
# octoBox

## *Features and Benefits*

This document describes the octoBox over-the-air RF test station for testing wireless devices in production, QA and R&D. It includes the octoBox specifications and a discussion of wireless test metrics and methods.

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## Wireless test solution with stable over-the-air (OTA) transmission

OctoBox™ is a dual-chamber RF enclosure that houses isolated and well controlled over-the-air (OTA) test setup for production, QA and R&D test. OctoBox can also be used for conducted testing when test antennas are bypassed with coaxial cabling.

Incorporating test instrumentation, test antennas and an easily accessible chamber for the device under test (DUT), octoBox is a space-efficient self-contained test station.

The Master chamber at the top typically houses test equipment or a partner device transmitting to and receiving from the DUT. The DUT chamber houses the DUT and the test antennas.

To achieve repeatable OTA test results, octoBox was designed for ease of customization to ensure:

- √ Far-field coupling between the DUT antennas and the test antennas
- √ Uniform antenna field between the DUT antennas and the test antennas – no nearby nulls that can cause sharp amplitude gradients in the field

Typically, OTA measurements are performed in a large anechoic chamber, which is impractical for densely furnished production floors or engineering labs.

octoBox offers a unique approach to achieving measurement stability in a footprint that fits in each engineer's office.

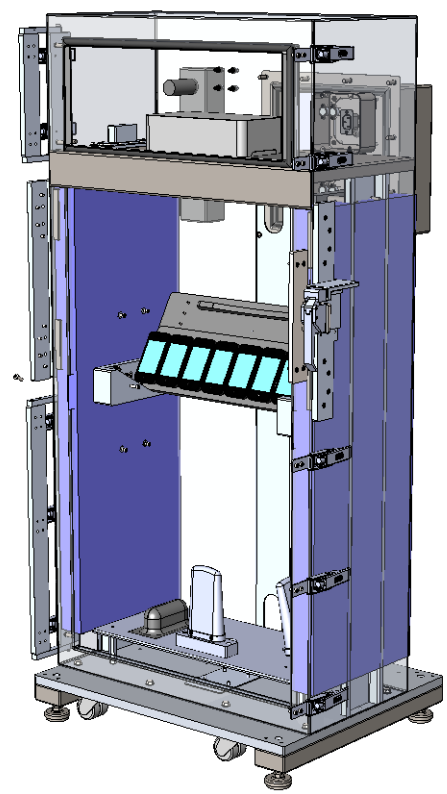

Figure 1: octoBox™

OctoBox is long enough in one dimension to allow for far-field conditions down to UHF frequencies. The next challenge is to avoid any nulls in the vicinity of the field between the DUT antennas and test antennas. The latter is achieved through a unique customization process developed by octoScope.

Customization involves:

- Careful analysis of the DUT antenna fields
- Adaptation of the DUT shelf and test antennas to the unique antenna pattern of each DUT

OctoBox is specifically designed for ease of such customization. The RF-transparent DUT shelf and the test antennas are customizable for a variety of DUT formfactors and operating requirements. MIMO DUTs are supported.

Another provision to control nulls in the OTA signals involves absorption, which is discussed below.

Isolated from the DUT and with controlled signal levels to the test antennas, test equipment in the Master chamber can reliably characterize radio performance of the DUT, including:

- TX EVM
- RX sensitivity
- RSSI
- Frame error rate
- Performance in the presence of interference
- Data rate or MCS (modulation coding scheme) adaptation
- Handoff behavior

*To achieve repeatable OTA test results in a small footprint, octoBox supports customization for far-field conditions and uniform fields between the DUT antennas and the test antennas.*

## Conducted vs. OTA testing

Wireless test methods include conducted and over-the-air (OTA) testing. Conducted tests are performed without the antennas via 50Ω coaxial cabling connected to the DUT antenna ports.

