(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 014 468 A2

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
28.06.2000 Bulletin 2000/26

(51) Int. Cl.[7]: **H01P 1/10**

(21) Application number: **99125180.2**

(22) Date of filing: **17.12.1999**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **21.12.1998 US 217681**

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(54) **Flexible microwave switch matrix**

(57) A planar microwave switch matrix including a plurality of inputs (22) for receiving input signals, a plurality of outputs (26) for transmitting output signals, and a plurality of nodes (20) connecting the inputs to the outputs. Each node (20) includes a switch (30), an input coupler (28) and an output coupler (32). The input and output couplers connecting input lines to output lines such that any input can be connected through a switch to any output. The planar microwave switch matrix is formed on a dual-sided circuit board to form a plurality of co-planar waveguide transmission lines. The layout of the microwave switch matrix allows any combination of input lines and output lines to be connected at a given time, while providing sufficient signal isolation to prevent interference.

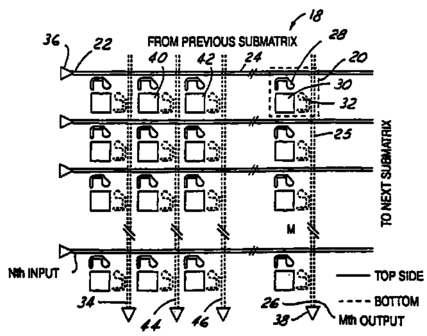

FIG. 2

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Description

Technical Field

[0001] The present invention relates generally to microwave switch matrices, and more particularly, to a flexible planar microwave switch matrix with redundancy.

Background Of The Invention

[0002] Microwave switching arrangements generally are formed of an array of electronic or electromechanical switches connecting N input signals to selected ones of M output circuits by cables or a switchable power divider/combiner arrangement.

[0003] To maintain sufficient isolation between the input signals and output signals, conventional microwave switch matrices were arranged in the form of a three-dimensional array. In the first stage of the array, there are N circuit boards arranged in a parallel-spaced relationship along a first axis of symmetry through and perpendicular to the boards, each of which contains a power divider or switch for one of the input circuits. A second stage, or output stage, comprises M circuit boards also arranged in a parallel-spaced relationship, but along a second axis of symmetry perpendicular to the first. Arranged this way, the connections between circuit boards can be made in such a manner as to maintain relatively high degree of isolation between the circuits. Owing to the complexity of their design, however, these arrangements have several disadvantages, including problems in construction, reliability, space and weight.

[0004] In satellite communication systems, there is a continuing effort to improve the reliability of communications devices while at the same time reducing both the size and weight of system components. Accordingly, there exists a need for an improved microwave switch matrix having high isolation and simplified construction.

[0005] In addition to good signal isolation performance, switch matrix redundancy is often desired for high reliability systems. Most space communication satellites have redundant switch matrices for reliability. A popular redundancy scheme is to use two separate and isolated switch matrix units, wherein each switch matrix provides redundant unit selection in case of a failure. The obvious drawback of such a system, is that it requires twice the hardware, electronics and switches or passive hybrids to provide the redundancy performance. Thus, there exists another need for a microwave switch matrix that provides for fail-safe operation, yet reduces the amount of required hardware, thereby eliminating additional power, volume, mass and complexity.

Summary Of The Invention

[0006] The present invention has several advantages over existing microwave switch matrices. The present invention is an improved microwave switch matrix, formed in a single plane having a high degree of isolation between input and output signals, and a simplified construction which allows for redividing.

[0007] These advantages are accomplished through the use of a planar microwave switch matrix which includes a plurality of inputs for receiving input signals, a plurality of outputs for transmitting output signals, and a plurality of nodes connecting the inputs to the outputs. Each node includes a switch, an input coupler and an output coupler. The input coupler connects an input line to the switch, and the output coupler connects an output line to the switch such that any input can be connected through a switch to any output. The nodes of the planar microwave switch matrix connecting the inputs to the outputs are formed on a dual-sided circuit board to form a plurality of co-planar waveguide transmission lines. The arrangement of the microwave switch matrix nodes allows any combination of input lines and output lines to be connected at a given time, while providing sufficient signal isolation to prevent interference.

