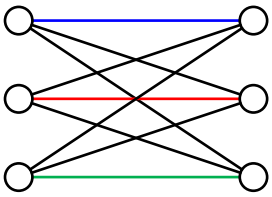
RF Matrix Switch Types and Functionality

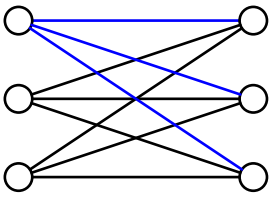
By JFW Industries, Inc.

JFW manufactures RF matrix switches in four distinct configurations: Blocking type, Non-blocking type, Super Non-blocking type and Common Highway type. Each of these configurations distributes RF signals in a different fashion. The different functionality is described in the below 3X3 block diagrams that have port connectivity descriptions. Before choosing a RF matrix switch for your application, you must know the answers to the below questions. JFW provides direct access to our engineering team. Please email our engineering team (jfwengr@jfwindustries.com) if you want any assistance in choosing a matrix switch type.

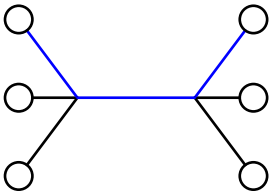
- Does the RF signal need distributed to multiple outputs simultaneously?
  - (Yes)
  - Do multiple input signals need combined onto a single output port?
    - (Yes) Use Super Non-blocking type
    - (No) Use standard non-blocking type
  - (No)
  - Do you require more than 1 active path through the matrix?
    - (Yes) Use standard blocking type
    - (No) Use Common highway type



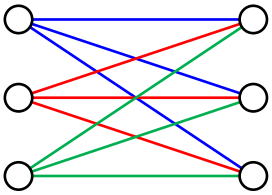
3X3 Blocking
up to 3 active paths
input ports allowed only one connection
output ports allowed only one connection



3X3 Non-Blocking
up to 3 active paths
input ports can have multiple connections
output ports allowed only one connection

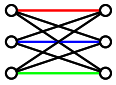


3X3 Common Highway
only one active path



3X3 Super Non-Blocking
up to 9 active paths
input ports can have multiple connections
output ports can have multiple connections

Blocking RF Matrix Switch



A blocking RF matrix switch is built with all RF switches. An input signal can only be connected to a single output port. The functionality of the RF switches is what makes this design blocking. The RF switches have no fan-out ability. Once the switch state is set, the unused switch ports block connectivity to all other switches. For the matrix switch this means that after an input port is connected to an output port, that input port is blocked from use by all other output ports.

The two most notable advantages of a blocking matrix switch are insertion loss and isolation. Because the design uses only RF switches, the insertion loss will be lower than any other configurations. The other configurations utilize power divider/combiners to fan-in and fan-out signals to multiple ports. Power dividers have much higher insertion loss than their corresponding RF switch. A 1P4T electro-mechanical RF switch will have about 0.1dB of insertion loss at 3GHz while a 4way power divider/combiner will be around 7dB of insertion loss at 3GHz. The RF switches also makes it possible to maintain very high isolation from input-to-output, input-to-input, and output-to-output because RF switches have better isolation characteristics than power divider/combiners. A typical electro-mechanical RF switch has port-to-port isolation >60dB while a power divider/combiner has only 20dB of port-to-port isolation.

Advantages

- Low insertion loss
- High port-to-port isolation
- High RF input power

Disadvantages

- An input port can not connect to multiple outputs simultaneously

Figure 1. 3 x 3 Blocking Matrix Switch (3 active paths maximum)