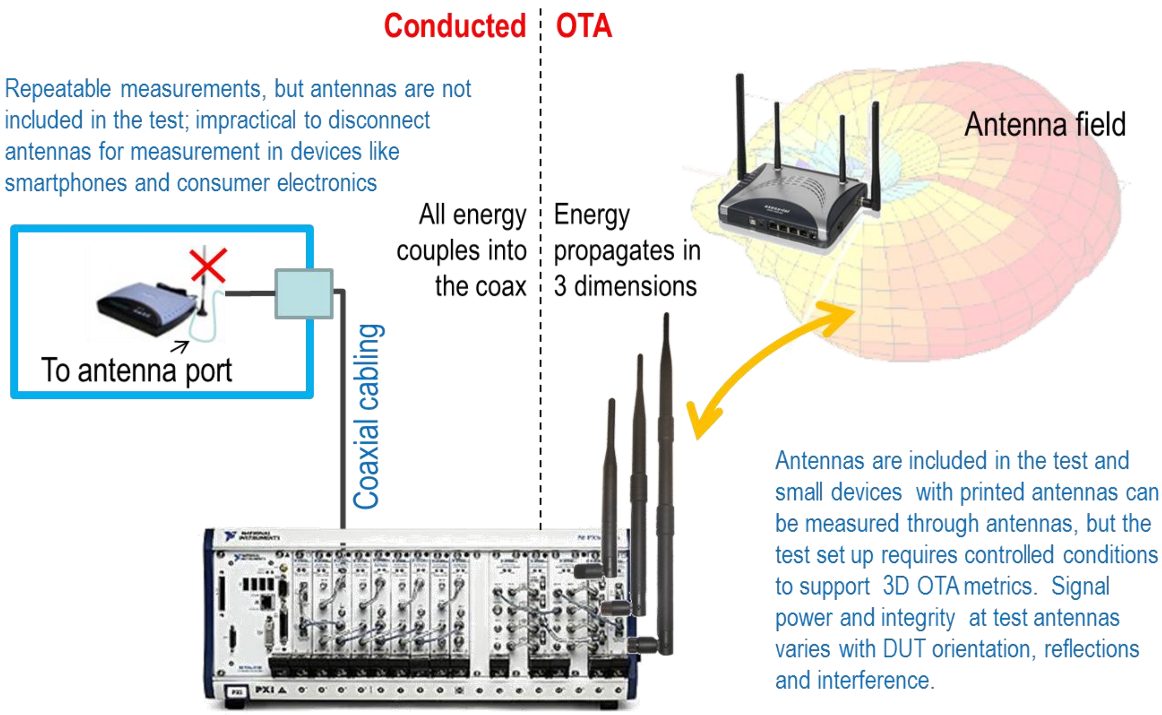


Figure 2: Conducted vs. OTA testing

Design and QA engineers often resort to conducted testing because the OTA test setup requires more work to achieve repeatable test results.

However, production testing is most expedient when done OTA on fully assembled units.

Conducted measurements include TX EVM (error vector magnitude), RX sensitivity, blocker testing, channel emulation and other tests. The same measurements can be performed OTA via the DUT antennas provided measurement repeatability can be ensured through stabilizing the OTA environment.

OTA testing is becoming increasingly important in R&D and QA with the emergence of smart antenna technologies such as MIMO and beamforming.

With its superior isolation and field stability, octoBox supports both OTA and conducted testing.

## RF isolation

Whether testing is OTA or conducted, RF isolation of the DUT from the Master and from the outside world is critical when measuring low signal levels.

Any coupling into the DUT chamber, either from the Master or from the outside, adds to the measurement as noise.

Isolation of the DUT from the Master and from the outside world has to be about 6 dB better than the signals being measured.

For example, Figure 3 shows the DUT's data rate adaptation behavior vs. RSSI all the way down to the RSSI level below -96 dBm, which demonstrates that noise coupling into the DUT chamber from the Master chamber and from the outside is extremely well-controlled and is likely below -100 dBm.

