Keysight Technologies

Millimeter Wave Technology and Test Instrumentation for V-E Band Applications

Application Brief

KEYSIGHT TECHNOLOGIES

Situation analysis

As users increasingly access the internet from mobile devices and use high-bandwidth services like high-definition video streaming, high-quality video conferencing, audio video downloads, and gaming, the demand for faster wireless broadband connections is growing. These applications have raised end-user expectations for network performance, which has contributed to the evolution of LTE networks and heightened the need to enlarge the capacity for backhauling data from base stations to the core network of carriers.

To increase the data throughput capacity, high data rate (> 1 Gb/s) communication links are necessary. One emerging solution is to use wireless backhaul in the E-band. There is 10 GHz of bandwidth available in E-Band: 71 to 76 GHz and 81 to 86 GHz. There are other application fields available around the unlicensed 60 GHz band, such as WiGig (WiFi), and the planned 57 to 64 GHz band for short distance backhaul for the impending small cell telecommunication network.

The latest semiconductor materials and new technologies have produced new transceivers that have made it feasible to better leverage these bandwidths. For example, Infineon's B7HF200 SiGeC bipolar technology with a transceiver family covering 57 to 64 GHz (BGT60), 71 to 76 GHz (BGT70), and 81 to 86 GHz (BGT80) bands. Figure 1 shows a schematic of how the Infineon BGT70 and BGT80 transceivers can be used in mobile communication backhaul applications.

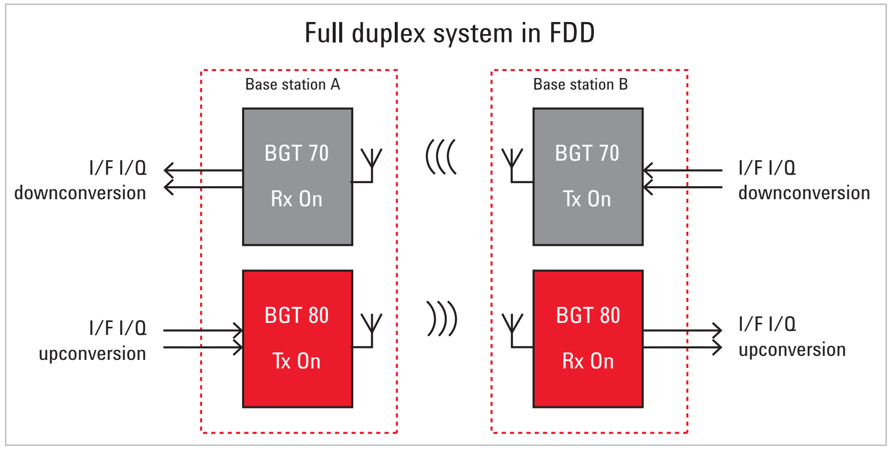

Figure 1: Typical application scenario in Mobile Backhauling using mmWave point-to-point link (can also be a TDD system).

These advances in mmWave technology are triggering a trend of shifting from using traditional backhaul such as optical and microwave links, to mmWave point-to-point links, which have the added benefits of providing network operators with price and performance advantages over the long term.

A block diagram of the BGT80 is illustrated in Figure 2. To evaluate the quality of the three main parts of these communication links (the transmitter, signal path, and receiver), mmWave devices like the BGT80 must be tested using the proper test and measurement instruments.

This paper shows how using the Keysight Technologies, Inc. M8190A wideband arbitrary waveform generator and high-performance Infiniium Series oscilloscopes with the 86901B vector signal analysis software provides the necessary signal generation, signal path emulation, and analyzer capabilities.