[0008] Other advantages of the invention will become apparent when viewed in light of the following detailed description and appended claims, and upon reference to the accompanying drawings.

Brief Description of the Drawings

[0009]

FIGURE 1 is a simplified perspective view of a microwave switch matrix according to the prior art;

FIGURE 2 is a schematic representation of a flexible microwave switch matrix in accordance with one embodiment of the present invention;

FIGURE 3 is a typical layout of the co-planar waveguide transmission lines in accordance with one embodiment of the present invention; and

FIGURE 4 is a schematic representation of a flexible microwave switch matrix according to another embodiment of the present invention.

Best Mode(s) For Carrying Out The Invention

[0010] In the following detailed description, spatially orienting terms may be used such as "left," and "right," "top," "bottom," and the like. It is to be understood that these terms are used for convenience of description of the preferred embodiments by reference to the drawings. These terms do not necessarily describe the absolute location and space, such as left, right, upward, downward, etc., that any part must assume.

[0011] Turning to Figure 1, a simplified perspective view of a conventional microwave switch matrix 10 is shown. The switch matrix 10 includes a plurality (N) of input circuit cards 12 connected to output switches arranged on M output boards 14. The input boards 12 are spaced uniformly along a first axis, and are disposed parallel with each other and perpendicular to the axis. The output boards 14 are also spaced in a parallel manner but along a second axis at right angles to the first, such that one set of parallel edges of the input boards 12 are adjacent to a set of parallel edges of the output boards 14, but with one set of edges at a right angle to the other. With this arrangement, all of the connections from the top input board, for example, can be brought out as an array of connecting conductors 16 practically co-planar or parallel with the board itself. These conductors 16 can be connected to the first input ports of the switches in the output boards 14 without having to cross any two wires. Similarly, the second of the input boards 12 can provide outputs that do not intersect with the first set from the top board, and so forth. In this manner, the entire switch 10 can be connected without intersection of the conductors 16, and consequently a sufficient degree of isolation can be obtained.

[0012] The microwave switch matrix 10 of Figure 1, is referred to as a 6 x 64 switch matrix because it contains six input cards 12 (N) with 64 channels each, correspondingly connected to 64 output boards 14 (M).

[0013] A simplified schematic representation of an embodiment of the present invention is shown in Figure 2. The implementation shown in Figure 2 uses a plurality of four port interconnection nodes 20 of any n x m matrix size to construct a larger N x M switch matrix of any size.

[0014] Each node 20 includes at least an input coupler 28 a switch module 30 and an output coupler 32. Input coupler 28 couples the signal on the input transmission line 24 to the switch module 30. If the switch module is on, the signal is coupled to the output transmission line 25 by the output coupler 32. Signals are carried on transmission line 24 upon entering input port 22, and are transmitted via output transmission line 25 and output port 26. The entire switch matrix is formed of inputs 22 through N and outputs 34 through M.

[0015] A signal entering any input port 22 will travel along the straight transmission line 24 and will be terminated into a matched load. Thus, the input port 22 is matched at all times. Any input signal received into an input port can be routed to any combination of output ports by way of the input couplers 28, switch modules 30, and output couplers 32.

[0016] The flexible microwave switch matrix 18 has a planar construction. The use of coupler technology and dual-sided microwave integrated circuit or strip-line construction allows the microwave switch matrix to be simple, flexible, and robust.

