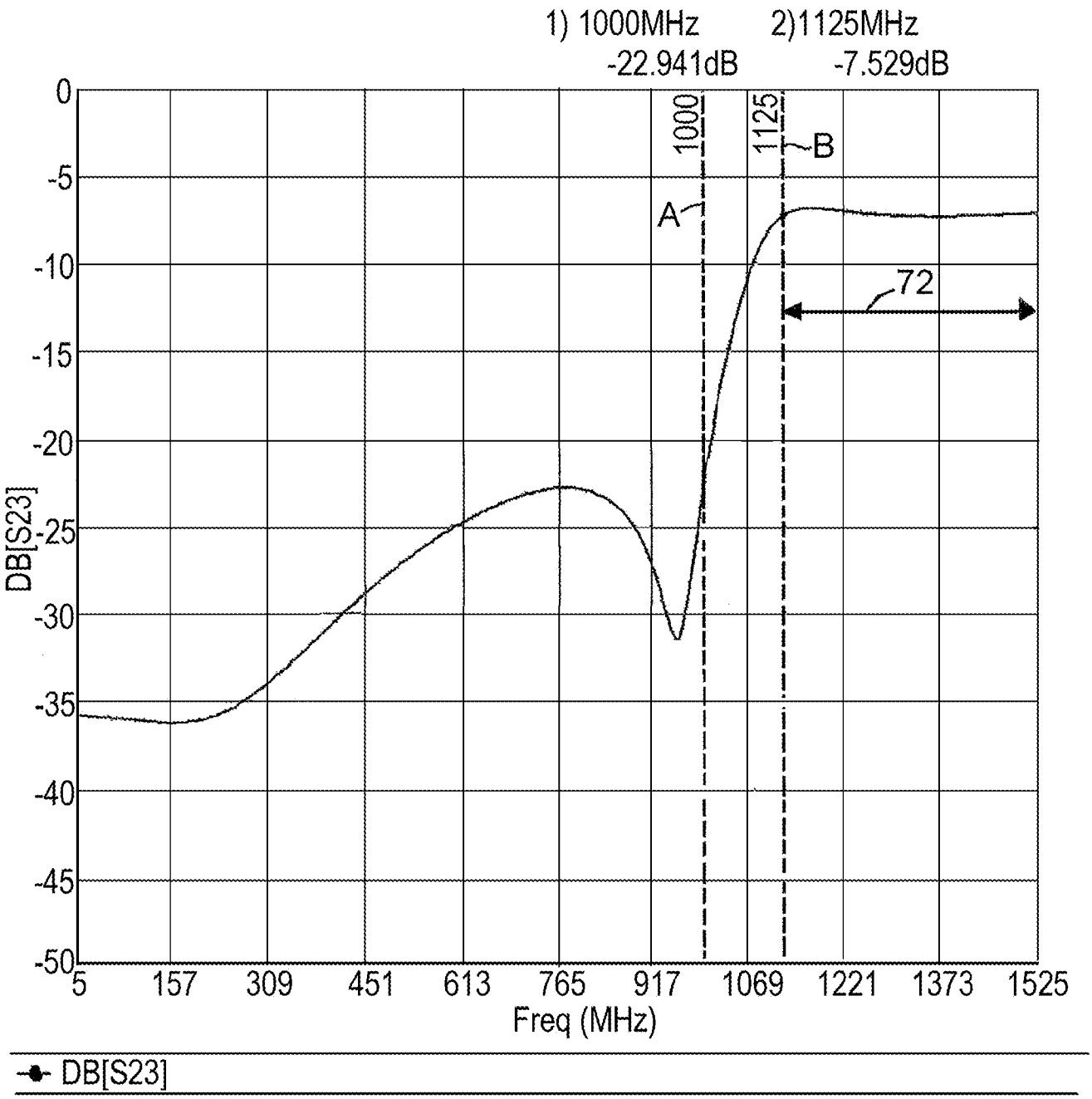

1) 1000MHz
-22.941dB
2)1125MHz
-7.529dB
1000
1125
A
B
72
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
DB[S23]
5
157
309
451
613
765
917
1069
1221
1373
1525
Freq (MHz)
DB[S23]

Fig. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2010/050824

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04N7/10 H03H7/46 H03H7/48
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04N H03H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 578 202 B1 (HOLLAND MICHAEL [US]) 10 June 2003 (2003-06-10) the whole document	1-9
X	US 2005/289632 A1 (BROOKS PAUL D [US] ET AL) 29 December 2005 (2005-12-29) the whole document	1-9
A	WO 02/093758 A2 (BROADCOM HOMENETWORKING INC [US]) 21 November 2002 (2002-11-21) page 5, line 17 - page 6, line 4	1-9
A	US 5 058 198 A (ROCCI JOSEPH D [US] ET AL) 15 October 1991 (1991-10-15) the whole document	1-9

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6578202 B1	10-06-2003	NONE	
US 2005289632 A1	29-12-2005	NONE	
WO 02093758 A2	21-11-2002	NONE	
US 5058198 A	15-10-1991	NONE	