octoBox Throughput Test Application Note

Automated test controls the octoBox turn table, RF attenuators, traffic and interference generators to measure MIMO-OTA (over the air) throughput

The octoBox® STACK throughput testbed is a stand-alone completely isolated semi-anechoic wireless testbed supporting 4x4 MIMO OTA measurements of very high throughput links, including Wave 2 Wi-Fi using 160 MHz channels. Devices in the testbed are completely isolated from one another and from external interference – industry's best isolated testbed. The OB-THROUGHPUT software automates the throughput test by programming RF attenuators, turn table, interference and traffic generators. The software plots measurements using Excel.

OCTOBOX STACK TESTBED HIGHLIGHTS

- Stand-alone compact industry-standard benchmark testbed used by SmallNetBuilder.com
- Wi-Fi (802.11a/b/g/p/n/ac), cellular (GSM, UMTS, LTE, LTE-Advanced), Bluetooth, ZigBee, etc.
- Excellent MIMO-OTA environment optimized for very high throughput
- Multipath emulation of IEEE standard 802.11 models
- Supports up to a 4x4 MIMO link of any channel width in the 700 MHz to 6 GHz frequency range
- Adds realistic multi-channel interference using the iGen™ interference generator module
- Automatically controls RF attenuators, turn table and traffic generators, iterating through measurements at each attenuation, rotation and interference setting
- Can be left running for days for extensive averaging or fine resolution of attenuation and rotation steps or multiple interference scenarios

Figure 1: *octoBox STACK-38-TT-MPE testbed*

FEATURES & BENEFITS

- Frequency range: 700 to 6000 MHz
- Integrated
    - Anechoic turn table rotates device during test for averaging of throughput vs. orientation
    - Multipath emulator (MPE) module introduces realistic multipath per IEEE 802.11 channel models
    - quadAtten RF attenuator module emulates path loss due to distance or walls; attenuator dynamic range: 60 dB; step: 0.5 dB; 4 RF attenuators per module powered and individually controlled via single Ethernet/PoE or USB
    - iGen interference generator (optional)
- Test automation software controls test conditions and provides graphical reporting

What test results does the OB-THROUGHPUT automation software produce?

The OB-THROUGHPUT automation software is a TCL script that controls programmable attenuators, turn table and a traffic generator. The traffic can be generated using iperf or IxChariot to produce *throughput vs. path loss* plots, such as the one shown in Figure 5.

If the turn table is used, every point on the plot in Figure 5 can be averaged vs DUT (device under test) rotation.