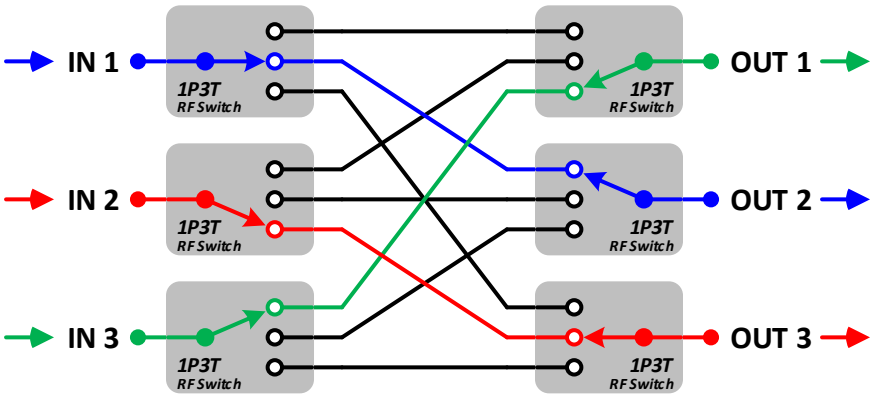
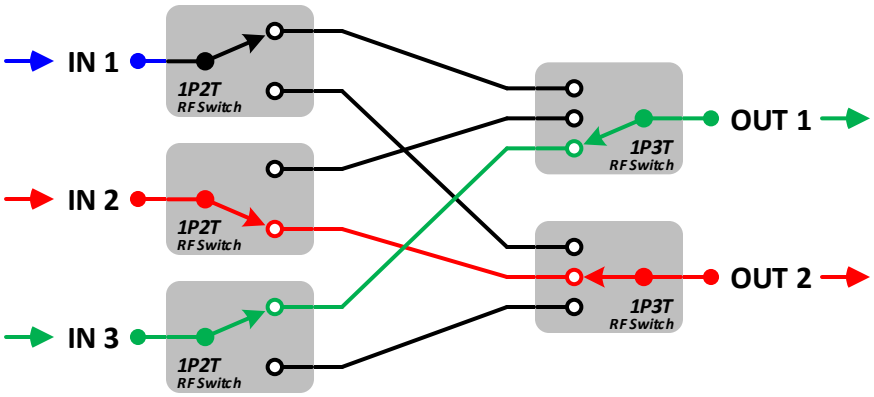


Figure 2. 3 x 2 Blocking Matrix Switch (2 active paths maximum)



Non-Blocking RF Matrix Switch

A non-blocking matrix switch is constructed with power divider/combiners and RF switches. The power divider/combiners provide the functionality that make this design non-blocking. The power divider/combiners fan-out the RF signal so that it is available for multiple simultaneous connections. If an input port is already connected to an output port, it is not blocked from use by other output ports. If need be, an input port can be connected to all output ports simultaneously. Power divider/combiners do have disadvantages. They have higher insertion loss and lower isolation than their corresponding RF switch. A typical electro-mechanical RF switch has port-to-port isolation >60dB while a power divider/combiner has only 20dB of port-to-port isolation. On the below block diagrams, the power dividers will cause the output-to-output isolation to be much lower than their corresponding blocking type design.

Depending on your application, the power divider/combiners can be on the input half or output half of the matrix. If you want to fan-out each input signal to all outputs, then the power divider/combiners will be located on the input half of the matrix. If you want to Fan-in all input signals to each output, then you use power divider/combiners on the output half of the matrix. Both block diagrams below are fan-out type. So, the below divider/combiners will fan-out the RF input signals so that they are available to all output ports simultaneously.

