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Untethered Desense Testing of Radio-Frequency Devices

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Untethered Desense Testing of Radio-Frequency Devices

ABSTRACT

An electronic device, e.g., laptop, etc., in radio-frequency communication with another electronic device can lose receiver sensitivity when certain components turn on. This is because electrical switching activity in the components can result in electromagnetic interference. Traditional methods of measuring receiver desensitization tether the device to a computer that carries out test sequences and logs measurements. However, the presence of the tethering cable itself causes additional electromagnetic interference. This disclosure describes techniques that enable untethered measurement of receiver desensitization. Per the techniques, an RF tester measures the packet error rate (PER) based on over-the-air acknowledgements received from the device under test. Receiver sensitivity, with and without active components, is measured by reducing transmit power until the PER just crosses a threshold. The device is characterized for receive-desensitization accurately and in a nearly real-use situation.

KEYWORDS

- Receiver desensing
- Device under test (DUT)
- Tethered DUT
- Untethered testing
- Service set identifier (SSID)
- WLAN signaling test
- Packet error rate

BACKGROUND

An electronic device, e.g., wireless camera, laptop, etc., in radio-frequency communication with another electronic device can lose receiver sensitivity when certain components or accessories (collectively, subsystems) turn on. This is because electrical switching activity in the subsystems can result in electromagnetic radiation that gets picked up as noise by the electronic device.

For example, a wireless camera can have as subsystem light-emitting diode (LED) floodlights connected via universal serial bus (USB) or universal asynchronous receiver/transmitter (UART). When the floodlights are off, the camera may have a receive-sensitivity of -110 dBm, e.g., it can receive and decode a signal at a level of -110 dBm or above, but not below. When the floodlights turn on, the receive-sensitivity may drop to -107 dBm. As another example, the WiFi module of a laptop may have a receive-sensitivity of -100 dBm when a disk drive is disconnected, but may have a receive-sensitivity of only -97 dBm when the disk drive is connected. The loss of receive-sensitivity upon the connection of a subsystem is known as receiver desensing or desensitization.

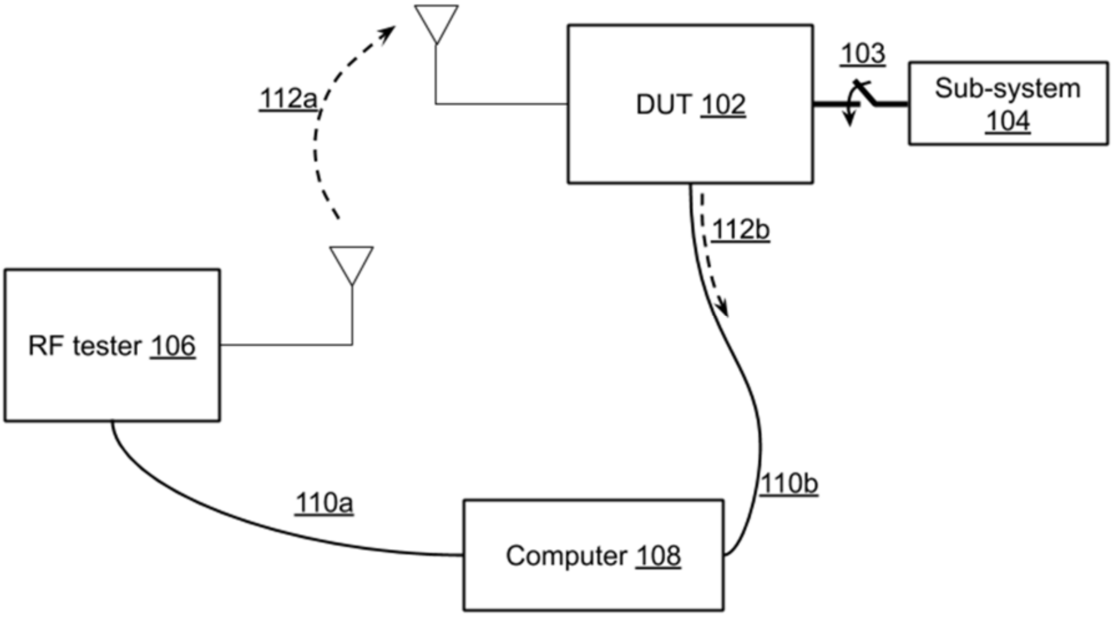

Fig. 1: Measuring receiver desensitization

Fig. 1 illustrates a conventional technique for measuring receiver desensitization. The device-under-test (DUT, 102) has a wireless, e.g., WiFi, Bluetooth, etc., module and is connected to a subsystem (104) via an electronically-controlled switch (103). A radio-frequency (RF) tester (106) communicates with the DUT via a radio link (112a).

