

WIDEBAND MULTI-OUTPUT RF SWITCHING DEVICE AND PIECE OF RF EQUIPMENT USING SUCH A SWITCH

5 The present invention relates to an optimized, multi-output, wide-frequency-band, radiofrequency switching device.

It also relates to a piece of radiofrequency transmitting and receiving equipment using such a switch.

10 The present invention more particularly relates to portable radiocommunication equipment. In this type of equipment, as in all radiocommunication devices, radiofrequency (RF) switches are among the essential components. They are especially mounted between the transceiver and the antenna.

15 In particular, on being output from the power amplifier, the signal must be directed towards a given filter from among a battery of filters, each corresponding to a usable sub-band.

There is a need to produce wideband multi-output RF switches able to handle powers of about 15 W, and with a number of outputs at least higher
20 than four.

To produce wideband switches of about 15 W with more than four RF outputs i.e. able to switch one channel to four or more channels, the technique that has been used up to now has been the use of pin diodes. However, to operate these pin diodes require a specific power supply able to supply a
25 high voltage (higher than 50 volts) and a current of several tens of milliamps. This solution has a number of drawbacks.

A first drawback is the large footprint occupied, in particular because of the space taken up by the high-voltage supply. Specifically, it is necessary to provide a converter able to convert a generally low DC voltage into another
30 higher DC voltage, the basic components of this converter being coils and capacitors. These elements are dimensioned by the DC blocking voltage of the pin diodes, which voltage is 50 volts or more, and the electrical currents needed to bias the diodes.

A second drawback is the high electrical power consumption due to this voltage and these currents. This electrical power consumption decreases the overall efficiency of the piece of radiocommunication equipment.

Present-day solutions employing pin diodes are therefore bulky and high-
5 consumption, this being disadvantageous for portable radiocommunication equipment. In addition to this, overall efficiency is decreased.

For a few years now, switches in CMOS technology able to operate up to 15 W have been commercially available. These switches especially solve the problems of bulkiness and electrical power consumption. Specifically, the
10 switches do not require a high-voltage supply and their electrical power consumption is very low. However, these switches still have a limited number of outputs. They possess at most four power outputs.

To obtain a number of outputs higher than four with this CMOS technology, it would be necessary to have a specific component produced. This would
15 require a very substantial development cost, incompatible with the often limited markets for portable radiocommunication equipment.

Thus, in the context of portable or carriable radiocommunication equipment, it is necessary to minimize the electrical power consumption and the size of the
20 switching functions, with a cost compatible with the requirements of the market. On the one hand, the conventional solution with pin diodes does not allow the needs as regards size and consumption to be met. On the other hand, the solution based on switches in CMOS technologies does not allow switches having a number of power outputs higher than four to be produced.

25 One aim of the invention is in particular to meet this need, i.e. to minimize both electrical power consumption and the size of the switching functions, at low cost.

For this purpose, one subject of the invention is an RF switching device, said
30 device connecting its input point to one of its outputs in order to form a switchable conducting RF channel, said device including at least two multi-output switches that are connected in parallel to said input point, each switch having at least one output left open-circuit, its other outputs being intended to be connected to RF functions, in operation a switch not containing said
35 conducting channel having its input connected to its open-circuit output, the

input of each of said switches being connected to said input point via a common matching network (33), said network matching an RF line when the latter is connected to an open-circuit output point, said switches for example being in CMOS technology.

- 5 In one possible embodiment, the input of each of said switches is connected to said input point via a common matching network (33), said network matching an RF line when the latter is connected to an open-circuit output point.

Each switch for example includes four outputs.

- 10 Said RF functions are RF filters.

Said switches are for example programmable.

- 15 Another subject of the invention is a piece of RF transmitting and receiving equipment, said piece of equipment including at least one RF switching device such as described above.

- Said piece of equipment including a power amplifier, a battery of filters and an antenna, said switching device is for example placed on the one hand between said amplifier and the battery of filters and on the other hand between said filter battery and said antenna, each filter being connected to a
20 single output of each of said switching devices.

Said amplifier, the filter battery and the two switching devices are for example mounted on the same board.

Said piece of equipment is for example portable.

- 25 Other features and advantages of the invention will become apparent using the following description, which is given with reference to the appended drawings that show:

- Figure 1, an illustration of the basic principle of tactical radiofrequency transmitting equipment;

- Figure 2, a presentation of an assembly of switches mounted in cascade;
- Figure 3, an exemplary embodiment of a radiofrequency switch according to the invention, and the illustration of the operating principle of such a switch;
- Figure 4, an exemplary layout of such a switch on a printed circuit board; and
- Figure 5, a second exemplary embodiment of a switch according to the invention.

Figure 1 illustrates the basic principle of tactical radiocommunication transmitting equipment and more particularly the use of RF switches. The transmitted power signals are routed to a series of filters, each filter corresponding to a frequency of use. A single antenna is used for the whole of the operating band.