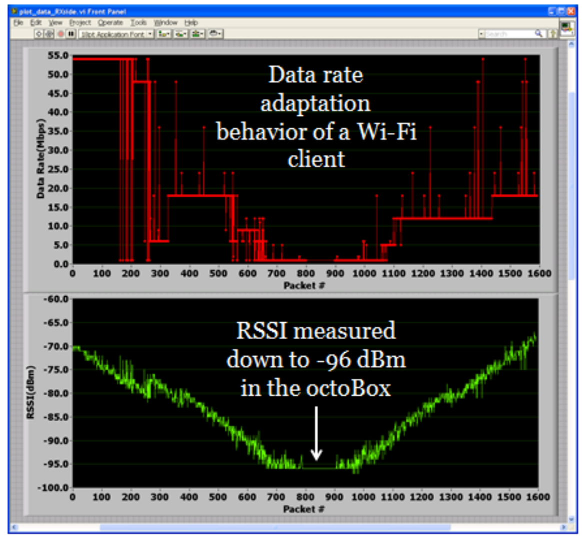


Figure 3: Example measurement: data rate adaptation vs. RSSI level

The DUT chamber must be isolated from both the Master chamber and from the outside world. The Master chamber also has to be isolated from the outside world to avoid coupling of external noise onto the test signals. The more isolation is achievable, the greater the dynamic range and accuracy of measurements.

*To keep the measurement error to a small fraction of a dB, any unintended leakage into the DUT chamber, either from the Master chamber or from the outside, should be about 6 dB lower than the lowest signal power being measured.*

## Design for optimum isolation

The octoBox is carefully designed for optimum isolation all the way up to 6 GHz. Isolation is a function of sealing the doors and seams of the box and filtering all the power and data lines entering the box.

Isolation is particularly difficult to achieve at higher frequencies in the GHz range because the shorter the wavelength of the radio transmission, the easier the signal propagates through seams in the box or over the copper cabling used to communicate with or power the test equipment and the DUT.

## Right angle seals

The octoBox design employs right angle seals on the doors for superior isolation at all frequencies of interest.

Gasketing, which seals the seams, tends to wear out with use.

The octoBox design makes it easy to change gasketing effortlessly at regular intervals. The gasketing is positioned in grooves with no glue for easy replacement.

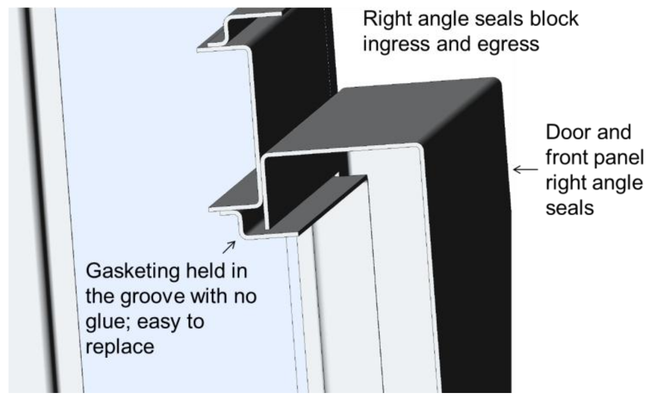


Figure 4: Right angle waveguide seals on the octoBox doors

## Filtering of power and data lines

Shielding, gasketing and sealing are not enough to get superior isolation. Just as important is filtering of copper lines (power, Ethernet, USB) since these can act as antennas bringing in noise from the outside.

All the filters (power, Ethernet, USB) are feed-through, which means they perform their filtering function as the signal traverses the metal wall of the enclosure.

Ethernet and USB filter design can be challenging because it must maintain the integrity of the high frequency data signals while attenuating the RF frequencies that interfere with the wireless test signals. Ethernet filter has the additional challenge of passing through the high-current PoE (Power over Ethernet).

*Isolation is a function of sealing the doors and seams of the chambers and filtering all the power and data lines entering the RF enclosure.*

## OctoBox isolation

With its careful design, incorporating shielding, right-angle seals, gasketing and feed-through power and data filtering, octoBox achieves superior isolation of:

- Better than 90 dB at 2.4 GHz
- Better than 80 dB at 6 GHz

The octoBox isolation is measured between the Master and DUT chambers and between the outside world and the Master and DUT chambers. It is measured with a fully cabled test setup, which demonstrates the effectiveness of feed-through filters.

