What applications are possible in the 7 GHz of unlicensed band around 60 GHz?

Applications include wireless gigabit or WiGig which is responsible for the last ten metres of cloud computing, 60 GHz multi-Gbit/s wireless local access network (WLAN) and wireless HD home entertainment systems. Imagine the possibility of going to any local video rental kiosk and downloading the latest blockbuster movies in rich HD 1080P content in matter of seconds without ever taking out your portable storage device. Once at home those movies can be wirelessly streamed in real time to any TVs that are within the vicinity of the setup box. Large files can be shared instantly and seamlessly between devices and people without ever physically touching each other.

What are the ideal properties that an integrated circuit should have for 60 GHz applications?

High speed, sensitivity and linearity to support multi-Gbit/s wireless communications with low power dissipation. Integrated circuits need to be very fast in order to process information at 60 GHz. They need to be very sensitive to the weak incoming signals at 60 GHz and more pronounced parasitic effects of the interconnect due to operating at 60 GHz and more pronounced parasitic effects of the interconnect due to operating at 60 GHz. The receiver needs to perform frequency down-conversion that translates the amplified signal from 60 GHz to lower frequencies. To eliminate interferences that may disrupt the signals and condition them to the appropriate levels, filtering and programmable gain selection follow to complete the receiver chain. The receiver was designed with low power dissipation in mind to make portable applications possible.

How does this compare to the state of the art?

The 60 GHz receiver achieves the highest conversion gain and lowest noise figure with the lowest power dissipation over the state of the art. This is significant because high conversion gain and low noise figure are essential to a quality 60 GHz wireless communication link that ensures fewer information bit errors and higher data-rates. This improvement in performance is achieved with the lowest power dissipation possible that makes the system more efficient. Conventional designs often trade off performance with power dissipation. So it’s possible to achieve high performances with prohibitively large power dissipation, or low power dissipation but at a cost of poor performances. To break this trade-off, a different design philosophy needs to be adopted. By relying on the transformer’s innate voltage or current amplification capability, a form of passive amplification is achieved to boost the overall performance without incurring any power consumption. The name, ‘Origami’, was coined for transformer-based designs to illustrate the signal folding between the two coils.

What did you do differently over previous studies to achieve this performance?

The approach that we used was to focus on passive amplification instead of its active counterpart wherever possible. By following this approach, high performance can be achieved without the excessive power penalties. In addition to utilising transformers, series resonance of differential inductors and cross-coupling of differential capacitors were other techniques used to boost the performance with no power overhead.

What are the main challenges that you faced?

The main challenges that we had to overcome in the design phase were modelling inaccuracies of the passive and active devices at 60 GHz and more pronounced parasitic effects of the interconnect due to operating...
at 60 GHz. During the measurement phase, instrumentation limitations and environmental disturbances often forced elaborate setups and long hours of debugging.

**What do you plan to do next to further develop your 60 GHz receiver?**

We are planning to widen our overall bandwidth to fully cover the 7 GHz band. This can be done either through staggering the resonance peaks of the passive elements so that the overall frequency response can be widened or by dynamically adjusting the resonance peaks from one end of the band to the other according to the circuit needs. More effort will also be invested in further improving the receiver’s overall linearity.

**What else are you working on?**

This 60 GHz receiver is only a precursor to an even more ambitious undertaking in our lab: a self-healing 4 Gbit/s 60 GHz SoC featuring an integrated receiver, transmitter, frequency synthesiser, analogue-to-digital converter, digital-to-analogue converter and digital baseband which has never been accomplished in the past. This SoC is truly one of a kind, not merely in its sheer level of integration, but also in its underlying philosophy: self-healing. It has the capability of detecting circuit level ailments that are the result of process and temperature variations and ‘heal’ them automatically by adjusting some key performance knobs embedded inside the circuits. The end result is a high performance 60 GHz system with high yields under all conditions.

**How do you think this field will advance in the future?**

This field will advance to the greater heights in the future: 4 Gbit/s high data-rate communication is only a first step. Within the next five to ten years, 60 GHz wireless communications can be pushed to have data-rates in excess of 20 Gbit/s to fully utilise its 7 GHz wide bandwidth. There are so many different applications possible with this high data-rate ranging from entertainment, connectivity, security and medical. We would like to see a more unifying standardisation of 60 GHz specifications so hardware developments can be more streamlined and efficient. It is our hope that within five years, 60 GHz enabled devices featuring our self-healing SoC can make inroads to every corner of the world.