The RF tester is controlled by a computer (108), which provides test sequences, test waveforms, etc., to the RF tester. The computer is connected to the RF tester via a cable (110a) and also to the DUT via another cable (tether, 110b). The radio-link performance is measured, e.g., by having the RF tester send out packets of data (112a) and logging the packet error rate (PER) or received signal strength indication (RSSI) (112b) at the computer.

The receiver sensitivity is measured with the subsystem connected (or disconnected) by measuring the RF power transmitted by the tester below which the PER becomes unacceptably high, e.g., crosses a threshold such as 1%. The difference in RF power needed to achieve a threshold PER between the two states, subsystem connected and subsystem disconnected, is the receiver desensitization.

The above-described technique for RF desensitization has some drawbacks such as:

- The DUT may have only one USB port, such that it can either connect to the computer or to the subsystem but not both, in which case the techniques of Fig. 1 cannot be used.
- In the case of a DUT that is battery-fed under normal operation, e.g., an untethered DUT, the cabled DUT-to-computer connection used for measurement in the laboratory can create interference. For example, the cable can pick up noise, or its data transmissions can cause spurious emissions, both of which can feed into the DUT and produce unrealistic experimental data or otherwise ruin measurements.

- In the case of a DUT that is connected to a cable under normal operation, the cable carries electrical power, not data. Because power waveforms switch at a low frequency (50 or 60 Hz) if they do at all, they do not radiate from cables of lengths typically used in consumer devices.
- The presence of the cable in and around the DUT creates a non-free-space environment for the antennas of the DUT. The antenna radiation pattern in the laboratory is therefore different in comparison to the real-use scenario, thereby affecting measurements.
- A tethered DUT, e.g., one that is cabled to a computer for the purposes of data communication, differs generally from the real-use scenario and is not a representative testing environment.

DESCRIPTION

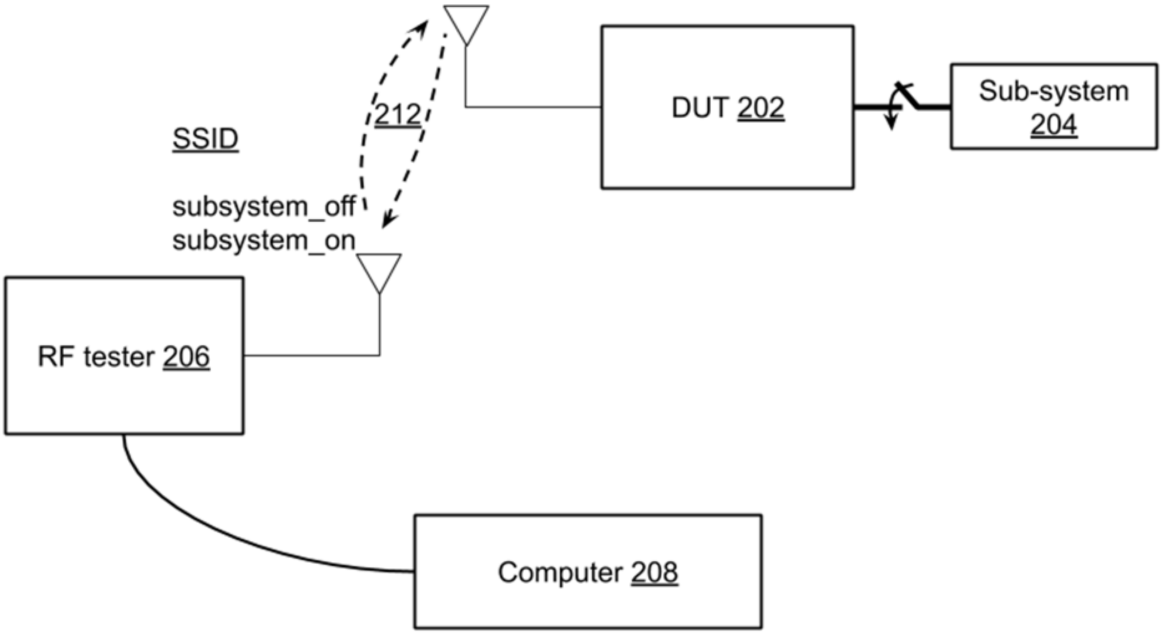

Fig. 2: Untethered desense testing of radio frequency devices

Fig. 2 illustrates untethered desense testing of RF devices, per the techniques of this disclosure. The RF tester (206) is configured to act as an access point such that it communicates with the DUT (202) over the radio link (212) using radio protocols such as WiFi, Bluetooth, etc. The RF tester continues to be connected to its controlling computer (208), but the computer is no longer cabled to the DUT. The DUT operates in an untethered fashion, closer to its real-use configuration.

