

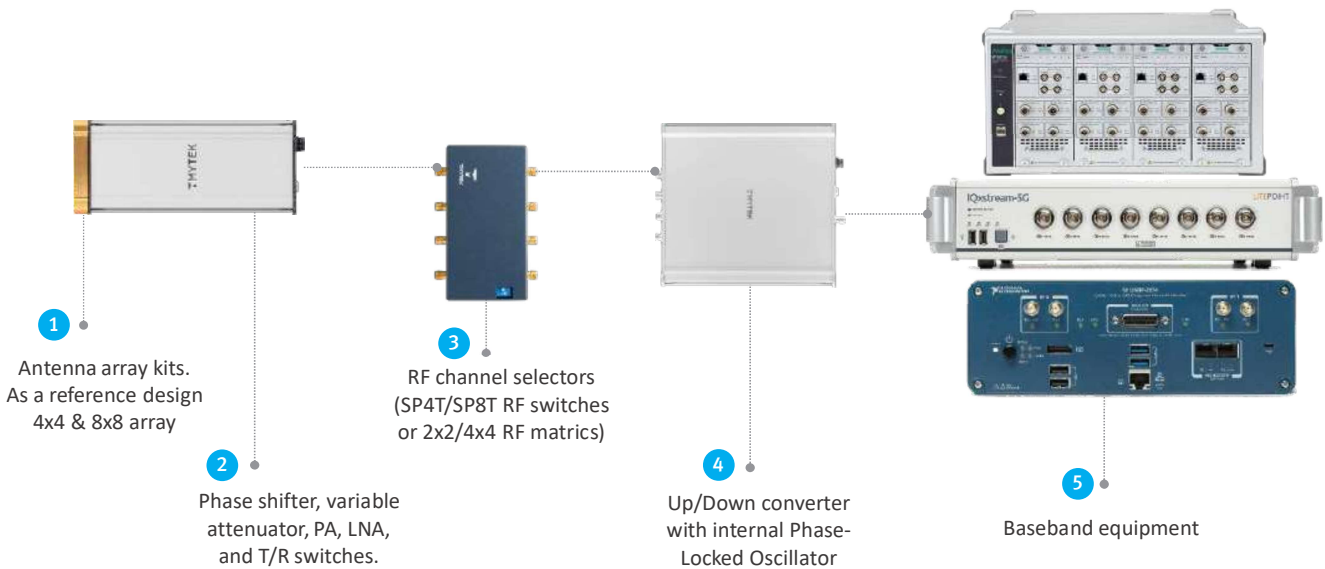
## 5G NR Products

### BBox™: Beamforming Development Kit

#### Introduction

Phase array is mandatory in 5G mmWave 28/39 GHz bands due to the small antenna gain. Analog beamforming turns out to be the most critical technique in R&D. The market is currently lack of a tool to control phase and amplitude. The creation of BBox by TMYTEK is to fill up this gap. TMYTEK's BBox consists of several building blocks as depicted below.

#### System Overview



#### 1 AA-Kits

AA-kits are our standard antenna kits offered to be used in conjunction with our  $\Phi$ A box. It is specifically designed for our  $\Phi$ A box for minimum path and phase loss. Our standard kits include up to 64 antenna elements kits.

#### 2 $\Phi$ A Box

The main part for phase and attenuation control covering the frequency range of 25 to 31 GHz (the 39 GHz band BBox will be available in 2020 Q1). It is compactly designed with the options to choose from 4 channels (BBox Lite) and 16 channels (BBox One). It is controlled by high-speed control interface and works perfectly with our AA-Kits.

#### 3 BB-Switch /Matrix

BB-Switch is the RF channel selector for use when several  $\Phi$ A Boxes are used together. TMYTEK offers up to four  $\Phi$ A Boxes to be used synchronously. This box have internal SP4T or SP8T RF switches for up to 50 GHz. BB-Matrix works similar to BB-Switch except it offers the matrix function for customers who wishes to do MIMO transmission.

