

# 5G

TMYTEK BBox 5G with UD Box 5G

## Extend Sub-6 GHz Equipment to mmWave Beamforming & Massive MIMO



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## OVERVIEW



**THIS APPLICATION NOTE** describes the integration of TMYTEK BBox 5G (beamformer) with UD Box 5G (up/down converter), which will demonstrate the ability, to conveniently extend existing sub-6GHz equipment to 5G beamforming and massive MIMO.

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# Extend Sub-6 GHz Equipment to mmWave Beamforming and Massive MIMO

## Overview

In the process of expanding 5G communications into the mmWave frequency bands, two important questions arise;

- How do we overcome the high attenuation characteristic of mmWave?
- How does this solution integrate with massive Multiple-Input-Multiple-Output (MIMO) to the operation of base stations?

Beamforming is the key technology for

mmWave communications. It increases transmission distance and reduces the interference between different RF channels. With the design of 5G NR networks, massive MIMO has become critical to 5G NR deployment. mmWave massive MIMO systems combine large number of antennas, complex algorithms, and beam steering controls, thereby, improving user's experience in 5G.



## UD Box 5G - Key Features

- Operating frequency: 26.5 to 29.5 GHz, 37 to 40 GHz
- Antenna designed for 5G n257 band
- Up to 16 controllable RF channels, each channel providing:
  - 360° phase shifter coverage with 5° per step
  - 15 dB attenuation range with 0.5 dB per step
- T/R half duplex operation
- Software control via RJ-45 Ethernet or SPI interface

## Solution Highlights

- Extend sub-6 GHz instruments to 5G beamforming, phased array, and massive MIMO
- Beam-steerable, ready-to-use, detachable mmWave antenna for 5G NR application
- Integrated software/hardware along with easy-to-access programming

# Extend Sub-6 GHz Equipment to mmWave Beamforming and Massive MIMO

## Overview

Antenna designers, 5G algorithm developers and baseband/system communication researchers are constantly looking for better solutions to extend existing sub-6 GHz equipment to 5G mmWave. As 5G communications expand into higher frequencies, the attenuation and signal loss become more prominent. So, expanding 5G communications to mmWave has some hurdles, e.g., how to overcome the high attenuation at these frequencies? Would this solution integrate with massive MIMO technology to the operation of base stations?

### Beamforming

Due to the high attenuation characteristic

of mmWave, beamforming becomes the key to 5G mmWave communications - increases transmission range, reduces RF channel noise, increases gain, and directivity. Yet, it still needs improvement when deploying onto 5G communication.

### Massive MIMO

mmWave massive MIMO systems need to combine a lot of these beamforming antennas to significantly improve transmission capacity and reduce interference to neighboring users. They combine complex algorithms and beam steering controls such that, the radio signals are concentrated to form a narrower beam for specific users.

## Extend Sub-6 GHz Equipment to mmWave

The integration of TMYTEK beamformer (BBox 5G) and up/down-converter (UD Box 5G) solution is useful for:

- mmWave beamforming, 5G antenna array design and phased array
- multiple-input and multiple-output

(MIMO) technology research and development

TMYTEK BBox 5G integrated with UD Box 5G extends sub-6 GHz equipment to 5G mmWave as shown in Fig. 1.