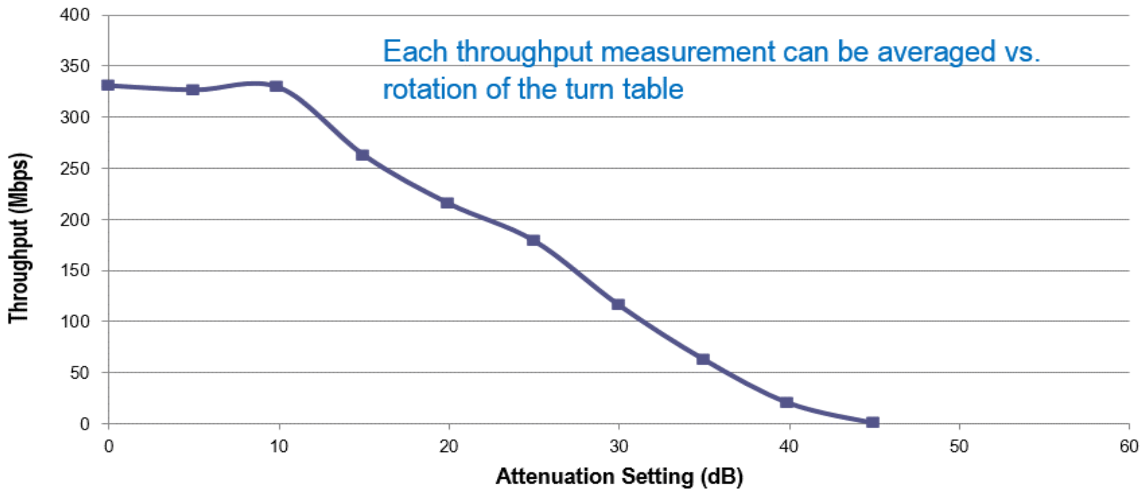


Figure 5: *OB-THROUGHPUT plot of throughput vs. path loss*

Another type of plot OB-THROUGHPUT can produce is the *throughput vs. path loss vs. orientation* plot, as shown in Figure 6. This polar plot can pinpoint issues with the antenna field (Figure 6, right) by revealing low throughput at some orientations of the DUT with respect to the test antennas.

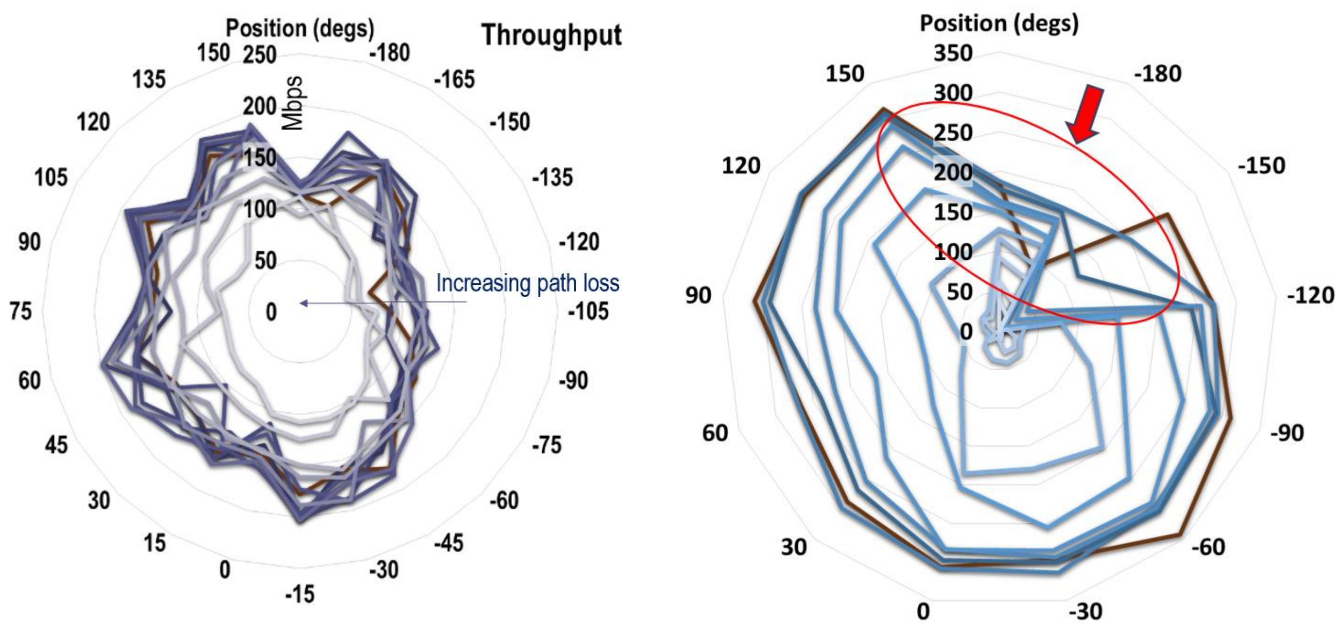
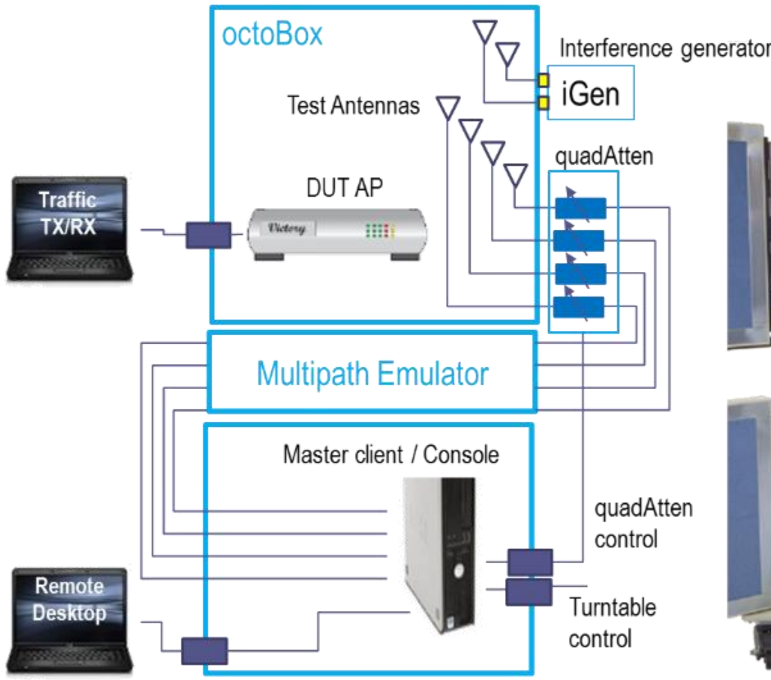