**4 UD Box**

Conversion to / from 28 GHz band (39 GHz is also covered in our UD Box) with a built-in local oscillator (LO). Our UD Box covers a very broad range of frequencies including all of the possible 5G NR bands (24/26/28/39 GHz):

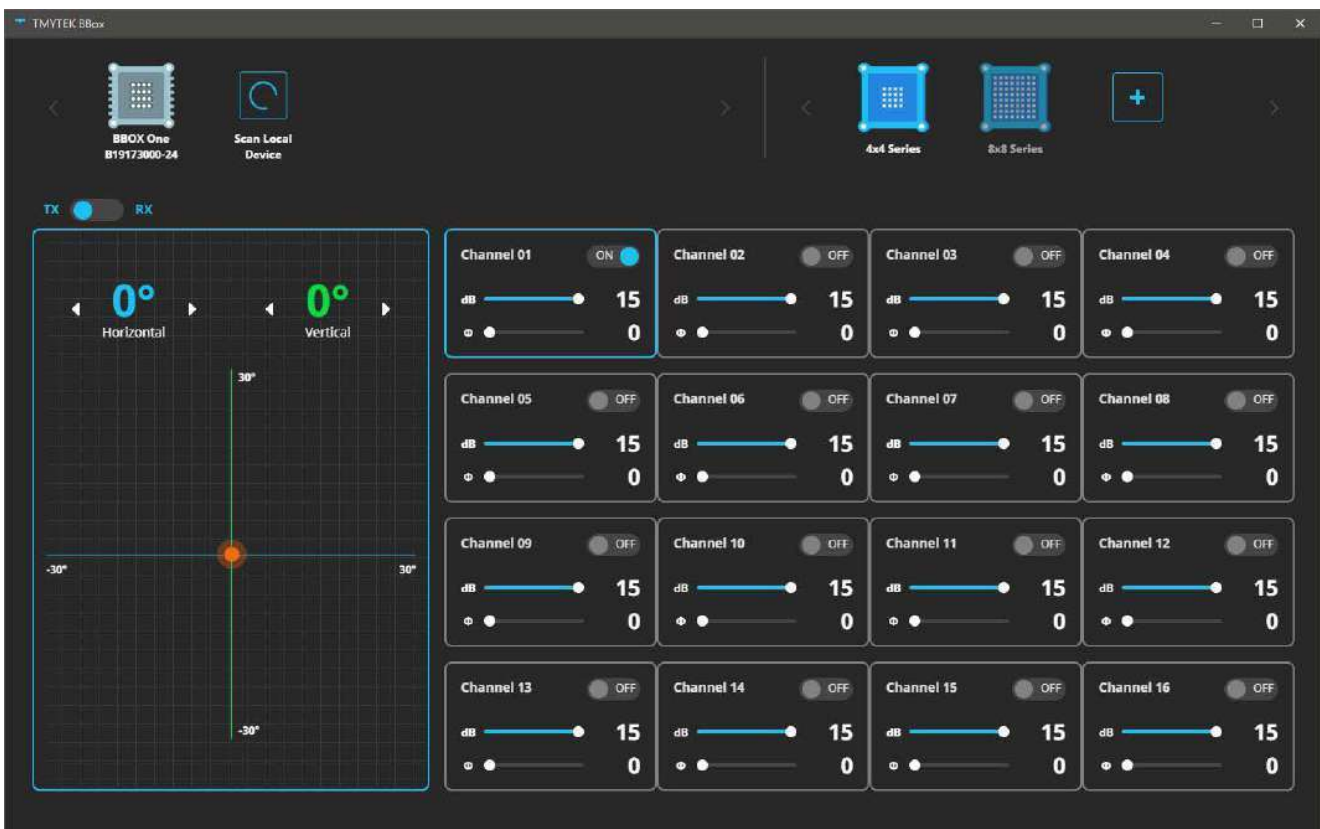
- RF band : 24 to 44 GHz
- IF band: 0.01 to 14 GHz
- Adjustable LO band: 16 to 32 GHz
- Single or Dual channels

**5 Baseband equipment**

Our BBox has been tested with various baseband instruments on the market. Major analyzers work well with our setups. This proves the usability of BBox system and enables a wide range of research topics that can be done, including protocol algorithm, beam tracking algorithm and more.