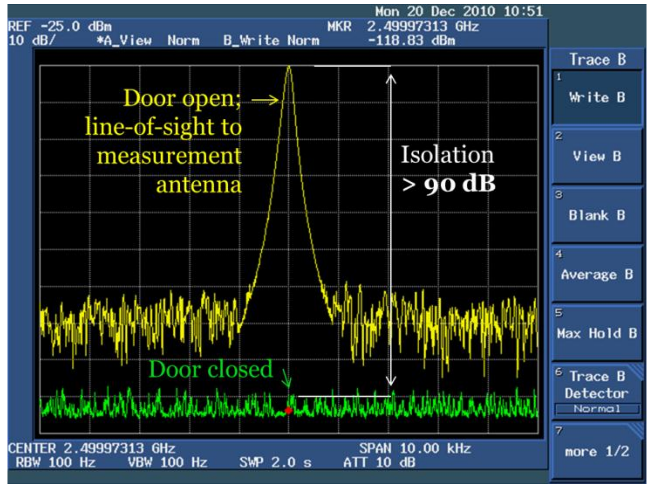


Figure 5: Measured isolation of the octoBox at 2.4 GHz

## OTA signal stability

Without proper absorption in a metal enclosure, signal levels can fluctuate as a result of reflections that add together creating standing waves. In-phase additions result in signal peaks. Out-of-phase additions result in nulls.

For controlled test conditions, it is necessary to create anechoic environment that ensures signal level stability.

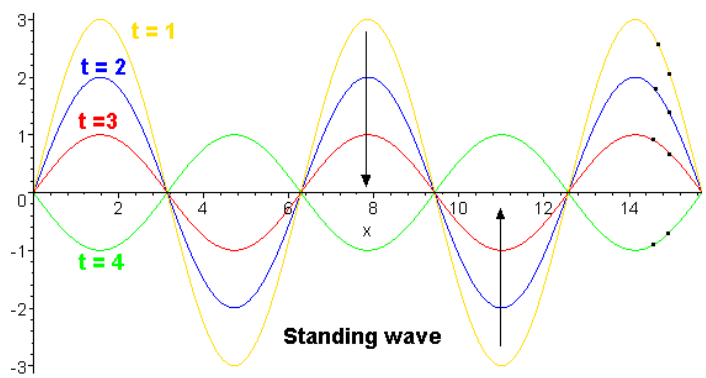


Figure 6: Standing waves create signal fluctuation vs. time

## Design for signal stability – absorptive walls

Signal reflections from the metal walls of the octoBox are absorbed by specialized absorptive foam. This eliminates standing waves and the nulls they cause in the signal, making the OTA signal in the box steady and measurements repeatable.

The job of the absorptive foam is to match the low impedance of the metal walls of the enclosure to the high impedance of air, thereby minimizing reflections due to impedance discontinuity.


Figure 7: Absorptive foam

To achieve proper absorption the foam needs several layers with monotonically increasing impedance – lowest towards the metal wall of the box; highest towards the air. The octoBox absorption with 2 ¼" foam is 20 dB at 2.4 GHz. This level of absorption guarantees reliable testing over the entire dynamic range of 802.11 devices.

The lower the frequency, the thicker the foam needed to provide a given level absorption. The octoBox Master and DUT chambers both allow room for up to 4" thick absorptive foam to stabilize OTA signal down to UHF frequencies.

## Design for stability – DUT orientation

Test equipment or a Master device in the top chamber of octoBox is cabled to the test antennas in the DUT chamber.

The position and orientation of the DUT shelf and of the test antennas are adjustable. For multiple-antenna DUTs, the test antennas can be arranged so as to point directly at the DUT antennas via a stable wave-front.

Reflections are absorbed by the absorptive material covering the walls of the box. Signal levels at each test antenna are controlled from the Master chamber where programmable attenuators or a multipath fading emulator can be integrated.

The customizable RF-transparent DUT shelf is machined out of soft plastic with guides for consistent positioning of the DUT to ensure repeatable propagation environment.