Thus, on being output from the power amplifier 1, a signal is directed to the antenna 2 via a battery of low-pass filters 10, each of which is designed for a sub-band of use. More precisely, the signal is directed to one specific filter 12 from among the battery of filters. For this purpose, the output of the amplifier is connected to this filter 12 and the output of the latter is connected to the antenna 2. A switch 3, 4 must therefore be used on the amplifier side and on the antenna side. Each switch is able to connect one input to a plurality of outputs, or a plurality of inputs to one output, this amounting to the same thing from the point of view of the switching function. Thus, multi-output switches will be spoken of below.

The RF signals that pass through these switches are power signals and the required number of filters may be relatively high and especially exceed four. As was indicated above, it is very complicated to implement a switch that is able to handle more than 10 W of RF power, that has a number of outputs higher than 4, that is of low bulk and that consumes little electric power.

Known solutions that allow multi-output switches having a high number of outputs (i.e. such as in the example in Figure 1) to be produced easily are based on pin diodes.

Pin diodes are used in two modes, a blocked mode and a conducting mode.

In the blocked mode, a quite high blocking voltage, higher than 50 volts for a 15 W piece of portable radiocommunication equipment, is required thereby. This implies the use of a specific DC-DC voltage converter, this type of converter generally being bulky.

- 5 In the conducting mode, the pin diode must be able to carry a current of several tens of milliamps, this decreasing efficiency in a piece of carriable tactile communication equipment.

Known solutions compatible with the bulk and electrical-power-consumption requirements are in CMOS technology. Commercially available switches that
10 are able to handle more than 10 W and that have more than four outputs either do not exist or are incompatible with wideband applications.

One solution would be to use CMOS switches limited to four outputs and to mount a plurality thereof in cascade as illustrated in Figure 2. Thus, for
15 example a first stage 21 composed of one four-output switch 210, then a second stage 22 composed of a plurality of four-output switches 221, 222, 223, each having its input connected to one output of the switch of the first stage 21, would be obtained.

Such a solution has a number of drawbacks. It requires a relatively
20 substantial number of switches to be used because of the cascaded stages, thereby increasing production costs, and it is not the optimum solution from the point of view of bulk. Moreover, placing switches in cascade complicates their control. In addition, the radiofrequency performance of such a system is degraded because placing switches in cascade increases radiofrequency
25 losses, this significantly decreasing the efficiency of the piece of equipment.

Lastly, if it is desired to obtain many outputs, it is necessary to place many stages in cascade, this further complexifying the layout.

Figure 3 illustrates an exemplary embodiment of an RF switching device according to the invention, this device minimizing as much as is possible the
30 number of switches used while permitting simplicity in the control or command of the latter. This RF switching device is optimized with regard to the various criteria or requirements described above.

The switching device 30 in Figure 3 is shown facing the antenna 2. Its structure would be the same if it were power-amplifier facing. This example
35 shows the design principle of a device according to the invention.

The solution proposed by the invention consists in placing in parallel a plurality of preferably CMOS switches 31, 32 in a given RF channel while making provision to leave in each switch an output 311, 321 open-circuit.

These switches are compatible with the frequency band and power of a given radiocommunication application in order to obtain a switching function having more than four outputs and not having the drawbacks mentioned in the description above. These switches have a limited number of outputs, four for example, but are easily sourced from commercial suppliers. More generally, it is possible to use any "1 to N" type multi-output switch able to connect its input to one of N outputs, or vice versa.

A matching network 33 is mounted between the "1 channel" inputs 310, 320 of the switches in order to match operation over a wide frequency band, for example in the VHF and UHF domains. This matching network especially compensates for the interference caused by the open-circuit outputs.

In each of these switches 31, 32, at least one channel 311, 321 is therefore left open-circuit, the other outputs being intended to be connected to other RF functions.

The open-circuit channel 321 is activated in the switch 32 the channels of which are not used, activated meaning that the input of the switch is connected to this open circuit. The switch 31 that contains the conducting channel is programmed and used conventionally.

This original parallel connection, combined with the use of open-circuit channels, will be better understood from the more detailed presentation of the operation of the RF switching device shown in Figure 3.

This device according to the invention includes two switches 31, 32 in parallel. Each switch is a four-output switch in CMOS technology, one input 310, 320 being switched to one of the four outputs. In each switch, there is at least one output that is left open-circuit. In the example in Figure 3, each switch has three used outputs, which are for example each connected to a filter, and one open-circuit output 311, 321. With these two switches in parallel, the device according to the invention may therefore connect one channel 301 to six RF functions TX1 to TX6.

Figure 3 shows a switching state in which the first switch 31 contains the conducting channel 312. In this state, the second switch 32 is not used. Its input 320 is thus switched to the open-circuit output 321.

In operation, an RF signal is routed over the conducting channel 312 of the first switch 31 to another RF function, a filter for example. Since the input of the second switch 32 is connected to the open-circuit output 321, the latter switch is seen as open-circuit. An incident wave is thus reflected. The wave
5 reflected by the open circuit may interfere with the operation of the other switch and of other upstream RF circuits.