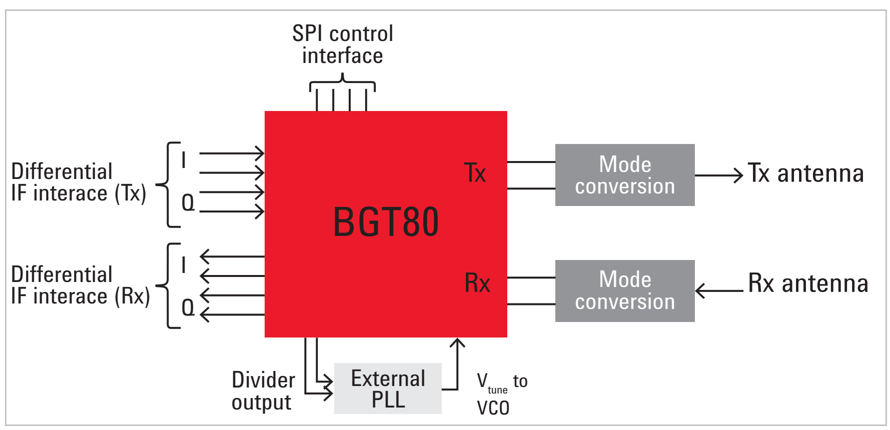

Figure 2: Block Diagram of Infineon's BGT80 (81-86GHz) Transceiver chipset

BGT80 evaluation board

BGT80 is a highly integrated (eWLB) E-Band transceiver chip with excellent phase noise performance. It has an integrated temperature sensor, power detectors, and an easy-to-use serial peripheral interface (SPI) interface for power control, mode switching (Tx or Rx), and calibration. The integrated power detectors enable power control in a feedback loop, as well as LO rejection and image calibration. Infineon's BGT80e evaluation board, as shown in Figure 3, provides all the interfaces needed to make quick link testing and has an on-board phase-locked loop (PLL). Table 1 highlights the performance specifications of these Infineon devices at the chip level.

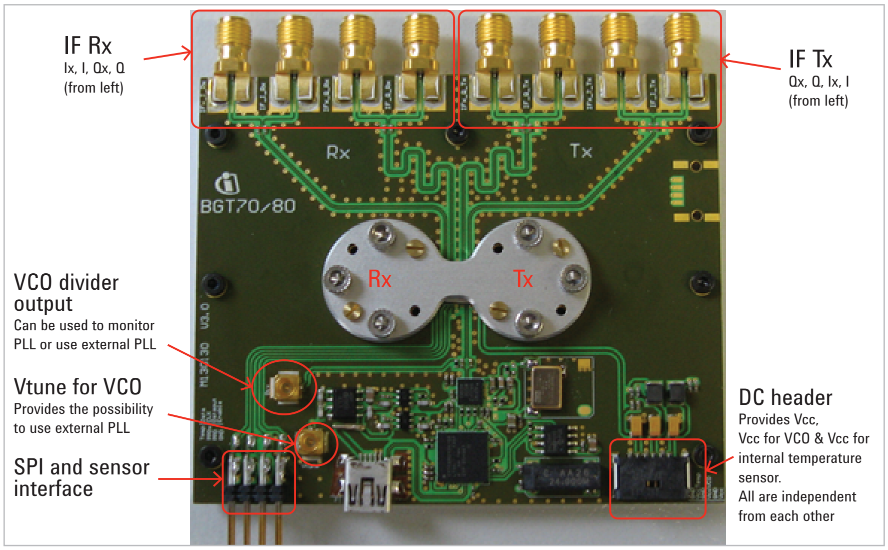

Figure 3: BGT80 Evaluation board used in link testing.

BGT80 (81-86GHz) transmitter specification		
Saturated output power	12	dBM
Phase noise @ 100kHz/1MHz offset	<-80/-100	dBc/Hz
Output IP3	20	dBm
Noise floor at Tx output	-130	dBm/Hz
Power consumption in Tx mode	1.5	W
BGT80 (81-86GHz) receiver specification		
Conversion gain	20	dB
Input 1dB compression point	-15	dBm
Noise figure DSB	9	dB
Power consumption in Rx mode	1.1	W

Table 1: Infineon BGT80 Transceiver Performance Specifications.

Test requirements and solution proposals

Using the BGT80 evaluation board, along with the Keysight M8190A AWG and Infiniium oscilloscope, the evaluation of BGT70/BGT80 transceivers is easy.

Testing a transceiver device requires a simulated transmitter and/or a simulated receiver. Ideally both should be flexible enough to generate real world distortions on the source side and compensate for them on the sink side. With the Keysight M8190A high performance arbitrary waveform generator working at 12 bit and 12 GSa/s or at 14 bit and 8 GSa/s, users have the ability to create these types of waveforms to use as a test source.

On the analyzer side, Keysight offers a broad portfolio of Infiniium series oscilloscopes which support up to 63 GHz of real time frequency bandwidth.

The test solution also includes software consisting of MATLAB® support for the signal creation and the 89601B vector signal analysis software for signal analysis. Figure 4 illustrates this comprehensive setup.