Figure 6: *OB-THROUGHPUT plot of throughput vs. path loss vs. orientation; nulls in the DUT antenna field can be seen at some orientations of the DUT*

How does the throughput measurement work?

A typical throughput test configuration has the DUT and a master/partner device connected through programmable attenuators in series with the MPE (multipath emulator) module, as shown in Figure 2. Traffic generator software, such as iperf or IxChariot, can be used to send traffic between the DUT and the master. Programmable attenuators add path loss while the MPE module adds multipath between the master and the DUT, simulating typical home or office conditions. The iGen module adds Wi-Fi or waveform interference into the testbed.



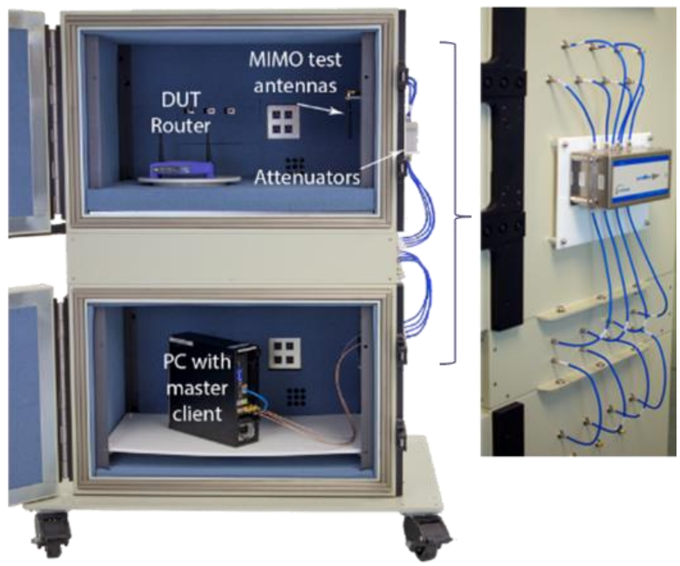
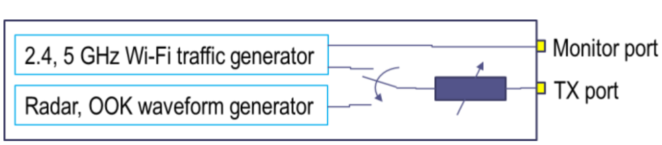


Figure 2: *STACK-38-TT-MPE throughput testbed block diagram (left); photo (right)*

If the DUT is a client device (e.g. phone, tablet or PC), the master is typically an access point (AP) or a base station (BS). If the DUT is an AP or a BS, the master is typically a client device.