Advantages

- More connectivity options than blocking type
- Each input port available to all output ports

Disadvantages

- Higher insertion loss than blocking type
- Lower port-to-port isolation than blocking type

Figure 3. 3 x 3 Non-Blocking Matrix Switch (3 active paths maximum)

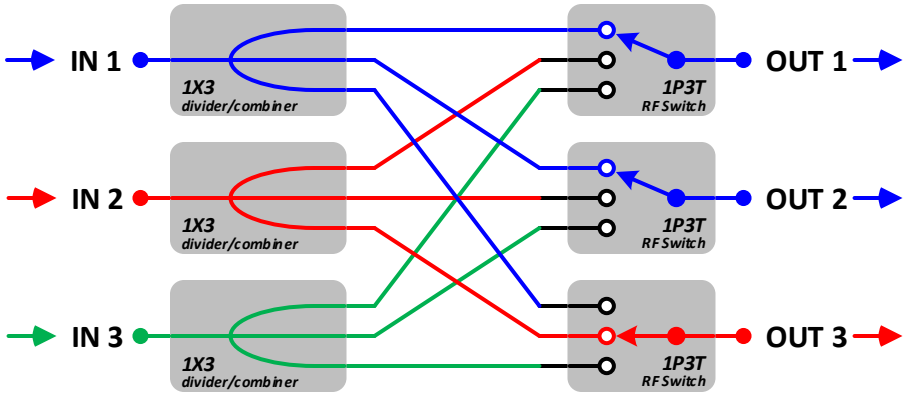
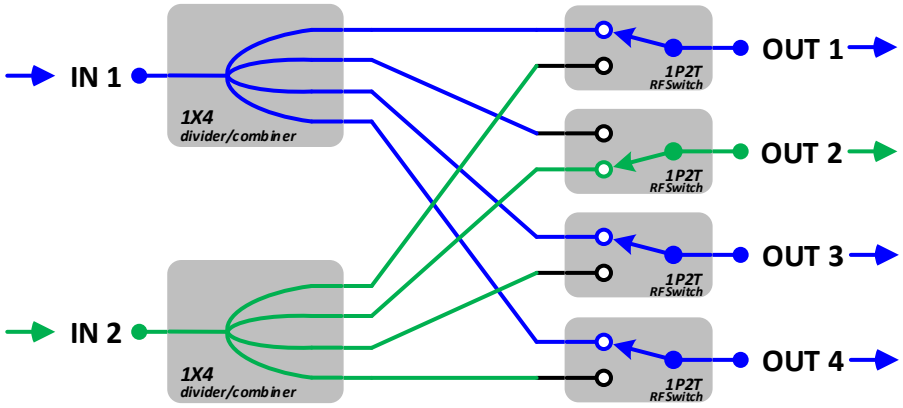
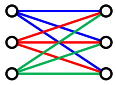


Figure 4. 2 x 4 Non-Blocking Matrix Switch (4 active paths maximum)



Super Non-Blocking RF Matrix Switch



The super non-blocking matrix switch is constructed with power divider/combiners and 1P1T switches. This configuration offers the greatest connectivity flexibility. Multiple input ports can be connected to multiple output ports simultaneously. The divider/combiners on the input ports will fan-out the RF input signals while the divider/combiners on the output ports will fan-in all of the RF input signals to each output port. The selection of each signal is done by the 1P1T switches. This type of matrix has greater insertion loss than all other matrix designs. The 20dB isolation rating for the power divider/combiners limits the input-to-input isolation and output-to-output isolation of the matrix switch. The input-to-output isolation of the matrix is determined by the isolation rating for the 1P1T switch.

