BOX-MMW mmWave OTA chamber

The BOX-MMW over the air (OTA) test chamber supports functional and performance testing in the sub-6 GHz and mmWave frequency bands.

octoScope’s BOX-MMW chamber, when used as part of the octoBox® wireless personal testbed supports mmWave frequency band for testing throughput, beamforming, beamsteering and roaming. You can test roaming and handover among radios operating in LTE, Wi-Fi and mmWave frequency bands.

**TEST APPLICATIONS**

- MIMO OTA (over the air) throughput
- Multi-User (MU) MIMO and beamforming
- Band steering
- Data rate and channel adaptation
- TX spectrum, EVM
- RX sensitivity
- Roaming
- Coexistence of mmWave, Wi-Fi, LTE, Bluetooth, ZigBee and other radios

**FEATURES & BENEFITS**

- mmWave bands: 24-86 GHz
- 802.11a/b/g/n/ac/ax operation in the 2.4 and 5 GHz bands
- Bluetooth, ZigBee operation
- Integrated endpoints for automated throughput testing
- Convenient Ethernet/PoE power and control interfaces, filtered for isolation
- Built-in turntable for beam-forming and beam-steering measurements
The octoBox personal testbed comes in 3 standard configurations shown below. These configurations can be extended or augmented for testbeds ranging from a single DUT (device under test) to a large scale system of devices.

### Table 1: Tests supported in the sub-6 GHz and mmWave bands

<table>
<thead>
<tr>
<th></th>
<th>2.4 and 5 GHz Wi-Fi</th>
<th>700 MHz - 6 GHz LTE, BT, Nest</th>
<th>mmWave 24-86 GHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Throughput</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>MIMO OTA</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Roaming</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Handover among all the bands</td>
<td></td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Coexistence</td>
<td></td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Mesh</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>DFS</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interference</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capacity</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Band steering</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load balancing</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RX sensitivity</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Rate/MCS adaptation</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MIMO adaptation</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MU-MIMO</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capture/replay</td>
<td>√</td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Expert analysis</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beamforming/beamsteering</td>
<td>√</td>
<td></td>
<td>√</td>
</tr>
</tbody>
</table>
While the sub-6GHz radios can be coupled into the test network OTA (over the air) or via RF cables, the mmWave radios can only be coupled OTA since massive MIMO and beamforming technologies are difficult to connectorize at RF.

An important aspect of mmWave technologies is their ability to quickly and frequently handover among the gNBs or in the D2D (device to device) topologies. Mobile devices incorporating mmWave radios are also expected to have Wi-Fi and LTE radios and be able to handover among different radio networks or to operate different applications over multiple networks and bands simultaneously. The octoBox supports operation on multiple frequency bands simultaneously and motion emulation enabling handover among multiple bands. Test antennas and programmable attenuators for the bands of interest must be installed in the octoBox testbed.

In the figure below, you see the following test antennas: two 2-6 GHz antennas for coupling, for example, Wi-Fi, and a mmWave horn antenna for coupling mmWave signals. The total number of installed antennas can be 16 or higher.

The DUT is placed on a turntable to test its ability to focus the beam on the test antenna or to measure its beam shape while the beam is fixed in some non-adaptive test mode.

Depending on the connections to the test antennas, a variety of tests can be performed (see Table 1 above). For example, the mmWave test antenna could be connected to a spectrum analyzer for spectral shape and power measurements. Alternatively, the test antenna could be coupled via a programmable attenuator to a gNB or an RRH (remote radio head) device in an adjacent chamber to test the throughput vs. range performance of a UE to base station link.

The turntable can be factory-installed on the left side or in the center of the octoBox. When installed on the left as shown above, the distance between a typical small DUT and the test antenna is about 46 cm.
When the turntable is installed in the center, multiple mmWave antennas can surround the DUT to test, for example, how the beam steering works.

In the above figure, both the gNB and the UE could be rotated to simulate the motion of these devices. The beam is coupled via two sets of test antennas and the programmable attenuators interconnecting the test antennas in two isolated chambers. The path loss between the gNB and the UE can be varied under software control to simulate distance or motion.

If multiple RF paths are configured between the two chambers, then the beam can switch among these paths to test the beamsteering ability of the DUT. In the above figure, as we rotate the UE or the gNB, the beam of either DUT can be coupled to its partner DUT via two paths and the DUTs have to adapt to find the best path. A test can be easily configured whereby the path losses on these two paths are varied to validate and optimize the beamsteering behavior in a variety of motion and orientation scenarios.
REMOTE RADIO HEAD SUPPORT

To incorporate a remote radio head (RRH) into the octoBox testbed, you can use octoScope’s BOX-RRH that is optimized for handling high power and heat dissipation.

octoScope’s BOX-RRH features sturdy rails for sliding a heavy RRH device into the enclosure.