The MPE module is stacked between the master and DUT chambers. The master and DUT chambers are coupled through the MPE and the octoBox quadAtten module (Figure 2). The attenuators are programmed to step through a range of 0 dB to 60 dB to measure throughput vs. path loss.

One or more iGen modules can optionally be added to the testbed to emulate interference from in-range Wi-Fi networks or from other unlicensed devices. iGen can generate 802.11a/b/g/n/ac traffic or waveform interference, including radar waveforms for DFS (dynamic frequency selection) testing.



iGen block diagram

Figure 3: *iGen block diagram and photo*

iGen can mount over the quadAtten or another iGen module

Typically the RF signals to the DUT are coupled OTA. Figure 4 shows a 4x4 MIMO-OTA link with 4 MIMO antennas on the right. The DUT is on a turn table.

An RF-transparent support (e.g. a block of Styrofoam) can be used to lift the DUT, if necessary, for better alignment with the test antennas. A Styrofoam fixture can also hold the DUT upside down to neaten and shorten the power and data cable connections

Power and data cables can be fastened to the octoBox cable bracket, as shown in Figure 5.

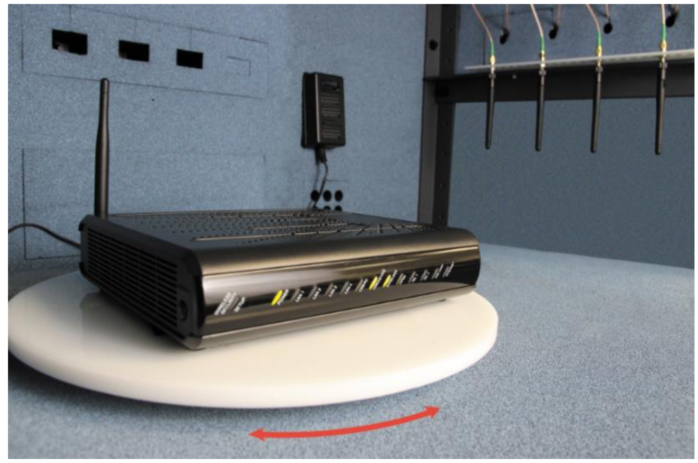


Figure 4: *octoBox anechoic turn table*

What is the path loss between the master and the DUT with RF attenuators set to 0 dB?

The path loss depends on whether the devices are coupled conductively or over the air (OTA) and in the case of OTA coupling on the antenna field pattern.

When the MPE is included in the octoBox STACK, the path loss will have a multipath transfer function, as shown here. The MPE adds approximately 15-20 dB of loss to the RSSI, channel and antenna dependent.

In a typical Wi-Fi test configuration where the master device is coupled conductively and the DUT is coupled OTA, the DUT's RSSI is approximately -40 to -50 dBm. Bypassing the MPE results in a strong, approximately -20 to -30 dBm, LOS (line of sight) signal at the DUT.

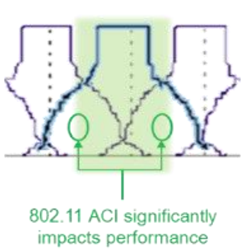
The DUT's RSSI reading will vary as a function of the master TX signal level, DUT's RX gain, operating channel, DUT's proximity to the test antennas, antenna coupling gains and other factors.

BRACKETS AND RAILS INSIDE THE OCTOBOX ARE PLASTIC AND FASTENED WITH NYLON HARDWARE TO AVOID REFLECTIONS

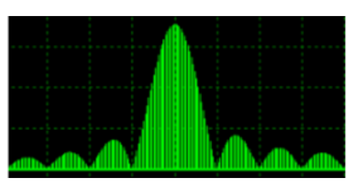
Figure 5: *octoBox cable bracket*

Why should I add controlled interference into the throughput testbed?