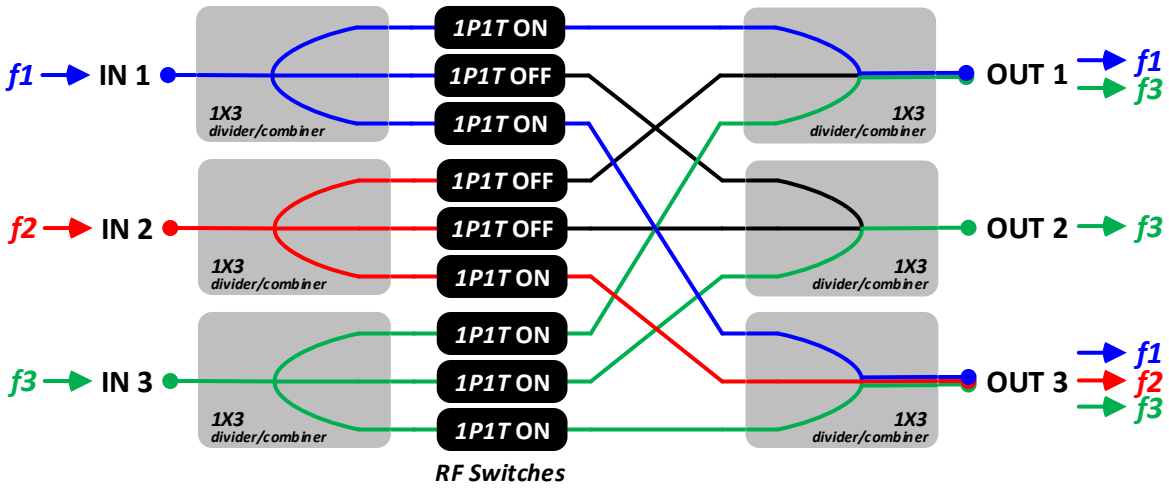
Advantages

- Maximum connectivity flexibility
- All input ports available to all output ports

Disadvantages

- Higher insertion loss than non-blocking type
- Low port-to-port isolation due to divider/combiners

Figure 5. 3 x 3 Super Non-Blocking Matrix Switch (9 active paths maximum)



Variation with Programmable Attenuators

The above block diagram uses 1P1T switch to turn on/off each path through the matrix. If you replace the 1P1T switches with programmable attenuators (i.e. 0-95x1dB), then instead of on/off functionality you are able to vary the signal level on each path individually from 0dB to 95dB in 1dB steps. JFW refers to this alternate design as *Handover Test Systems*. Our handover test systems are typically used by customers performing cellular testing. The input ports are attached to handsets. The output ports are connected to mobile access points. The programmable attenuators allow the signal level between the handsets and access points to be faded up/down. Please visit the Handover Test Systems pages on our JFW website for existing models (with block diagrams) at frequency ranges up to 6 GHz.

Common Highway RF Matrix Switch

The common highway matrix switch is built with only RF switches. The common port of each switch is connected together so that there is a single path through the matrix. It is the least costly matrix switch design. It also has less functionality than all other matrix switch designs. There can be only one active input and one active output port. Once an input port is in use, all other input ports are blocked from use. Once an output port is in use, all other output ports are blocked from use.

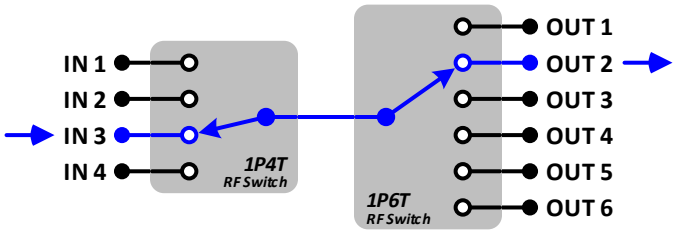
Advantages

- Low cost
- Low insertion loss
- High port-to-port isolation
- High RF input power

Disadvantages

- There is only 1 active path

Figure 6. Common Highway Matrix Switch (1 active path maximum)



Conclusions

When choosing a matrix switch design for your application, it is important to understand the functionality of each of the matrix switch design types. This article provided the pros and cons of each matrix design type. We list many existing matrix switch models on our JFW website with data sheets, output drawings and block diagrams. If you would like a recommendation for your application our engineering team (jfwengr@jfwindustries.com) is available for direct contact.

If you have a block diagram or description of a matrix switch you would like JFW to bid on, then please email your requirement to sales@jfwindustries.com. We will respond with ROM (rough order of magnitude) pricing in 1-2 days. JFW does not charge NRE's for custom models. We pride ourselves in being able to offer custom models with pricing that is in-line with our standard models.

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