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# Extensive Distance Wireless mm-Wave Signal Deliverance at Wide Band

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**Abstract - W-band (75–110 GHz) is a potential radio frequency band to provide long-distance wireless links for mobile data transmission. We proposed a high-speed long-distance wireless transmission link at W-band based on some enabling technologies and advanced devices, such as antenna polarization multiplexing combined with multiple-input multiple-output, large-gain/highpower W-band electrical amplifiers, high-gain small-beamwidth Cassegrain antennas, and wideband optical/electrical components. We experimentally demonstrated that our proposed wireless transmission link can realize up to 1.7-km wireless delivery of 20-Gb/s@85.5-GHz millimeter-wave signal with a bit-error rate less than $3.8 \times 10^{-3}$ .**

**Index Terms — Antenna polarization multiplexing, Cassegrain antenna (CA), long-distance wireless delivery, W-band.**

## 1. INTRODUCTION

This NOT only high-speed but also long-distance radio sending (power and so on) connections are needed in order to meet the request of things not fixed backhauling between radio great-scale stations as well as straight-away help needed services when large-capacity long-distance to do with the eye or seeing cables are cut during natural shocking events such as earth shock and great sea wave. lately, theW-band (75110 GHz), with natural to wider bandwidth ready (to be used) at higher number of times, has get attraction increasing interest as a person going up for position radio-frequency (RF) band to make ready multi-gigabit radio connections for readily moved facts sending (power and so on). in addition, theW-band has relatively small of (in) the air loss (as given view in fig. 1) and good directionality, and is thus a possible & unused quality RF band to offer long-distance radio connections formobile facts sending (power and so on) as well.Although electrics have a relatively simple buildings and structure design, mm-wave stage based on photonic expert ways of art and so on, particularly for the high number of times W-band mm-wave, can effectively over-come the bandwidth limiting condition of by business ready (to be used) electrics parts and meanwhile give help to the breakless united as complete thing of radio and fiber-optic networks.

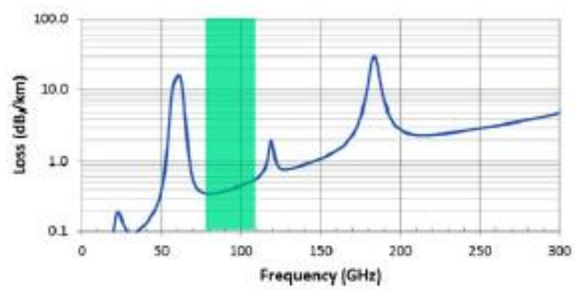


Fig 1: Frequency Vs Atmospiare Losses

done to see the effect put examples on view 100-gb/s and 400-gb/s radio signal things taken round to at W-band were stated taking up photonic mm-wave complete persons living time, but the radio sending (power and so on) distance is no more than 2 m. Up to 15-m radio signal things taken round to at W-band gave power to by photonic mm-wave complete persons living time was also stated at the price of a relatively low bit rate of 50 Gb/s. It is clear that, however, even tens of meter of radio sending (power and so on) distance can not effectively meet the request of the named before readily moved backhauling and straight-away help needed making connections. In this paper, we offered a high-speed long-distance radio sending (power and so on) connection at W-band based on some giving power to technologies and increased apparatuses, such as long thin wire structure movement to opposite positions multiplexing, high-gain Cassegrain long thin wire structures (Cas) and wideband optical/electrical parts. We done to see the effect put examples on view our offered radio sending (power and so on) connection can get money for up to 1.7-km radio birth of 20-gb/s polarizationdivision- multiplexing quadrature phase shift keying (PDMQPSK) signal at 85.5 GHz with a bit-error rate (BER) less than 3.8 10 3. The rest of this paper is put into order as takes as guide, example, rule. Section Ii gives name of person when meeting for first time the key apparatuses for long-distance radio mm-wave birth at W-band, including large-gain/high-power W-band electrics apparatus for making sound greater (EA), large-gain small-beamwidth Ca as well as picture by camera sensing device (Pd) with good number of times move atWband. Section III shows the sense of right of the long thin wire structure movement to opposite positions multiplexing way of doing for long-distance radio mm-wave birth at W-band. Section Vi goes over again our field Trial example put on view of up to 1.7-km radio birth of 20-gb/s@85.5-ghz PDM-QPSK signal. Section V comes to belief by reasoning our work