[0017] The planar configuration of the microwave switch matrix 18 will now be described with reference to Figure 2. The input transmission lines 24, input couplers 28 and switch modules 30 are formed on the top side of a dual-sided radio frequency (RF) circuit board. The output transmission lines 25 and couplers 32 are formed on the bottom side of the RF circuit board. The microwave switch matrix 18 can provide equal or tapered output levels by adjusting the coupling value of the input couplers 28 or output couplers 32. Thus, any loss associated with the input coupling can be matched to the losses associated with the output coupling by modifying the coupler design. Losses associated with the input couplers 28 and output couplers 32 can be offset by input amplifiers 36 or output amplifiers 38. Bias voltages for the switch modules 30 are supplied by a distribution board (not shown) placed on top or bottom of the flexible microwave switch matrix 18.

[0018] The switch modules 30 can make use of any switch technology. For example, switch modules 30 could include FETs, diodes, ferrite switches, piezoelectric, electromechanical switches, or MEM-type switches to provide the switching function.

[0019] In operation, a distribution board mounted on top or bottom of the flexible microwave switch matrix 18 will control the on/off state of the switches 30. For example, assume an input signal is present at input port 22. The signal would be present at all points along transmission line 24. Thus, if switch module 30 is on, the input signal would transmit to output port 26. Likewise, if switch modules 40 and 42 are on, the signal will also be available on output ports 44 and 46, respectively. If switch 42 were in the off state, the input signal along transmission line 24 would still be available to any combination of switches to the right or left of switch module 42 to transmit the signal to the respective output port. Accordingly, any combination of input signals to input ports 22 through N can be transmitted to any combination of output ports 34 through M. By constructing submatrices from four port interconnection nodes 20, larger N x M switch matrices of any size can be constructed.

[0020] To maintain isolation of the input signals from the output signals, the microwave switch matrix of the present invention is preferably formed in a dual-sided RF circuit board using co-planar waveguide transmission line technology as shown in Figure 3.

[0021] As shown in Figure 3, transmission line crossing occurs on opposite sides of the circuit board. Input signals are isolated from output signals by a plurality of holes 50 plated with conductive metallic material connecting the respective ground planes in which the transmission lines reside. The co-planar waveguide transmission line layout of the microwave switch matrix provides uniform microwave grounding as well as signal isolation. This allows for a flexible, planar, single-board implementation of the microwave switch matrix. This configuration is also readily expandable to an extremely high N x M matrix.

[0022] As a result of the flexible and expandable nature of the present microwave switch matrix, redundancy can readily be provided by adding extra input and output ports and connecting them via nodes.

[0023] As shown in Figure 4, ring redundancy can be achieved by adding input ports and output ports and connecting them through the switch modules. For example, signal input 60 can be coupled to output line 62 by switch module 64 in conjunction with input coupler 66 and output coupler 68. To provide a redundant signal, output line 62 can be connected to input 70, making the original signal received by input 60 available to any output coupled to input 70 as well. Additional or alternative redundancy can be accomplished by coupling input signal 60 with output 72 by way of switch module 74. Thus, the same signal can be present at inputs 60 and 70 and outputs 62 and 72, and connecting output 72 to input 76 provides additional redundancy.

[0024] From the foregoing, it will be seen that there has been brought to the art a new and improved flexible microwave switch matrix which overcomes the drawbacks of prior non-planar, cable-connected microwave switch matrices.

[0025] While particular embodiments of the invention have been shown, it will be understood, of course, that the invention is not limited thereto, since modifications may be made by those skilled in the art, particularly in light of the foregoing teachings. It is, therefore, contemplated that the invention include all such alternatives, modifications, and equivalents as may be included within the spirit and scope of the appended claims.

Claims

1. A planar microwave switch matrix comprising:

    a plurality of input lines (22, 24) for receiving a plurality of input signals;
    a plurality of output lines (25, 26) for transmitting a plurality of output signals; and
    a plurality of nodes (20) connecting each of said input lines (22, 24) to each of said output lines (25, 26) such that any combination of input lines and output lines can be connected at a given time, each of said nodes (20) comprising a switch (30), an input coupler (28) and an output coupler (32), said input coupler (28) connecting said input line (24) to said switch (30) and said output coupler (32) connecting said switch (30) to said output line (25) such that said switch (30) couples said input line (24) to said output line (25), said input coupler (28), output coupler (32) and said switch (30) being constructed on a dual-sided circuit board to form a plurality of to-planar waveguide transmission lines.