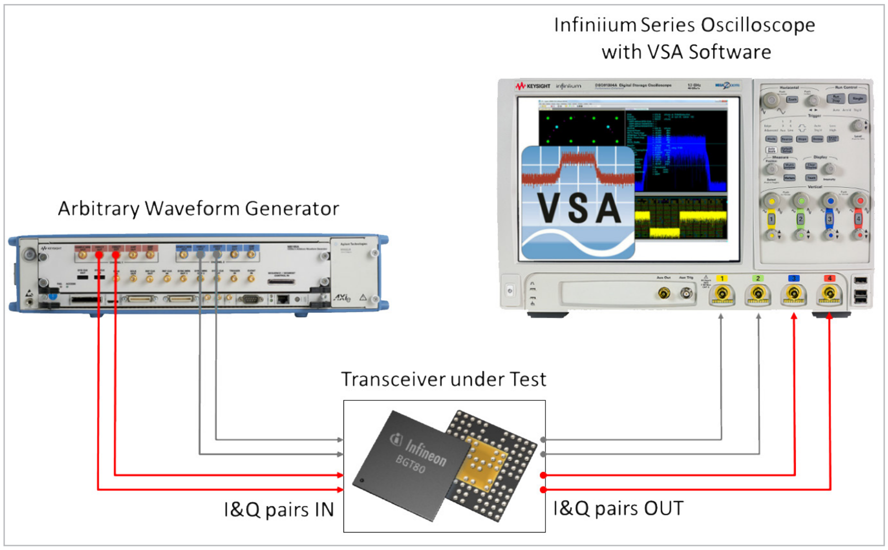

Figure 4: Basic Test and Measurement Setup for Transceiver Test.

Measurements

When measuring transceivers, it is prudent to start off with a simple modulation scheme such as QPSK and advance step-by-step to higher orders like QAM64. The reason for this approach is that it allows the operator to find the transceiver's sweet spot where it will achieve the best performance results.

This sweet spot requires tuning in amplitude/phase mismatch, carrier feed-through, side band suppression, and inter-modulation performance. The LO leakage and sideband leakage are direct results of amplitude and phase imbalances. LO leakage can be caused by DC offset in the I and Q signal paths, or by incorrect bias points of the modulator. LO leakage can be reduced by optimizing the bias voltages of the IQ modulator. Intermodulation distortions come from amplifier non-linearities. In other words, the input signal has too high of a voltage swing, causing the amplifier to leave the linear operation range of its transfer function. This can be improved by regulating the input voltage of the signal.

With the differential outputs of the Infineon BGT80 transceiver, testing the device requires an instrument that is able to receive differential signals and convert them to single-ended measurements. In this test solution a four-channel, high performance oscilloscope is used for this purpose. Internally the software calculates the difference between the I and $\overline{I}$ signals creating a logical first channel, or the I-channel. This is also done for the Q and $\overline{Q}$ signals on the other two oscilloscope channels, creating the logical second channel, or the Q-channel.

Figure 5 shows a signal generated by an AWG, up-converted by the Infineon BGT80, transmitted over the air in an 86 GHz link, down-converted by the same type of transceiver chip, and analyzed by an oscilloscope using vector signal analyzer software.

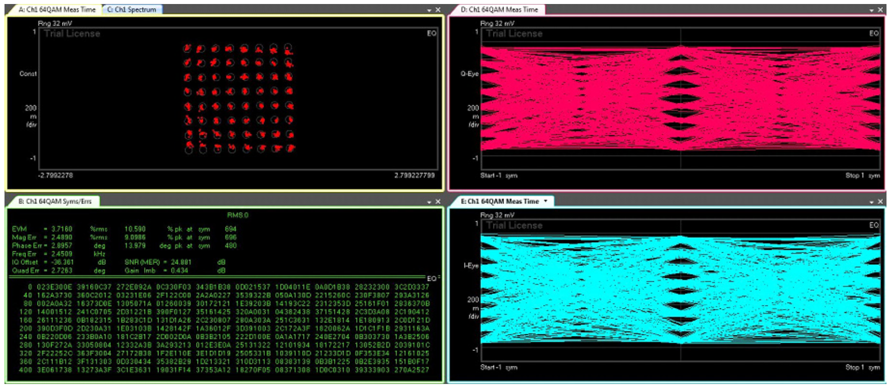

Figure 5: 64-QAM Constellation with 3GSymb/s and a Q-eye respectively I-eye diagrams on a 86GHz communication link

Optimizing performance

To locate the ideal operating point of the modulator, achieve the best possible linearity, and ultimately the highest EVM performance, several tips are worth noting.

The outputs of the modulators are normally designed to drive high impedance loads because of the limitations in electrical current availability. Therefore additional care needs to be taken when connecting an oscilloscope to the receiver side of the transceiver chip. The oscilloscope input impedance needs to be set to 1 MΩ. If this setting is not possible, consider using high impedance probes or operational amplifier circuitry to transform the impedance values.

Ideally the full digital-to-analog converter (DAC) voltage range is used to achieve the best signal quality. In this test configuration, it can vary between 350 mVpp and 700 mVpp at the M8190A arbitrary waveform generator's direct DAC output. Tuned for low power consumption, the transmitter devices usually work with input voltage levels around 100 mVpp or fewer. In order to reach these levels without limiting the DAC's resolution and without lowering signal quality, it is recommended that the DAC operates at the lowest possible voltage range and that attenuators are used to adjust the signal levels to the desired range.

Using matched cable pairs on the receiver and on the transmitter side is also recommended. These will reduce time delay differences between the single signal paths and with that, unwanted spurious emissions.

Using the described precautions, lab engineers will be able to quickly find an ideal operating point for the modulator to achieve the best possible linearity, resulting in highest EVM performance.

Infineon

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