TWEETHER project for W-band wireless networks

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***Abstract*—The European Horizon 2020 project TWEETHER aims to make a breakthrough in wireless networks to overcome the congestion of the actual mobile networks and foster the new 5G networks. A European Consortium including four universities and five companies from four European countries is devoting a relevant effort to realize novel terminals and transmission hubs to operate in the W-band (93 – 95 GHz). This paper will describe the advancement of the project.**

Keywords—millimeter wave; wireless; traveling wave tube; backhaul; access

I. Introduction

The Horizon 2020 is a large research program funded by the European Union to foster the progress by a collaborative approach among the best researchers in Europe. TWEETHER "Traveling wave tube based W-band wireless network with high data rate, distribution, spectrum and energy efficiency" [1, 2] proposes a novel approach to exploit the millimeter wave portion of the spectrum for wireless communications. The challenge is to overcome the high atmospheric attenuation [2] with an affordable and powerful front end. The technology at millimeter wave is not yet mature as it is at microwave frequencies. A relevant design and fabrication effort is on going to provide components suitable for outdoor wireless communications. In particular, the enabling device is a W-band high power traveling wave tube (TWT) that requires to be built by state of the art facilities and novel solutions [4 – 6].

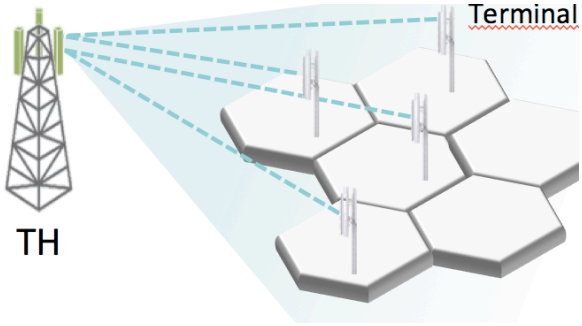

Fig. 1 Point to multipoint concept (TH: Transmission Hub)

II. Millimeter wave front end

Most of the millimeter waves transmission systems are available for point to point (PtP) applications in V-band and E-band [7]. Due to the limited output power available by solid state power amplifiers (SSPA) and the strong atmospheric attenuation, the use of high gain antennas is mandatory to achieve a useful range.

The network architecture for enabling high capacity small cell structure has to be based on a three tiers scheme. The first tier is the fiber infrastructure. The tier three is the final distribution network to serve mobile users with LTE technology and in the future with the 5G. The same technology can be used for fixed access where it is needed.

The second tier has to distribute the multi-gigabit capacity coming from the fiber optics infrastructure to a number of Point of Presence (PoP) in point to multipoint configuration for affordable deployments. This can be only achieved by a millimeter wave network with a wide frequency band not available at sub 6-GHz frequencies. The second tier has been so far not feasible with the avaialble technology.

The TWEEHER project aims to fill this gap. The availability of electronic devices at W-band (92 – 95 GHz) is still limited. GaN SSPAs are recently presented with output power in the range of 1 W [8, 9]. This power level is not sufficient for enabling the coverage of wide area corresponding to a sector with a wide angle, as required in the three tiers architecture (Fig. 1).

The novelty of the TWEETHER project consists in introducing a traveling wave tube (TWT) [10] with saturate power of about 40W as enabling device. This permits to use a

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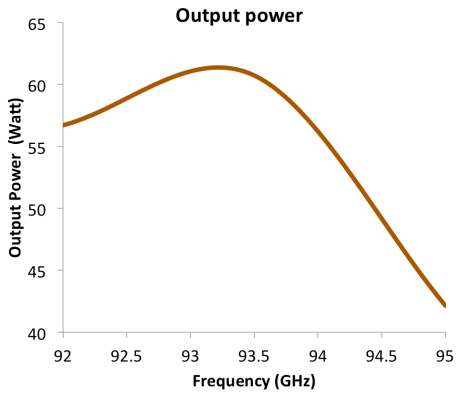