2. An N x M planar microwave switch matrix constructed on a dual-sided circuit board substrate said planar microwave switch matrix comprising a plurality of n x m interconnect modules (20) each of said interconnect modules commonly connected to at least one input line (24) formed on a first side of said circuit board and at least one output line (25) formed on a second side of said circuit board such that any combination of input lines and output lines can be connected at a given time, each of said interconnect modules comprising:

    at least one switch module (30) formed on said first side of said circuit board;
    at least one input coupler (28) formed on said first side of said circuit board, said input coupler (28) connecting said input line (24) to said switch module (30);
    at least one output coupler (32) formed on a second side of said circuit board, said output coupler (32) connecting said switch module (30) to said output line (25);
    said input line (24), output line (26), input coupler (28) and output coupler (32) forming coplanar waveguide transmission lines in said dual-sided circuit board substrate.

3. The planar microwave switch matrix of claim 1, characterized in that said input coupler (28), output coupler (32) and said switch (30) are constructed on a dual-sided circuit board using microwave integrated circuit architecture.

4. The planar microwave switch matrix of claim 1, characterized in that said input coupler (28), output coupler (32) and said switch (30) are constructed on a dual-sided circuit board using strip-line architecture.

5. The planar microwave switch matrix of any of claims 1 - 4, characterized in that said input coupler (28) and said output coupler (32) have an equal coupling value.

6. The planar microwave switch matrix of any of claims 1 - 5, characterized in that said input coupler (28) and said output coupler (32) have different coupling values.

7. The planar microwave switch matrix of any of claims 1 - 6, characterized in that said input lines (22, 24) include an input amplifier (36) to offset signal attenuation associated with said input coupler (28) and said switch (30).

8. The planar microwave switch matrix of any of claims 1 - 7, characterized in that said output lines (25, 26) include an output amplifier (38) to offset signal attenuation associated with said output coupler (32) and said switch (30).

9. The planar microwave switch matrix of any of claims 1 - 8, characterized in that said switch (30) comprises a field effect transistor (FET) switch.

10. The planar microwave switch matrix of any of claims 1 - 8, characterized in that said switch (30) comprises a diode switch.

11. The planar microwave switch matrix of any of claims 1 - 8, characterized in that said switch (30) comprises a piezoelectric switch.

12. The planar microwave switch matrix of any of claims 1 - 8, characterized in that said switch (30) comprises an electromechanical switch.

13. The planar microwave switch matrix of any of claims 1 - 8, characterized in that said switch (30) comprises a ferrite switch.

14. The planar microwave switch matrix of any of claims 1 - 8, characterized in that said switch (30) comprises a micromachined electromechanical (MEM) switch.

