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Routing RF signals via a network of RF relays

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ABSTRACT

Devices that use radio frequency (RF) signals, e.g., Wi-Fi devices, are tested for performance and regulatory compliance. Testing typically covers radio propagation conditions found in the field, e.g., multipath channels, varying interference levels, etc. A device-under-test (DUT) is tested by placing it within an anechoic RF chamber or enclosure. An RF path is created between a test equipment and a DUT, using an RF shielded cable. This provides a fixed RF path between enclosures. When working with multiple enclosures, if the experimental setup needs a change in RF path connectivity, e.g., to test a new multipath condition, current practice is to reconnect ("patch in") cables for the new path. Because of the one-to-one patching connections between cables, it is not possible to have a one-to-many experimental setup unless an additional RF path is created. Manual patch-in of RF cables limits automation and remote management of the test.

This disclosure provides techniques for connecting RF enclosures via a network of RF relays. Each RF relay is controlled by a switch controller, and can be turned on or off, such that RF signals are routed to particular node(s) of the network. In this manner, multipath conditions, or connectivity between multiple enclosures containing DUTs, can be easily and remotely changed. Techniques disclosed herein lead to faster characterization of or experimentation with RF devices, and are suitable for automated testing.

KEYWORDS

Radio frequency testing; RF relay; RF switch controller; SCPI

BACKGROUND

Radio frequency (RF) devices, e.g., consumer equipment using Wi-Fi, are designed and tested for performance and interference control. Such devices need to comply with regulatory norms, e.g., minimize spurious emissions or interference for other devices, performance and workability under various channel conditions, etc. Typically, a device-under-test (DUT) is tested by placing it within an anechoic RF chamber or enclosure. The enclosure containing the DUT, e.g., a consumer Wi-Fi device, is connected to RF test equipment, e.g., an RF transceiver, via a shielded cable. This configuration, of a shielded cable connecting RF test equipment to DUT, serves adequately as a fixed path between enclosures. When working with multiple enclosures, current practice is to patch in a cable to establish connectivity to each enclosure. This is a time-consuming and labor intensive process.

DESCRIPTION

This disclosure describes techniques to connect multiple RF chambers or enclosures using a network of RF (microwave) relays. Each relay is controlled by a switch controller that can turn a relay on or off. The switch controller is accessible via a control interface, e.g., SCPI (Standard Commands for Programmable Instruments). The control interface can be controlled over an internet protocol (IP) socket such that the network of switches and connected RF enclosures can be remotely managed, and testing or experimentation can be automated.