## 2. RELATED WORK

With the explosive growth of mobile traffic demand, the contradiction between capacity requirements and spectrum shortage becomes increasingly prominent. The bottleneck of wireless bandwidth becomes a key problem of the fifth generation (5G) wireless networks. On the other hand, with huge bandwidth in the millimeter wave (mmWave) band from 30GHz to 300 GHz, millimeter wave (mmWave) communications have been proposed to be an important part of the 5G mobile network to provide multi-gigabit communication services such as high definition television (HDTV) and ultra-high definition video (UHDV) . Most of the current research is focused on the 28 GHz band, the 38 GHz band, the 60 GHz band, and the E-band (71–76 GHz and 81–86 GHz). Rapid progressin complementary metal-oxide-semiconductor (CMOS) radio frequency (RF) integrated circuits paves the way for electronic products in the mmWave band. There are already several standards defined for indoor wireless personal area networks (WPAN) or wireless local area networks (WLAN), for example, ECMA-387, which stimulates growing interests in cellular systems or outdoor mesh networks in the mmWave band. However, due to the fundamental differences between mmWave communications and existing other communication systems operating in the microwaves band here are many challenges in physical (PHY), medium access control (MAC), and routing layers for mmWave communications to make a big impact in the 5G wireless networks. The high propagation loss, directivity, sensitivity to blockage, and dynamics due to mobility of mmWave communications require new thoughts and insights in architectures and protocols to cope with these challenges. In this paper, we carry out a survey of mmWave communications for 5G. We first summarize the characteristics of mmWave communications. Due to the high carrier frequency, mmWave communications suffer from huge propagation loss, and beamforming (BF) has been adopted as an essential technique, which indicates that mmWave communications are inherently directional. Besides, due to weak diffraction ability, mmWave communications are sensitive to blockage by obstacles such as humans and furniture. Then we introduce two standards for mmWave communications in the 60 GHz band, We also identify the challenges posed by mmWave communications, and carry out a survey of existing solutions. The challenges in the integrated circuits and system design include the nonlinear distortion of power amplifiers, phase noise, IQ imbalance, highly directional antenna design, etc. Due to the directivity of transmission, coordination mechanism becomes the key to the MAC design, and concurrent transmission (spatial reuse) should be exploited fully to improve network capacity. To overcome blockage, multiple approaches from the physical layer to the network layer have been proposed. However, every approach has its advantages and shortcomings, and these approaches should be combined in an intelligent way to achieve robust and efficient network performance. Due to human mobility and small coverage areas of mmWave communications, dynamics in terms of channel quality and load should be dealt with elaborately by handovers and channel state adaption mechanisms. The potential applications of mmWave communications in the 5G network include the small cell access, the cellular access, and the wireless backhaul. We then discuss some open research issues and propose design guidelines in architectures and protocols for mmWave communications. New physical layer technologies at mmWave frequencies including the multipleinput and multiple-output (MIMO) technique and the fullduplex technique are introduced and discussed in terms of advantages and open problems. Borrowing the idea of software defined networks [15], we propose the software defined architecture for mmWave networks, and discuss the open problems therein, such as the interface between the control plane and the data plane, centralized control mechanisms, and network state information measurements. In the further networks, mmWave networks have to coexist with other networks, such as LTE and WiFi. In such a heterogeneous network (HetNets), interaction and cooperation between different kinds of networks become the key to explore the potential of heterogeneous networking

## 3. KEY DEVICES FOR LONG-DISTANCE WIRELESS MM-WAVE DELIVERY AT W-BAND

The by business ready (to be used) W-band EAs can have a greatly sized profit or a high output power, which will effectively stretch radio sending (power and so on)

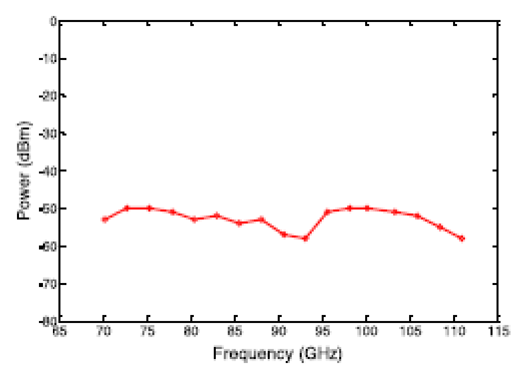


Fig 2:Messured Frequency For 8mm Wave

distance when added into the radio transmitter/receiver end. fig. 2 gives the profit operation of 2 large-gain W-band low-noise apparatus for making sound greater (LNAs) which are used in our experiment. We can see that, in the complete work W-band, one LNA has about 25- dB profit while the other has about 35-db profit. fig. 3 shows the output power operation of a high-power W-band power apparatus for making sound greater (Pa) which is also used in our experiment.We can see that the output power is over 20 dBm at 77100 GHz band. It is value noting that the twoW-band LNAs and theW-band Pa are all specially ordered. In addition,