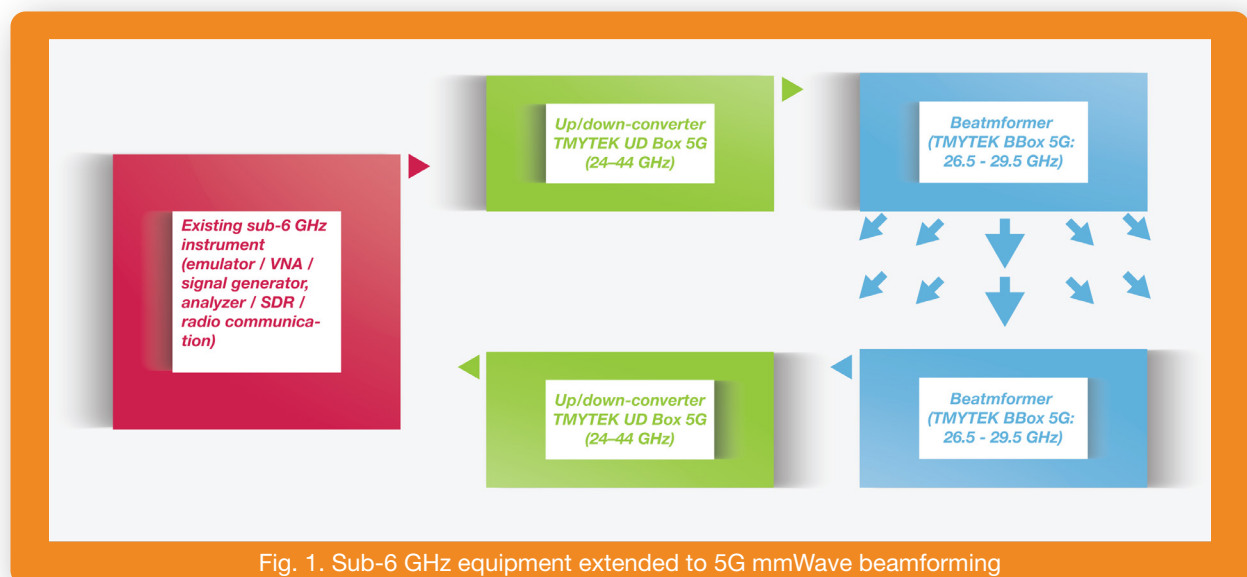


Fig. 1. Sub-6 GHz equipment extended to 5G mmWave beamforming

# Extend Sub-6 GHz Equipment to mmWave Beamforming and Massive MIMO

## TMYTEK Beamformer - BBox 5G

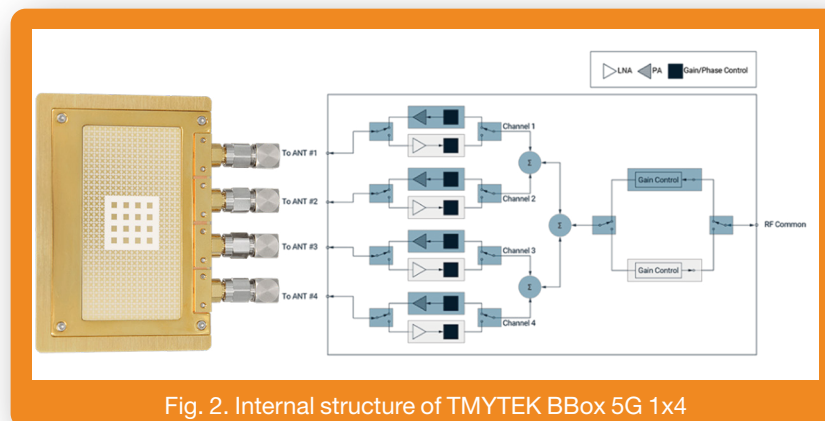
BBox 5G is mmWave NR beamforming development tool that focuses on 5G antenna array design and mmWave application development.

### BBox 5G - Key Features

- mmWave analog beamformer: it has transmit/receive (T/R) switch, power amplifier, LNA, phase shifters along with TMYTEK's standard antenna for 5G beam steering
- detachable array antenna kit (AA kit): antenna is easily detachable and replaceable
- integration of software/hardware: in-house software interface offers both GUI/API control - better accuracy and easier control on the beam angles for 5G R&D
- highly compatible beamforming solution: integrable/compatible with 5G NR beamforming Over-The-Air (OTA) communication, fast mmWave scanning channel sounding system, and mmWave radar applications