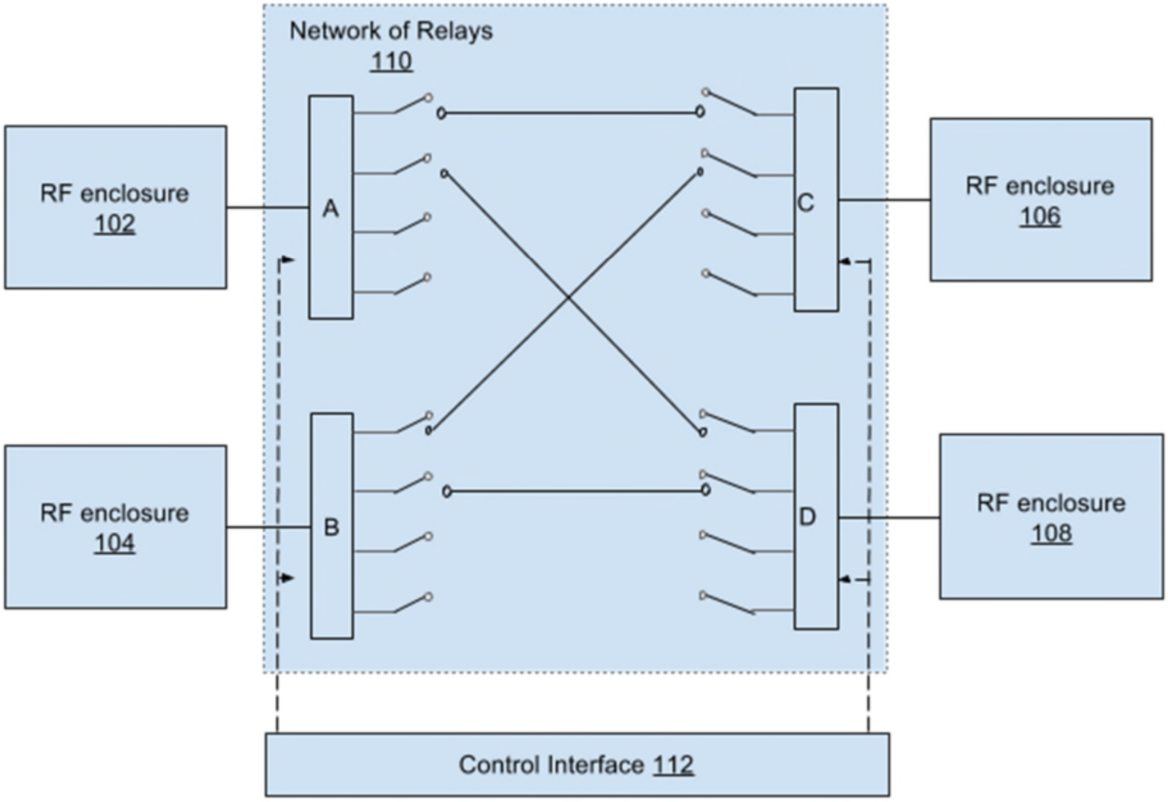

Fig. 1: Routing RF signals via a network of RF relays

Fig. 1 illustrates routing of RF signals via a network of RF relays, per techniques of this disclosure. RF enclosures (102-108) each contain a device-under-test, e.g., a cellular phone or other device that uses RF or microwave frequencies. Zero, one or more of RF enclosures may include test equipment, e.g., a transceiver, spectral analyzer, etc. The RF enclosures are connected to each other via a network of RF relays (110).

The network of relays, also referred to as RF switching system, comprises the RF relays A through D, connected as shown in Fig. 1. Each relay is controlled by a controller using a control interface (112). By controlling, e.g., switching on or off a particular combination of relays, certain paths between RF enclosures are activated, and other paths are deactivated. In this manner, an experimental configuration of RF connectivity is changed rapidly without cabling changes or manual intervention. Testing, characterization, or experimentation can be performed remotely as control interface 112 has an IP socket.

Examples

Example 1: RF enclosure 104 includes test equipment that generates an RF signal. RF enclosures 106 and 108 each contain a device-under-test. The experiment is to test each DUT simultaneously under the presence of the RF signal generated by the test equipment. To conduct the experiment, control interface 112 can be used to turn on the BC and BD connections, while turning off the AC and AD connections. In this manner, the DUTs within RF enclosures 106 and 108 each simultaneously receive the RF signal, and the performance of each DUT can thereby be tested and recorded.

Example 2: RF enclosure 102 includes test equipment that generates RF signals. RF enclosures 106 and 108 each contain a device-under-test. The experiment is to test each DUT one after another, e.g., first 106, then 108. To conduct the experiment, control interface 112 can be first used to turn on relay A and turn off relay B. Subsequently, the control interface can be used to turn on relay C, turn off relay D and test the DUT within RF enclosure 106. Further, relay C is then turned off, relay D is turned on and the DUT within RF enclosure 108 is tested. In this manner, each DUT receives the RF signal in sequence, and the performance of each DUT is recorded in sequence.

Example 3: RF enclosures 102 through 108 each contain devices-under-test. The experimental setup is one in which RF enclosures 102 and 108 are RF-coupled to each other and RF enclosures 104 and 106 are RF-coupled to each other. Controller interface 112 can be used to activate connections AD and BC, while deactivating connections AC and BD. In this manner, the pattern of path connectivity between devices-under-test is achieved.

By switching on multiple relay connections, RF multipath can also be created. In this manner, a one-to-many RF path connectivity is achieved without necessitating a new cable connection.

Example 4: RF enclosures 104 and 108 contain no devices or equipment. The experiment is to create RF multipath between devices-under-test enclosed within RF enclosures 102 and 106. This can be achieved by turning on links AC, AD, DB and BC. In this manner, two paths are created between RF enclosures 102 and 106, namely paths 102-A-C-106 and 102-A-D-B-C-106.

The relay network described herein is operable at any radio or microwave frequency. For example, Wi-Fi devices typically operate at around 2.4 GHz or 5 GHz. For such Wi-Fi devices, usage of relays that are operable up to 6 GHz ensures that Wi-Fi devices tuned to either of 2.4 GHz or 5 GHz can be tested. While Fig. 1 shows four RF enclosures and a network that includes four relays, any number of enclosures and relays can be configured per requirements of specific experiments.

CONCLUSION

Techniques of this disclosure provide an RF switching system between multiple RF enclosures. The RF switching system is constructed by interconnecting RF relays with a switch controller. Connections between RF enclosures can be modified through the control interface, without a need for adding or removing cables. The RF switching system enables testing and/or characterization RF devices under a variety of conditions rapidly and with minimal manual intervention. The RF switching system permits automation and remote management of tests.