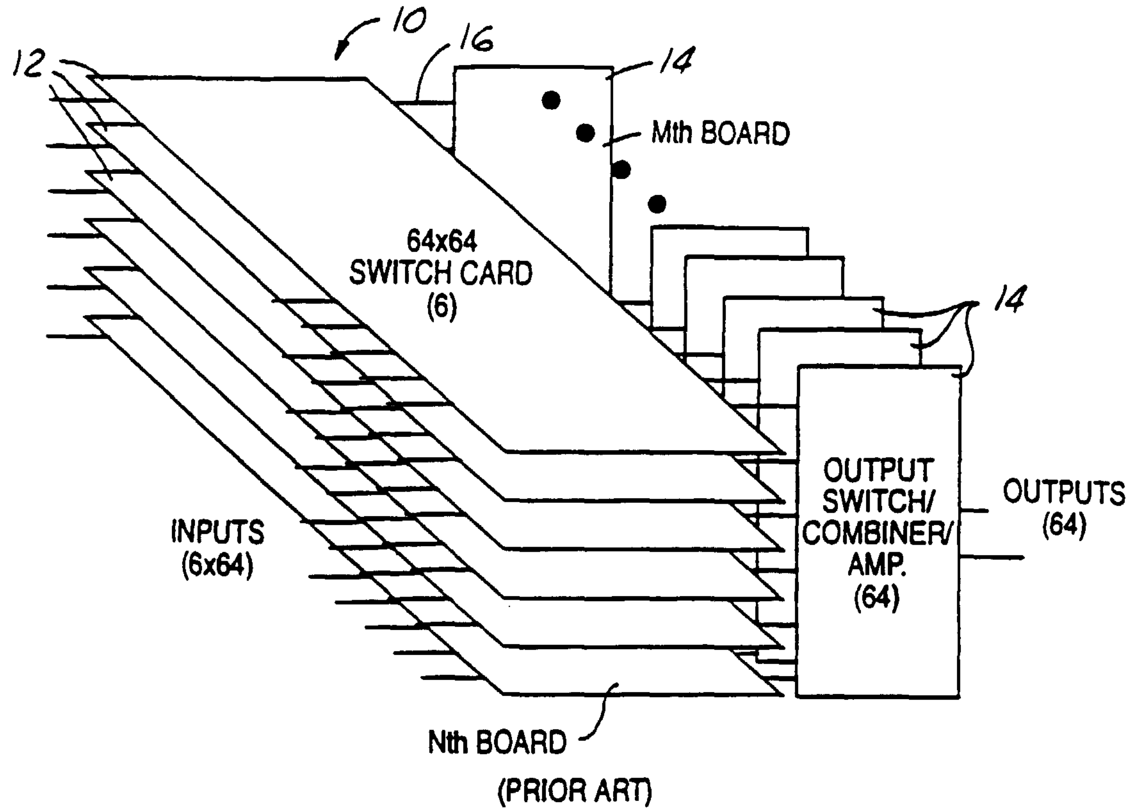
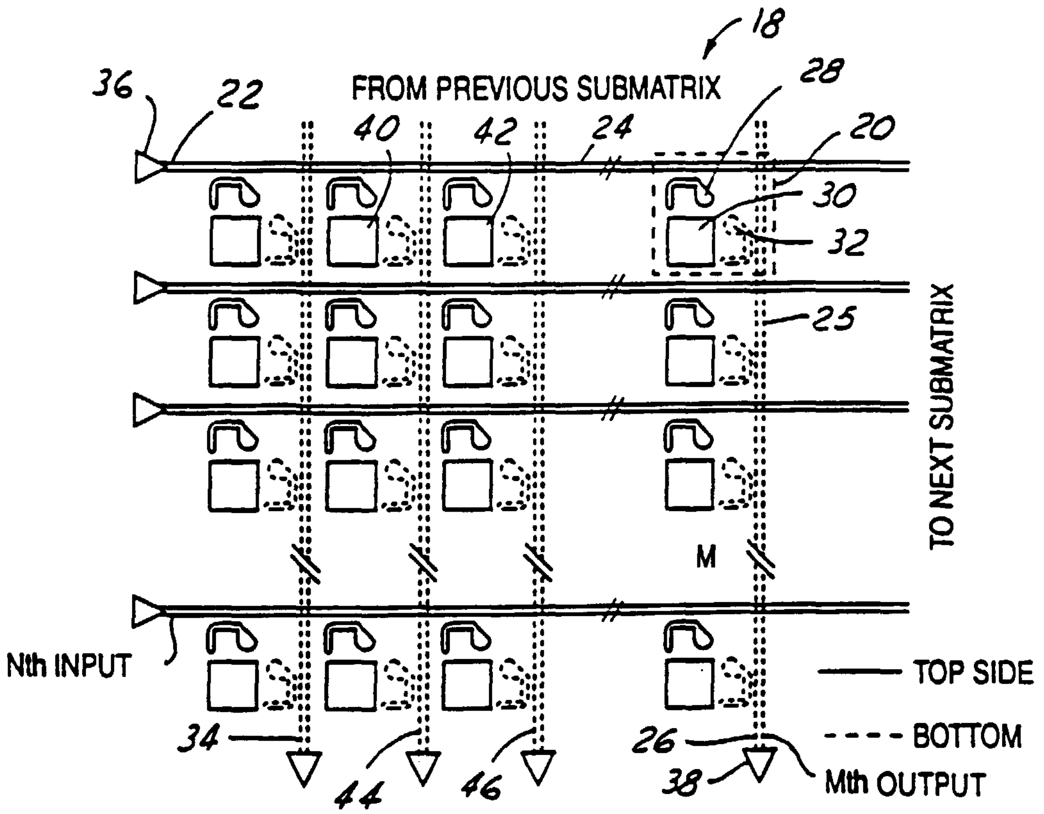