The rails attached to the DUT also include brackets that hold auxiliary fans for dissipating the heat.

To handle high power dissipated by the RRH DUTs (500 – 1000 Watts), octoScope offers a magnetic attachment to connect an off-the-shelf spot cooler (e.g. Tripp Lite SRCOOL12K) to cool the air pumped into the enclosure.
MMWAVE FREQUENCY BANDS

For the sub 40 GHz Ka band, the implementation of programmable attenuators is typically silicon-based (i.e. switched resistor topology or PIN-diodes).

Above 40 GHz, a waveguide-based implementation is required. The waveguides can be mechanical in nature with the variable, sometimes motorized, cavity size and relative position of resistive films. Waveguide attenuators may only work in the designated frequency band. For example, WR-15\(^1\) waveguide frequency range is typically 50 to 75 GHz. Lower frequencies can't propagate in the guide below cut off, which is based on electromagnetic physics. Operation above the highest frequency is not recommended because the waveguide develops multiple propagation modes.

BOX-MMW can be configured with the required antennas, attenuators, connectors and waveguides according to the frequency band of operation.

TEST AUTOMATION

octoScoope’s test automation software operates over all the radio bands with test traffic on the TCP/UDP/IP layer and includes:

- **octoBox software suite** based on the MERN stack (Node.js, mongo.DB and Angular browser based GUI)
  - Web server based controls
  - Remote controllable via any browser from multiple browser clients simultaneously
  - Database for test records and testbed components; can be cloud-based and shared by multiple testbeds
  - API for test automation with API control for every GUI element

- **The Pal and iGen instruments** are the brains of the octoBox testbed, performing traffic generation, adaptation testing, monitoring, interference generation and more.

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\(^1\) Rule of thumb is the number after WR is the inside width in 10's of mills, so WR-15 is 0.150" inside dimension.
**Roaming test** controlling the motion profiles in the octoBox testbed

**Throughput test** covering an extensive number of throughput test cases using octoScope’s multiPerf™ point to point, point to multipoint and multipoint to multipoint traffic generator, including RSSI reporting and noise generation test cases.

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**BOX-MMW and BOX-RRH PRELIMINARY SPECIFICATIONS**

The BOX-MMW and BOX-RRH dimensions and weight are:

<table>
<thead>
<tr>
<th></th>
<th>American</th>
<th>Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Outside</strong></td>
<td>24” H x 38.35” W x 31.2” D</td>
<td>61cm H x 97cm W x 79cm D</td>
</tr>
<tr>
<td><strong>Inside</strong></td>
<td>19.35” H x 31.5” W x 21.5” D</td>
<td>49cm H x 80cm W x 55cm D</td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>172 LBS</td>
<td>78 kg</td>
</tr>
</tbody>
</table>

The built-in turntable enables software controllable DUT rotation while you measure throughput, RX sensitivity and other parameters.

- RPM controllable from 0 to 6 RPM
- Precision angular resolution of 1°
- Flexible DUT mounting system
- Ethernet control interface
- Provided software automates measurements vs. orientation of the DUT

Rack-mountable stackable sections and retractable shelving help build compact and neatly interconnected testbeds with multiple instruments and partner devices.

Modules can be mounted on top, on the sides or on retractable shelves.
**ISOLATION IN THE SUB-6 GHz BAND**

All octoBox models support sophisticated data and power filters for maintaining complete isolation inside the testbed (verified under 6 GHz) and avoiding interference that couples onto copper cables, such as Ethernet, USB and power cables. Waveguides for fiber optic feeds are provided on all octoBox models.

![Image](image1.png)  
OBS-05-X2 Ethernet filter  
OBS-09 Eth+USB filter  
OBS-09 Eth+USB filter  
OBS-07 DC filter  
OBS-08 HDMI filter  
OBS-10 3.5 mm phono

**THE BENEFITS OF THE OCTOBOX PERSONAL TESTBED**

The octoBox® wireless personal testbed, incorporating the Pal and iGen instruments, offers three important benefits and enables you to:

- **Reduce test time from weeks to hours**
  - Complete isolation under 6 GHz and repeatable RF environment minimize time-consuming open-air testing. Test automation accelerates data collection and improves test coverage and product quality.

- **Demonstrate highest achievable performance**
  - Ideal MIMO environment for highest possible throughput. Supports latest technologies, such as mmWave, 160 MHz 802.11ac, 802.11ax, MU-MIMO, beamforming, and beyond.

- **Demonstrate handling real-world challenges**
  - Programmable range of condition from best MIMO environment to challenging real-life impairments

To learn more, view our instructional videos featuring the octoBox test configurations.

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