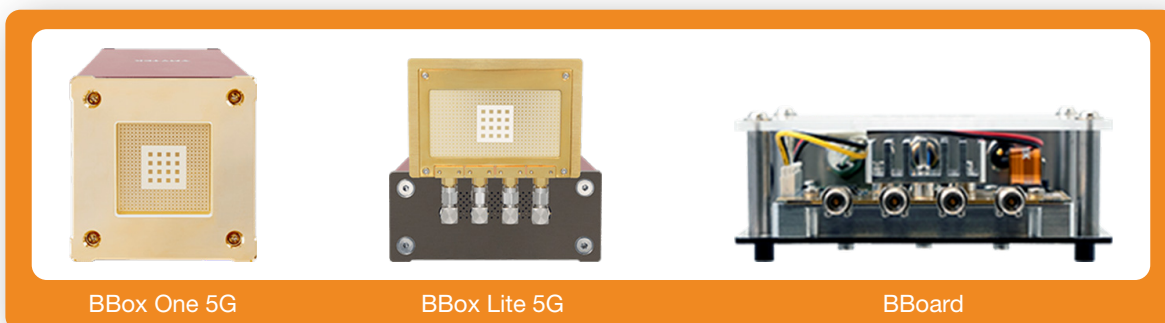
## Internal Structure

The BBox 5G 1x4 series has the internal structure shown in Fig. 2.



## Beamformer Series

There are 3 types of beamforming devices available - BBox One 5G (4x4 RF channels), BBox Lite 5G (1x4 RF channels) and BBoard (5G/B5G beamforming educational kit).



# Extend Sub-6 GHz Equipment to mmWave Beamforming and Massive MIMO

## Beamformer Series Key Features

Type	BBox One 5G		BBox Lite 5G		BBoard	
Frequency	28 GHz (26.5 - 29.5 GHz)	39 GHz (37 - 40 GHz)	28 GHz (26.5 - 29.5 GHz)	39 GHz (37 - 40 GHz)	28 GHz (26.5 - 29.5 GHz)	39 GHz (37 - 40 GHz)
RF Channels	4x4		1x4		1x4	
Phi-A Tx/Rx gain	8-12/0-4 dB	1-5/-1-3 dB	16/12 dB	15/10 dB	15/11 dB	14/9 dB
Phi-A Phase Shifting Range	360 deg	360 deg	360 deg	360 deg	360 deg	360 deg
System Tx/Rx Range	36/28 dB	29/25 dB	34/30 dB	31/26 dB	—	—
Beam Steering Range (Ver.)	±45 deg	±40 deg	Fixed	Fixed	—	—
Beam Steering Range (Hor.)	±45 deg	±40 deg	±45 deg	±45 deg	—	—
Dimensions (mm)	153.8 x 80 x 80		117.4 x 100 x 99.2		105.6 x 98 x 37	

## TMYTEK Up/Down Converter - UD Box 5G

TMYTEK UD Box 5G is an ultra-broadband 5G NR mmWave frequency converter that covers up to 44 GHz. It is an up/down converter with an integrated mixer, internal LO as well as optional IF and RF filters that are explicitly made for 5G and satellite communications.

### UD BOX 5G Key Specs

Number of RF Channels	1/2
RF Frequency	24 - 44 GHz
IF Frequency	0.01 - 14 GHz
LO Frequency	24 - 44 GHz
LO Frequency Resolution	0.01 MHz
Build-in LO	Yes
Size (mm)	143 x 152 x 65
Power	24 W