The packet error rate (PER) is measured by the RF tester as follows. For every frame that is transmitted by the tester to the DUT and received correctly by the DUT, the DUT sends back an acknowledgment (ACK). For every packet that is received incorrectly or not at all by the DUT, no ACK is sent. The PER is measured as the ratio of unacknowledged packets to the total number of packets sent by the tester. Receiver sensitivity is measured as the level of power below which the PER increases beyond a threshold, e.g., 1%. The difference in RF power needed to achieve a threshold PER between the two states - subsystem connected and subsystem disconnected - is the receiver desensitization.

Furthermore, during testing stages, the DUT often lacks features that enable its connected subsystems (204) to directly be commanded to power on or off. In such a case, per the techniques described herein, the tester broadcasts wireless packets over one of two or more SSIDs, e.g., subsystem_off, subsystem_on, etc. When the DUT connects to the SSID by name subsystem_off, it disconnects its connected subsystem to enable receive-sensitivity testing under the condition of disconnected subsystem. When the DUT connects to the SSID by name subsystem_on, it connects its subsystem to enable receive-sensitivity testing under the condition of a connected subsystem. Effectively, the SSID is made an indicator for the DUT to enable or disable its connected system(s) for the purposes of desense testing.

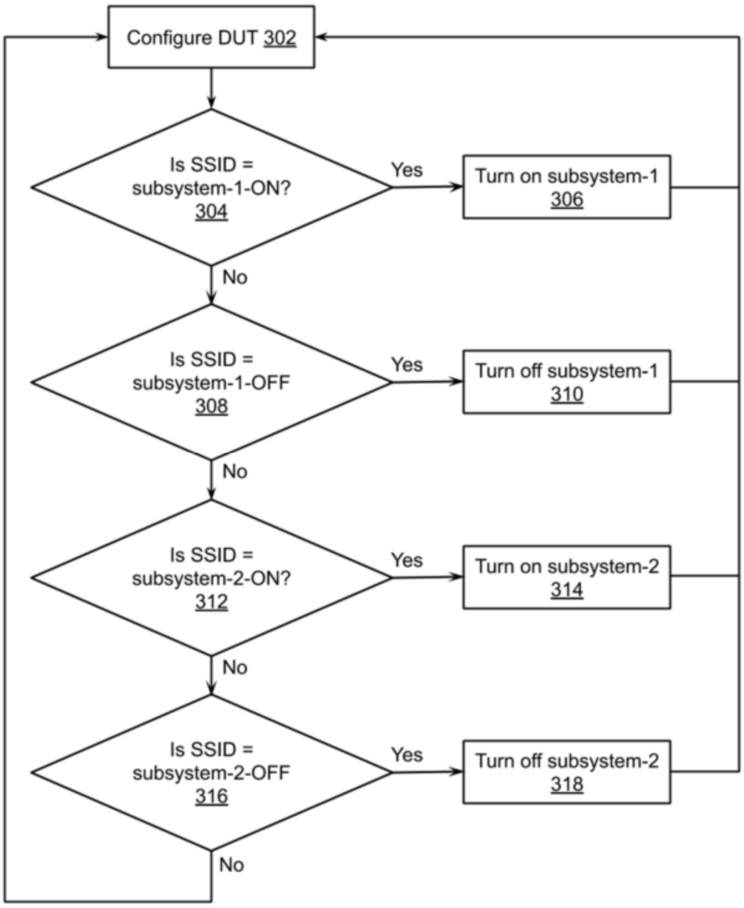

Fig. 3: Using SSIDs to configure the connected subsystem

For the DUT to switch in or out a connected subsystem based on the SSID, a daemon runs on the DUT. Fig. 3 illustrates the process executed by the daemon to configure the connected subsystem based on the SSID. After configuring the DUT (302), the daemon checks if the SSID indicates that a subsystem should be on (304). If the SSID indicates that the subsystem should be on, then that subsystem is turned on (306). If the SSID (308) indicates that that subsystem should be off, then that subsystem is turned off (310). As illustrated in Fig. 3, the same paradigm can be used to control multiple subsystems that may be connected to the DUT. For example, the daemon can check the SSID if it indicates that a second subsystem is to be turned on (312), and turn on the second subsystem (314). Similarly, the daemon can check the

SSID if it indicates that a second subsystem is to be turned off (316), and turn off the second subsystem (318). The daemon runs in a loop, checking the SSIDs to turn on and off subsystems as indicated. An experimentalist can control the name of the SSID by programming the computer that controls the RF tester.