The matching network 33, connecting the inputs 310, 320 of the switches and the input 301 of the switching device "cancels out" the reflected wave. More precisely, it matches the RF line to the impedance presented by the open
10 circuit and compensates for the parasitic capacitances created when circuits are opened or closed.

The basic components of this matching network are conventionally inductors and capacitors. Since the reflected wave is "filtered out" because the circuit is matched, the first switch 31 is thus able to function as a standard switch
15 because it is not affected by the interference caused by the presence of the second open-circuit switch 32.

Figure 4 shows an exemplary layout of a device according to the invention on an RF printed circuit board. By way of example, an exemplary layout of the
20 device in Figure 3 is shown. The two switches 31, 32 are mounted in parallel, each having one output 311, 321 left open-circuit, the other outputs being connected via tracks to other RF functions, TX1 to TX6. The input 301 of the device is connected to the inputs of the switches via the matching network 30 decoupling the two switches, which matching network 30 is made up of
25 capacitors 41 and inductors 42.

In a piece of RF emitting and receiving equipment, the function illustrated in Figure 1, with the exception of the antenna, may be mounted on one and the same board. In particular, the power amplifier 1, a first switching device 30 according to the invention, the battery of filters (10) and a second switching
30 device (30) according to the invention may be mounted on one and the same printed circuit board. In this case, the layout of a switching device according to the invention is of the same type as that illustrated in Figure 4.

Figure 5 shows another exemplary embodiment of an RF switching device
35 according to the invention allowing a switching function having 9 outputs to

be obtained. In this exemplary embodiment, with respect to the layout in Figure 3, the switching device includes a third four-channel switch 53. Just like the other switches 31, 32, this third switch 53 includes three used outputs that are connected to other RF functions, and one output left open-circuit.

5 Figure 5 shows an operating state analogous to that in Figure 3. In particular, the first switch contains the conducting channel. The two other switches 32, 53 each have their input connected to their open-circuit output 321, 531. The matching network 33 decouples these switches from the first switch, which may thus operate normally.

10

An RF switching device according to the invention may advantageously be used in a piece of wide-frequency-band, carriable, tactical radiocommunication equipment.

15 It may, as in the schematic diagram in Figure 1, be mounted between a power amplifier 1 and low-pass filters 10 and between low-pass filters 10 and an antenna 2. It allows the system to select the low-pass filter corresponding to the used frequency band and to use a single antenna for the whole band.

20 The preceding exemplary embodiments show that the invention in particular provides the following advantages:

- A low bulk, because the invention does not require a high-voltage supply and commercially available CMOS switches are relatively small in size;
- Operation over a wide frequency band, CMOS switches naturally being wideband;
- A low electrical power consumption, because of the low consumption of CMOS components;
- The ability to easily produce a switching function with many outputs; specifically, placing a plurality of switches in parallel is easy;
- 30 - A good performance reproducibility, especially because of the simplicity of implementation; and
- Commercially available electronic switches may be used without adjustment.

CLAIMS

1. RF switching device, said device connecting its input (301) to one of its outputs in order to form a switchable conducting RF channel, said device
5 being characterized in that it includes at least two multi-output switches (31, 32) that are connected in parallel to said input point (301), each switch (31, 32, 53) having at least one output (311, 321) left open-circuit, its other outputs being intended to be connected to RF functions, in operation a switch (32, 53) not containing said conducting channel (310, 312) having its input
10 (320) connected to its open-circuit output (321, 531), the input of each of said switches (31, 32, 53) being connected to said input point via a common matching network (33), said network matching an RF line when the latter is connected to an open-circuit output point.
- 15 2. Switching device according to Claim 1, characterized in that said switches (31, 32, 53) are in CMOS technology.
3. Switching device according to either one of the preceding claims, characterized in that each switch (31, 32, 53) includes four outputs.
- 20 4. Device according to any one of the preceding claims, characterized in that said RF functions are RF filters.
5. Device according to any one of the preceding claims, characterized in that
25 said switches (31, 32, 53) are programmable.
6. Piece of RF transmitting and receiving equipment, characterized in that it includes at least one RF switching device (30) according to any one of the preceding claims.

7. Piece of transmitting and receiving equipment according to Claim 6, characterized in that it includes a power amplifier (1), a battery of filters (10) and an antenna (2), said switching device (30) being placed on the one hand
5 between said amplifier (1) and the battery of filters (10) and on the other hand between said filter battery (10) and said antenna (2), each filter being connected to a single output of each of said switching devices (30).

8. Piece of transmitting and receiving equipment according to Claim 7,
10 characterized in that said amplifier (1), the filter battery (10) and the two switching devices (30) are mounted on the same board.

9. Piece of transmitting and receiving equipment according to one of Claims 6 to 8, characterized in that it is portable.