**6 Software GUI/API**

At TMYTEK, we customize our own software control for our BBox product line. The BBox can be controlled either by software user interface (UI) or Application Programming Interface (API) which are both developed in house by our software team. The software UI is easy to understand and allows users to get a quick start on beamforming while the API is for advanced users who are ready to run their own beamforming sequences. The software control can run on either mini USB or RJ45 Ethernet interface.



**6** Software GUI of BBox™ One

**BBox One vs BBox Lite**

TMYTEK has created two versions of BBox: BBox™ One and BBox™ Lite. BBox One is a 16-channel phase array integrated with AA-kit,  $\Phi$ A Box, and software control aimed to emulate base station beamforming performance. BBox Lite is a 4-channel phase array integrated with AA-kit,  $\Phi$ A Box, and software control aimed to emulate UE beamforming performance. More details are being compared below.

|                              | BBox™ One        | BBox™ Lite               |
|------------------------------|------------------|--------------------------|
| No. of Controllable Channels | 16               | 4                        |
| AA-Kit (detachable)          | 4x4 or 8x8 array | Series Patch             |
| Beamsteering Dimension       | 2D               | 1D                       |
| Target Emulation             | Small Cell       | UE (smart phone, tablet) |
| Software Control             | UI or API        | UI or API                |
| Control Interface            | RJ45 or mini USB | RJ45 or mini USB         |
| Size (with AA-kit)           | 156 x 62 x 62 mm | 125 x 102 x 110 mm       |



BBox™ One



BBox™ Lite

## BBox™ and UD Box Specification

### Standard Products

#### BBox Module

| Part Number      | RF (GHz) | Tx EIRP (dBm) | Transmitter Max. Gain (dB) | Receiver Max. Gain (dB) | Phase Shifter Range (°) | Attenuator Range (dB) | Package (mm)    |
|------------------|----------|---------------|----------------------------|-------------------------|-------------------------|-----------------------|-----------------|
| BB-LITE-JF-28-04 | 25-31    | 29            | 46                         | 31                      | 360                     | 20                    | 125 x 102 x 110 |
| BB-ONE-JF-28-4x4 | 25-31    | 36            | 44                         | 34                      | 360                     | 20                    | 156 x 62 x 62   |
| BB-ONE-JF-28-8x8 | 25-31    | 41            | 49                         | 39                      | 360                     | 20                    | 156 x 62 x 62   |

#### AA-Kits

| Part Number       | Antenna Type | NR Frequency Band | 3 dB Bandwidth (GHz) | Antenna Array Gain (dB) | Broadside Beamwidth (°) | Beam Steering Range | Package (mm)  |
|-------------------|--------------|-------------------|----------------------|-------------------------|-------------------------|---------------------|---------------|
| BB-LITE-ANT-28-04 | Series Patch | n261              | 27.5 - 28.35         | 15.0                    | ±11.0                   | ±45                 | 84 x 67 x 8.7 |
| BB-ONE-ANT-28-4x4 | 4x4 Patch    | n261              | 27.5 - 28.35         | 17.0                    | ±13.0                   | ±60(V)/±45(H)       | 62 x 62 x 12  |
| BB-ONE-ANT-28-8x8 | 8x8 Patch    | n261              | 27.5 - 28.35         | 22.0                    | ±6.5                    | ±25(V)/±25(H)       | 62 x 62 x 12  |

#### BB-Switch

| Part Number     | Switch Type | RF (GHz)  | Insertion Loss (dB) | Isolation (dB) | IIP3 (dBm) | Package |
|-----------------|-------------|-----------|---------------------|----------------|------------|---------|
| BB-SW-SP4T-0050 | SP4T        | 0.05 - 50 | 0.7                 | 41             | 40         | TBD     |

#### UD Box

| Part Number            | RF (GHz) | LO (GHz) | IF (GHz)  | Conversion Loss (dB) | Supply Voltage (V) | No. of Channels | Package        |
|------------------------|----------|----------|-----------|----------------------|--------------------|-----------------|----------------|
| BB-UDC-2444-0014-(S/D) | 24 - 44  | 16 - 32  | 0.01 - 14 | 10                   | 15                 | Single or Dual  | 139 x 152 x 77 |

### Customization Requirement

If you require any customized BBox™, please contact us for more details. We also offer 39 GHz and sub-6 GHz solutions.