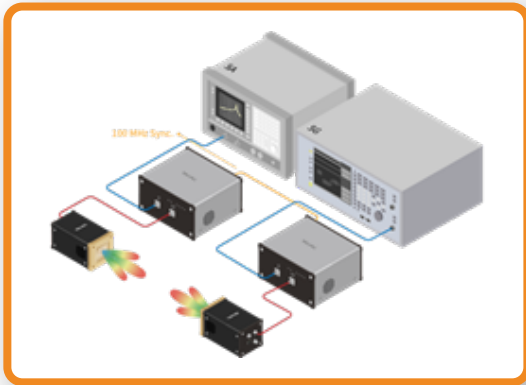
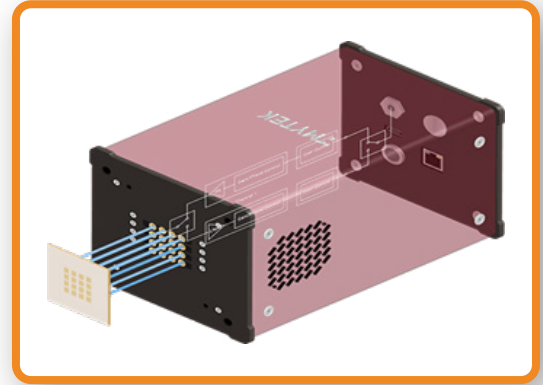


# Extend Sub-6 GHz Equipment to mmWave Beamforming and Massive MIMO

## Beamforming Use cases

### 5G mmWave Antenna Design

BBox 5G has 2 separable components – AAKit and PhiA box. Antenna designers can detach and replace the AAKit with their own antenna array designs.

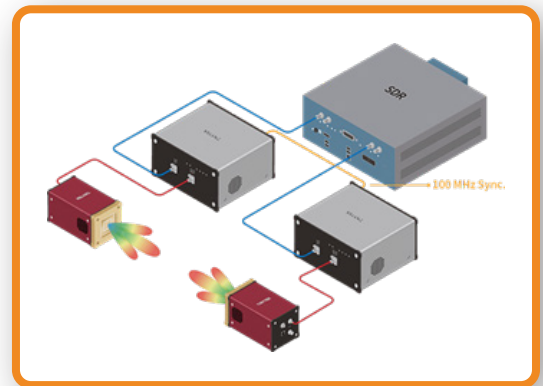


### 5G mmWave Far-field Measurements

Extend sub-6 GHz equipment to mmWave far-field measurements by using multiple UD Boxes and BBoxes.

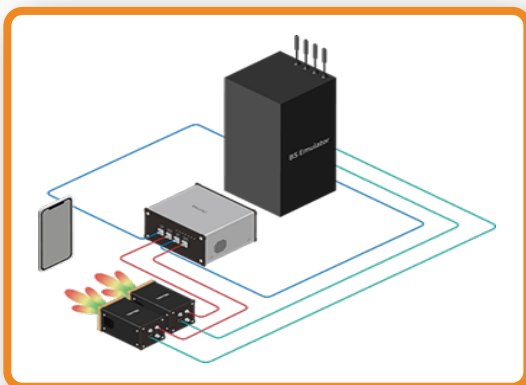
### 5G mmWave Solution for Algorithm Developers

BBox allows 5G protocol developers and engineers to precisely control the gain and phase, making it ideal for the research and development of beamforming algorithms and protocols.



### 5G mmWave System/Communication Development Tool

Baseband developers can implement advanced algorithms for beam tracking, beam control by radiating controllable beam patterns.