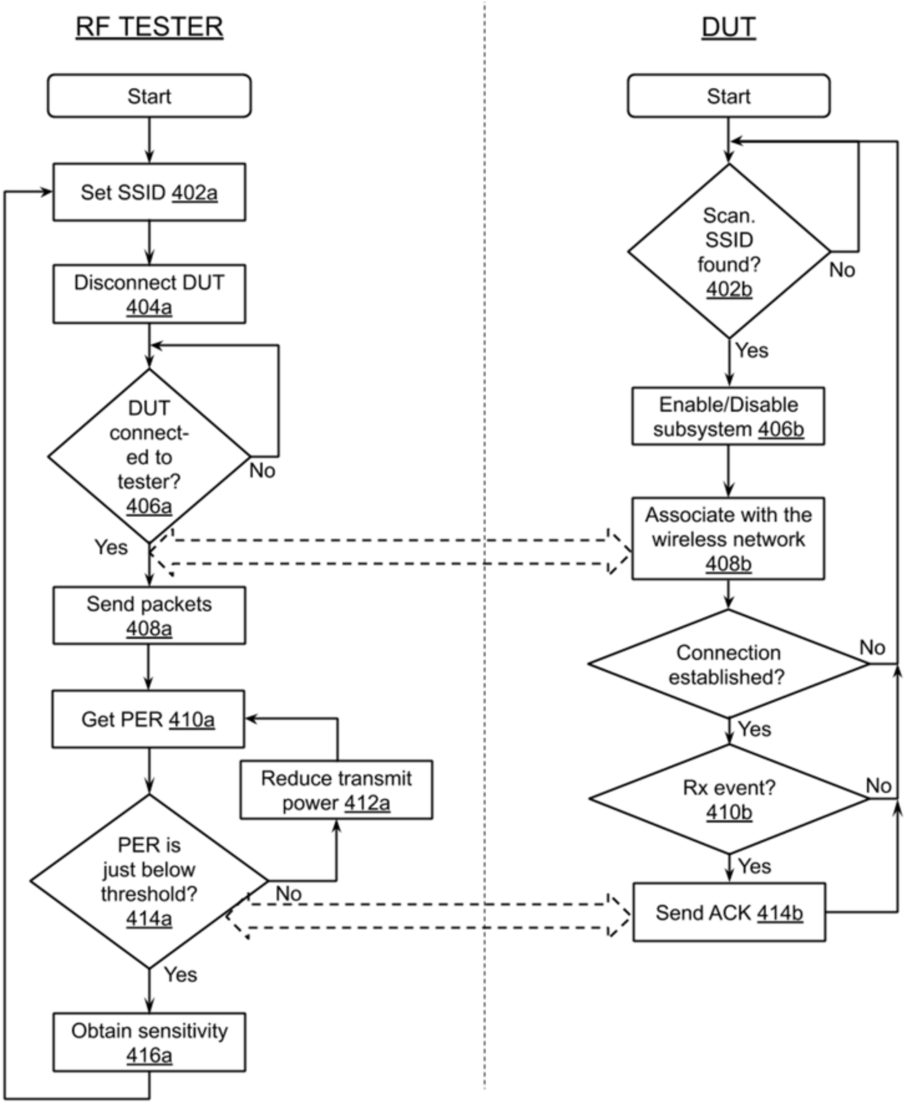

Fig. 4: Parallel daemons running on the tester and on the DUT and interactions between them

Fig. 4 illustrates the parallel daemons that run on the tester and on the DUT, and the interactions between them. The RF tester sets the SSID (402a), which, as explained earlier, enables the DUT to enable or disable subsystems. It disconnects the DUT (404a). The DUT scans for a wireless network (402b). When found, it enables or disables its connected subsystem(s) based on the SSID (406b).

The DUT associates with the wireless network (408b). When the DUT connects to the tester (406a), the tester starts sending packets to the DUT (408a). Once connection is established, the DUT awaits an Rx event (410b), e.g., the receipt of a packet. If it receives a packet, it transmits an ACK (414b). The tester receives the ACK to compute the PER (410a) (as explained before) as the ratio of the unacknowledged packets to the total number of packets transmitted. The tester reduces transmit power (412a) until the PER is just below a specified threshold (414a), e.g., 1%. The transmit power that achieves the specified PER is a measure of receive sensitivity (416a). Both daemons loop to test sensitivity for subsystem after subsystem under conditions of connectedness and disconnectedness of subsystem.

In this manner, the described techniques enable untethered desense testing of electronic devices, which is close to the real-use scenario of such devices. The lack of a tether to the device under test simplifies experimentation, reduces electromagnetic interference, enables the antennas of the DUT to experience a radio environment closer to a real-use situation, and produces an accurate measurement of receiver desensitization.

CONCLUSION

This disclosure describes techniques that enable untethered measurement of receiver desensitization of a device under test. Per the techniques, an RF tester measures the packet error rate (PER) based on over-the-air acknowledgements received from the device under test. Receiver sensitivity, with and without active components, is measured by reducing transmit power until the PER just crosses a threshold. The device is characterized for receive-desensitization accurately and in a nearly real-use situation.