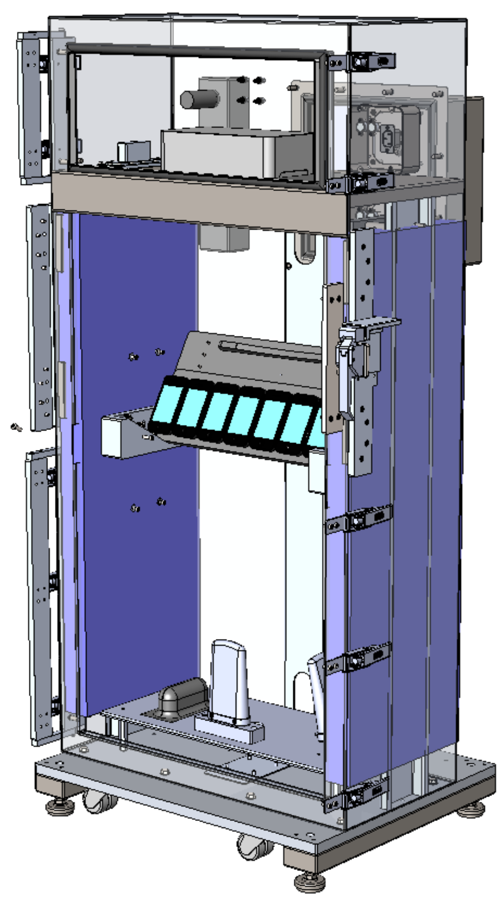

Figure 8: Internal structure of the octoBox

Extremely important for measurement accuracy and repeatability is to consider the 3-dimensional aspect of the antenna field. OTA measurements could be presented as follows:

- 3-dimensional plotoctobox two
- Integrated over a sphere
- Performed through a stable lobe in the antenna field (e.g. for fast production testing)

octoScope has developed a patent pending process of stabilizing the 3-dimensional measurements for fast and accurate production testing.

Please inquire about our octoBox consulting services that include customizing the DUT shelf for stability of measurements.

## Testing MIMO systems

When testing MIMO (multiple input multiple output) systems, it may be necessary to generate and receive multiple coherent signals via carefully arranged test antennas.

MIMO devices employ a variety of multiple antenna techniques, including:

- Spatial multiplexing, whereby multiple data streams are sent simultaneously
- Beamforming, whereby antenna fields are combined for waveform directionality
- TX diversity (e.g. STBC, CDD, SFBC, etc.)[1]
- RX diversity (e.g. MRC)[2]

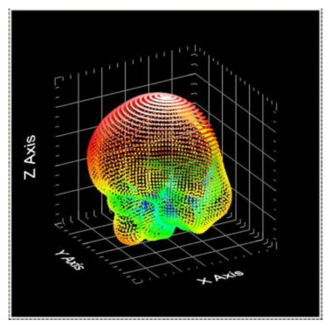


Figure 9: Example of a directed antenna field formed via beamforming techniques

Testing the behavior and performance of such multiple antenna techniques in the octoBox requires special consideration for the test instrumentation and antenna placement.

When setting up MIMO testing in the octoBox, it is important to understand the 3D nature of the antenna fields and position the test antennas appropriately. Specialized test set-up and equipment may be required. For example, to evaluate beamforming, several test antennas may be needed to sense the shape of the signal emanating from the DUT. For other MIMO modes, test antennas may need to be aimed at the specific DUT antennas.

The octoScope engineers are available for consultations on the intricacies of MIMO test setup. We can measure, plot and analyze antenna fields in 3D.

[1] CDD = cyclic delay diversity; SFBC = space frequency block coding; STBC = space time block coding
[2] MRC = maximal ratio combining

## Specifications

The octoBox mechanical, electrical and RF specifications can be found below

### Mechanical specifications

Tables 1, 2 and 3 present octoBox mechanical specifications.

Table 1: OctoBox Dimensions

| | |
|---|---|
| Height: | 59" |
| Width: | 22 ¼" |
| Depth: | 24" |
| Weight: | 270 LBS |
| Antenna to DUT: | ~21" |
| | Base counterweight for stability |
| | Casters for easy moving |
| | Adjustable leveling feet |
| | DUT door can be set up to hinge from left or right to optimize back-to-back placement of octoBox test stations in tight spaces. |