# Extend Sub-6 GHz Equipment to mmWave Beamforming and Massive MIMO

## Massive MIMO Use cases

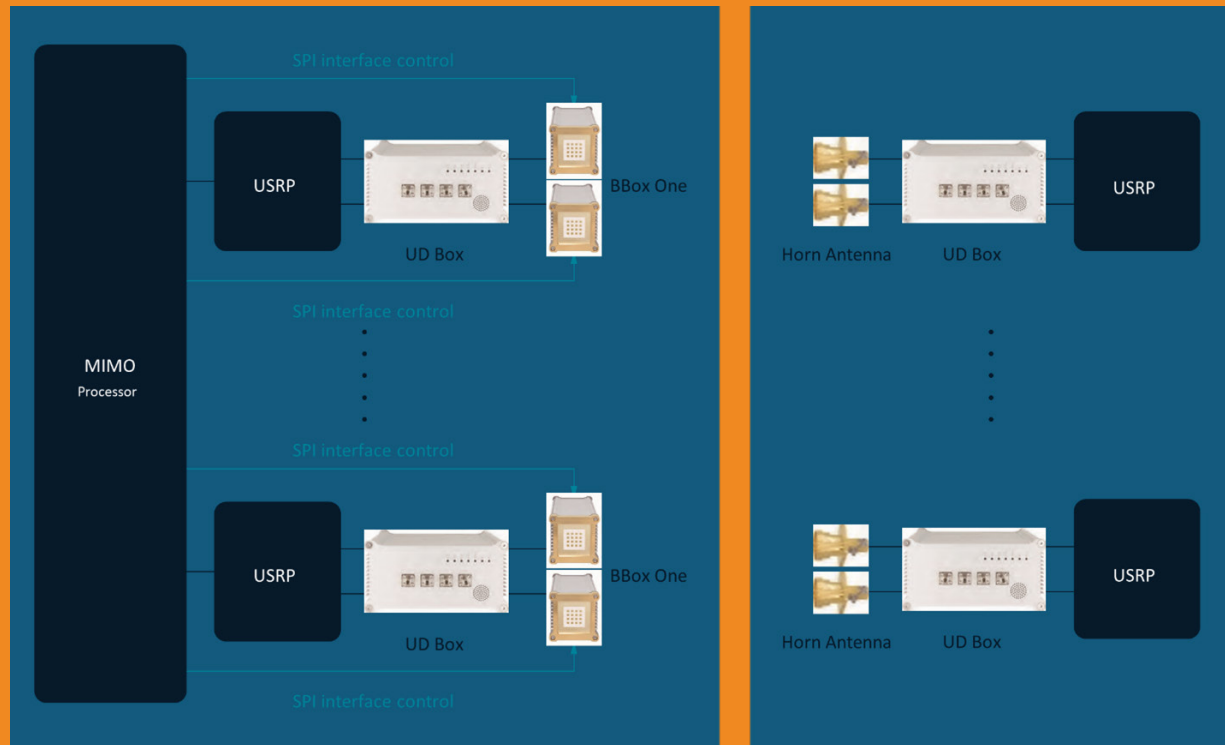


Fig. 3. TMYTEK mmWave Massive MIMO total solution (a) base station (b) user equipment

## Extend Sub-6 GHz Equipment to mmWave

As shown in Figure 3., the mmWave massive MIMO solution package is provided by TMYTEK and National Instrument (NI) in cooperation. This system consists of 4 parts: beamformer, up/down converter, RF transceiver, and MIMO processor. This system currently supports up to 128 channels at the base station and can support

12 users at the same time. It is also capable of doing fast three-dimensional beamforming control. BBox One has 16 independent RF channels. By controlling the phase and the amplitude of each channel, it can achieve up to 90 degrees of beam control range in both horizontal and vertical directions.



# Extend Your T&M to mmWave Bands

## Summary

This mmWave massive MIMO solution, proves to be very helpful in research and system development. This solution can be used in a wide range of research fields, including algorithm research, millimeterwave field data collection and verification, RU system development etc. to further enhance and strengthen the communication world.

The accumulation of knowhow and the application of massive MIMO and beamforming are probably the most important technologies to enable 5G / B5G mmWave communication system.

## References

Related documents:

- Refer to [5G BBox | 5G Beamforming Development Tool](#) for antenna & protocol designers | TMYTEK for TMYTEK BBox 5G features, versions, and specifications
- Refer to [UD Box 5G | Up/down converter, frequency converter | Up to 44 GHz](#)
- [TMYTEK](#) for TMYTEK UD Box 5G features, capabilities, and more details
- Refer to [mmWave Beamforming and Massive MIMO \(tmytek.com\)](#) for TMYTEK massive MIMO solution

# Extend Sub-6 GHz Equipment to mmWave Beamforming & Massive MIMO

TMYTEK BBox 5G with UD Box 5G



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