10
12
16
14
Mth BOARD
64x64
SWITCH CARD
(6)
14
OUTPUT
SWITCH/
COMBINER/
AMP.
(64)
OUTPUTS
(64)
INPUTS
(6x64)
Nth BOARD
(PRIOR ART)

FIG. 1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44
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38
Mth OUTPUT

FIG. 2

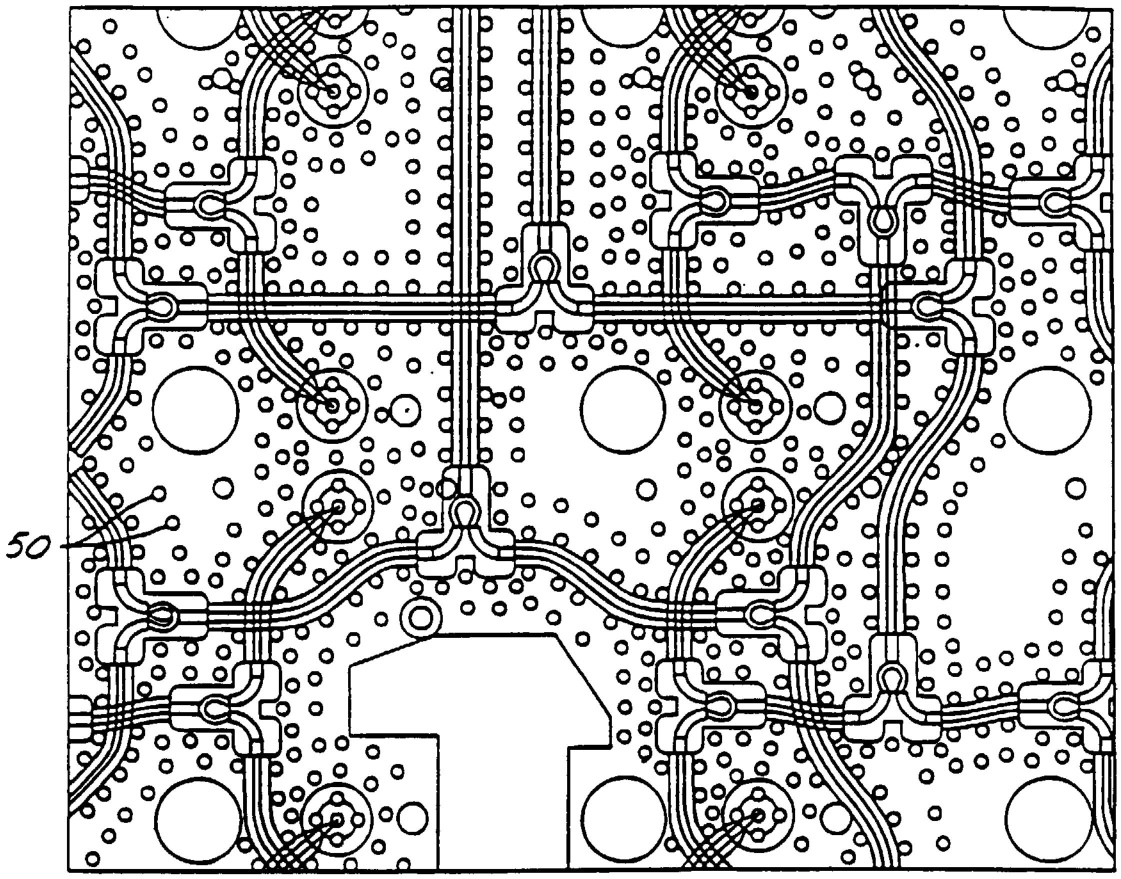