In real-life installations, particularly in apartment or office buildings, there may be 30 or more Wi-Fi networks in-range of one another. Interference can be stronger than the operating channel with the spectral skirts of the interfering channels severely impacting throughput. Adding ACI (adjacent channel interference) or CCI (co-channel interference) to the throughput testbed lets you qualify the impact of interference. You can also add waveform interference, including tones or pulse-train based radar waveforms.



Traffic Interference, example of 2 adjacent channel interferers



Waveform interference, example of a radar pulse-train

Interference and desired signal can be injected into the DUT chamber using the octoBox iGen module via extra antennas. You may consider incorporating more than one iGen module to inject ACI, CCI and waveform interference.

octoBox iGen can emulate common sources of wireless interference, including radar interference for 802.11h DFS (dynamic frequency selection) testing. Using tones, iGen can emulate cordless phones, Bluetooth devices, microwave ovens, baby monitors and other common sources of interference.

iGen has the same formfactor and mounting arrangement as the octoScope quadAtten and is controllable and powered from a single Ethernet/POE (power over Ethernet) cable, making it easy to integrate into the octoBox wireless testbed.

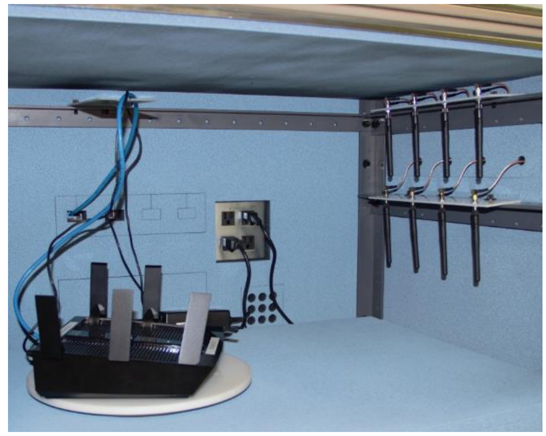


Figure 6: *Mounting of 2 antenna modules*

Do the octoBox quadAtten and iGen modules couple surrounding interference into the testbed?

While most off-the-shelf attenuators or RF combiners pick up Wi-Fi interference and couple it into the testbed, all octoBox building blocks, including the quadAtten and iGen are carefully designed for testbed impenetrability by stray interference.

To maintain high isolation, both the quadAtten and iGen modules features filtered Ethernet and USB connections. Their enclosures are carefully machined and extensively gasketed.

The modules are mounted on the side of the octoBox and are powered and controlled from a console PC using filtered Ethernet/POE or USB ports.

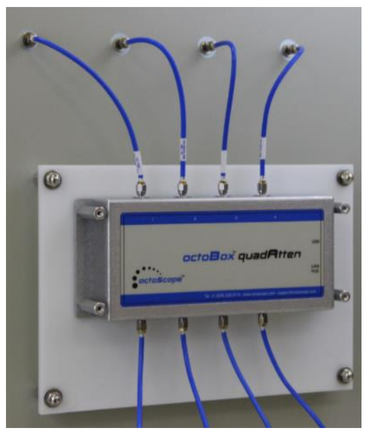
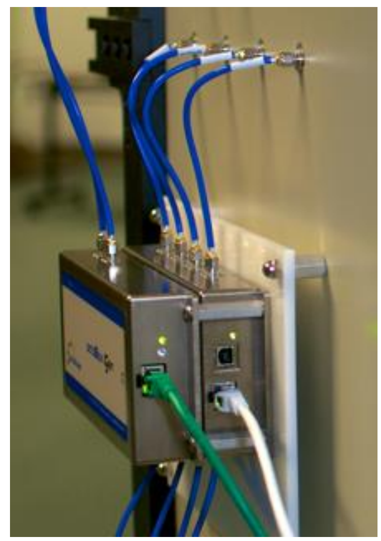


Figure 7: *octoBox quadAtten and iGen modules*



CONTACT

octoScope, Inc.
305 Foster Street
Littleton, MA 01460
Tel: +1.978.376.5841
sales@octoscope.com