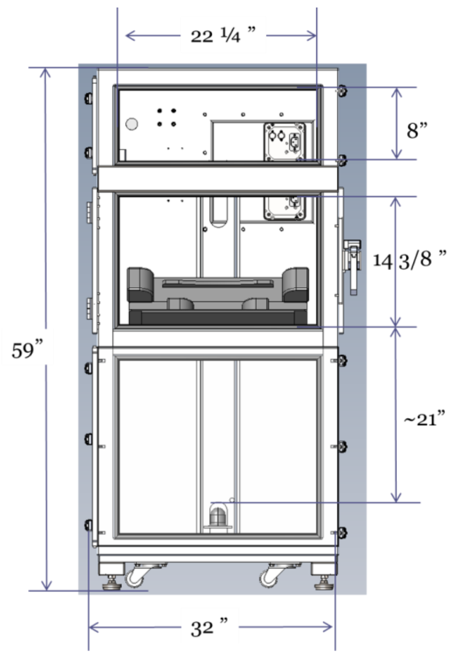


Figure 10: octoBox dimensions

Table 2: Master chamber interior dimensions

| | |
|---|---|
| Height: | 9" (with 2 ¼" foam on ceiling) |
| Width: | 22 ¼" (foam on left and right walls) |
| Depth: | Varies; 13" max |
| Door opening: | 8" x 22 ¼" |
| Filters: | Ethernet, AC power |
| RF ports: | 4 SMA to outside; 4 SMA to DUT chamber |
| Power: | 1 IEC AC power inlet |

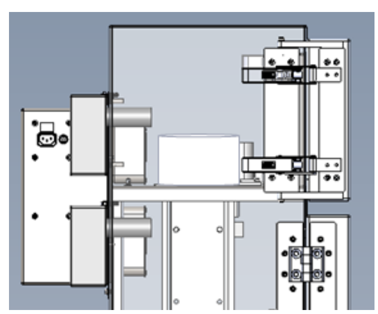

Figure 11: Master chamber

Table 3: DUT chamber interior dimensions

| | |
|---|---|
| Height: | 43" |
| Width: | 22 ¼" |
| Depth: | 11" max with 2 ¼" foam |
| Filters: | Ethernet, AC power |
| RF ports: | 4 SMA connectors feeding through to the Master chamber |
| DUT shelf: | Vertical position is adjustable in 6.7" intervals; held by 4 screws |

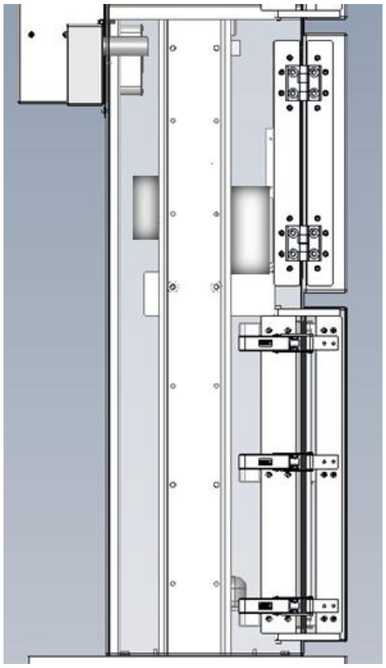

Figure 12: octoBox DUT chamber

## RF and electrical specifications

Table 4 summarizes RF and electrical specifications of octoBox.

Table 4: RF and electrical specifications

| | |
|---|---|
| RF isolation: | 90 dB at 2.4 GHz<br>80 dB at 6 GHz<br>Measured with a fully cabled test setup relative to line-of-site reference |
| AC power inlet: | IEC-60320 C14<br>120/240V 50/60 Hz<br>6A max (5x20 mm fuse) |
| Ethernet ports: | Support IEEE 802.3i (10Base-T), 802.3u (100Base-T), 802.3ab (1000Base-T), 802.3af (PoE) |
| Ethernet filter out-of-band rejection: | 100 dB |

## Ordering information

To order, please contact:

octoScope, Inc.
+1.978.222.3114
sales@octoscope.com

| Part # | Description |
|---|---|
| OB2010 | OctoBox dual isolation chamber, including test setup consultation |
| OB2010-LBA6 | 6-6000 MHz programmable attenuator with Linux USB driver for automated control |
| OB2010-Maint | OctoBox Maintenance Contract - 1 year (see below for details) |
| OB2010-Crate | OctoBox reusable shipping crate with ramp |
| | Consulting on test methodology, instrumentation and test automation software development |

### Maintenance

The annual maintenance for the octoBox includes the following:

- Replacement of worn-out gasketing
- Replacement of worn-out connectors
- Replacement of any other worn-out components that impact performance
- Verification of path losses on all cabled connections
- Maintenance report

Calibration of test signal levels specific to the test procedure can be added to the annual maintenance; to be quoted separately.


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