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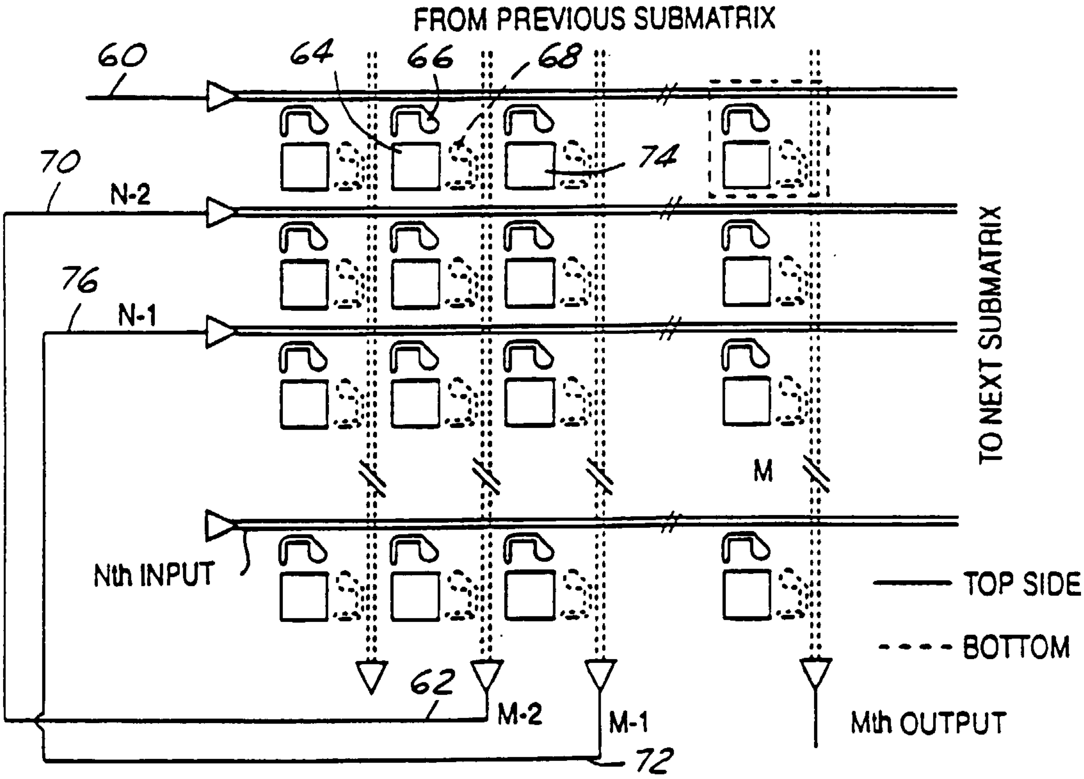
FIG.3


FROM PREVIOUS SUBMATRIX
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64
66
68
70
N-2
74
76
N-1
TO NEXT SUBMATRIX
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Nth INPUT
TOP SIDE
BOTTOM
62
M-2
M-1
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72

FIG. 4