Fig. 2 TWT output power

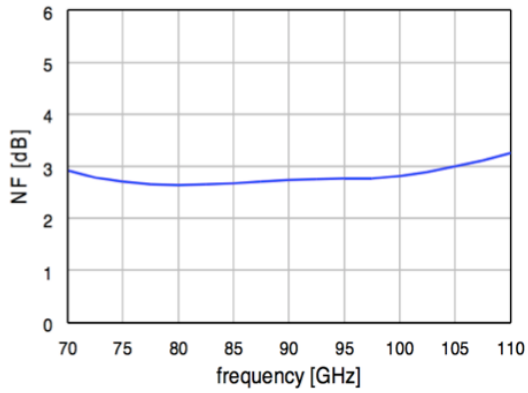

Fig. 3 Low Noise Amplifier: Noise figure (NF)

low gain antenna at the transmission hub (TH) to cover a given sector with aperture angle in the range 22° - 90°. The omnidirectional coverage can then be obtained by 3 or 4 sectorial antennas. This approach will enable the first Point to Multipoint [2] system at W band (Fig.1).

Preliminary designs of the W-band TWT show high linearity and particle in cell simulations with MAGIC-3D and CST MWS-PS provide output power exceeding 40W (Fig. 2).

The Transmission Hub also includes a low power section based on a W-band GaAs chipset, purposely designed and fabricated. It consists of a power amplifier, a down-converter, an up-converter, a low noise amplifier (noise figure in Fig.3) and a multiplier. It also includes a low-phase noise synthesizer.

One of the main challenges is the integration of the full transmission hub in a compact and reliable case.

The great advantage of the W-band operation is the small footprint due to the short wavelength.

A specific deployment model has been developed. It predicts a capacity density of 10 Gbps/km^2 distributed over a circular sector with about 1km radius. These results satisfy the needs of both backhaul and access at high data rate.

III. Conclusions

The TWEETHER project is a novel approach for wireless networks at millimeter waves that will enable high capacity backhaul and access. The use for the first time of a TWT represents a relevant novelty in the mobile communication sector.

IV. Acknowledgment

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V. References

[1] TWEETHER website [Online]. Available: http://www.tweether.eu

[2] C. Paoloni, F. Andre, F. Magne, M. Rocchi, M. Marilier, R. Letizia, R. Zimmerman, V. Krozer, A. Ramirez, R. Vilar, "Millimeter wave wireless system based on point to multi-point transmissions", EUCNC 2016, Athens, Greece

[3] ITU-R P.838-3, "Specific attenuation model for rain for use in prediction methods," 2005.

[4] C. Paoloni, A. Di Carlo, F. Bouamrane, T. Bouvet, A. J. Durand, M. Kotiranta, V. Krozer, S. Megtert, M. Mineo, and V. Zhurbenko, "Design and Realization Aspects of 1-THz Cascade Backward Wave Amplifier Based on Double Corrugated Waveguide," *IEEE Transactions on Electron Devices*, vol. 60, no. 3, pp. 1236–1243, Mar. 2013.

[5] C. Paoloni and M. Mineo, "Double Corrugated Waveguide for G-Band Traveling Wave Tubes,", *IEEE Trans. on Electron Devices*, vol.61, no.12, pp.4259,4263, Dec. 2014.

[6] M. Kotiranta, V. Krozer, and V. Zhurbenko, "Square helix TWT for THz frequencies," in *35th International Conference on Infrared, Millimetre, and Terahertz Waves*, 2010.

[7] C. Colombo; M. Cirigliano "Next-generation access network: A wireless network using E-band Radio frequency (71–86 Ghz) to provide wideband connectivity," in *Bell Labs Technical Journal* , vol.16, no.1, pp.187-205, June 2011.

[8] A. Brown, K. Brown, J. Chen, K. C. Hwang, N. Kolias, and R. Scott, "W-Band GaN Power Amplifier MMICs," in 2011 IEEE MTT-S International Microwave Symposium Digest (MTT), pp. 1-4, Jun. 2011.

[9] J. M. Schellenberg, "A 2-W W-Band GaN Traveling-Wave Amplifier With 25-GHz Bandwidth," in *IEEE Transactions on Microwave Theory and Techniques*, vol. 63, no. 9, pp. 2833-2840, Sept. 2015.

[10] C. Paoloni, F. Andre, F. Magne, S. Kohler, M. Rocchi, M. Marilier, R. Letizia, R. Zimmerman, G. Ulisse, V. Krozer, A. Ramirez, R. Vilar, "W-band TWTs for new generation high capacity wireless networks", *Proc. IEEE 17th Int. Vac. Electron. Conf. (IVEC), 2016.*