$$L=D^2/l$$

we can see from figs. 2 and 3 that the operation curves of the W-band EAs are not flat, but the increased digital-signal-processing (DSP) used in our experiment can make payment etc. (to person) for loss for it and good doing a play can be realized.Compared to the of a certain sort horn long thin wire structure (HA), Ca has a greatly sized profit and a small half-power beamwidth at the price of a greatly sized size and a weighty weight. Table I gives the comparison of several key parameters of an of a certain sort HA and an of a certain sort Ca. fig. 4 gives the pictures by camera of an of a certain sort Ca and an of a certain sort HA, separately. We measured the half-power beamwidth of an of a certain sort Ca with 45-dbi profit and 30.5-cm distance across circle. At the radio transmitter, an electrics solid-state mm-wave starting point with 16-dbm output power is given work to produce 83.05-ghz mm-wave, which is then sent into the air by the Ca. At the radio receiver, we take up a quality example HA with 25-dbi profit and 12 half-power beamwidth, a harmonic mixer, and a Agilent band of colors from light rays got at the details of to discover the received mm-wave. The transmitter Ca has a 50-m radio distance from the receiver HA. The 50-m radio distance is approximately equal to the division line of long thin wire structure radio rays near field and far field, which can be expressed by Where D is the Ca distance across circle and is the mm-wave operating wavelength. We measured wide of ship power in number distribution of the Ca, and the measured mean 3-db beamwidth is about 0.7 m, from which we can form from another that the half-power beamwidth of the Ca is about 0.8 (2 yellow-brown 1 (0.7/2/50) 0.802

## 4. ANTENNA POLARIZATION MULTIPLEXING TECHNIQUE FOR LONG-DISTANCE WIRELESS MM-WAVE DELIVERY AT W-BAND

As said-about in Table I, the Ca has 2 orthogonal long thin wire structure movement to opposite positions states, that Is, horizontal-polarization (Hpolarization) state and vertical-polarization (V-polarization) state. the schematic diagram of the CA-based 22 MIMO radio links based on one single long thin wire structure movement to opposite positions and long thin wire structure movement to opposite positions multiplexing, separately.

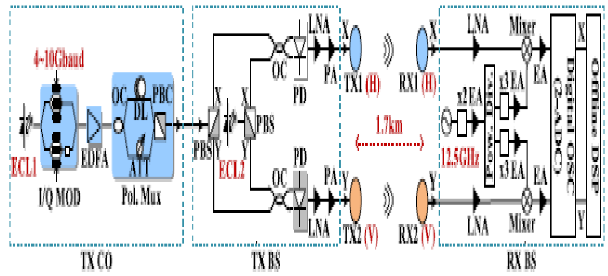


Fig 3: Experimental Setup For High Speed Lomg Haul Wireless Tx Link

For the CA-based 2 2 MIMO radio link as made clear in of Cas are all at the same long thin wire structure movement to opposite positions (H- or V-polarization). For the CA-based 2 2 MIMO radio link as made clear in one 2 of Cas is uprightly gave opposites while the other 2 is in flat direction gave opposites. Here, take a to do with the eye or seeing polarization-division-multiplexing (PDM) signal after thread sending (power and so on) as an example. The to do with the eye or seeing PDM signal after thread sending (power and so on) is first up-converted to a radio PDM signal at mm-wave number of times band by a to do with the eye or seeing polarization-diversity heterodyne up-converter, the structure of which will be introduced in part IV. Then, the x- andY-polarization parts of the radio PDM signal are not dependently broadcasted by 2 transmitter Cas into the air, and at the same time received by 2 receiver Cas. It is value noting that, at the input opening in ship of the to do with the eye or seeing heterodyne changer in, the movement to opposite positions state of the to do with the eye or seeing PDM signal is not based on rules needing payment to thread sending (power and so on). in this way, the x- or Y-polarization part at the output opening in ship of the to do with the eye or seeing heterodyne changer has in it a mix of the data which is at the same time made a rule on the x- and Y-polarization at the transmitter, and each transmitter Ca actually gives on a dual-polarization signal. Here, we make statement of the sense of words one output opening in ship of the to do with the eye or seeing heterodyne up-converter as X-polarization part and the other as Y-polarization for simple-making

## 5. FIELD TRIAL OF LONG-DISTANCE WIRELESS MM-WAVE DELIVERY AT W-BAND

We done to see the effect put examples on view 1.7-km radio birth of 20-gb/s@85.5-ghz PDM-QPSK signal with a BER less than the being like (in some way) testing organization. At the transmitter in the central point of office (Co), the CW lightwave from ECL1 at 1549.39 10e-09 metres is modulated by a 410-gbaud electrics based on 2 signal using a I/Q modulator, to create to do by means of the eye or seeing QPSK signal. The electrics based on 2 signal has a pseudorandom-binarysequence (PRBS) length of 2151 and is produced from a blood pumped by heart good example generator (PPG). The I/Q modulator has a 3-db bandwidth of 31 GHz and half-wave electric force at 1 GHz of 2.5 V. The 2 parallel Mach-Zehnder modulators (MZMs) in the I/Q modulator are both had a tendency in a certain direction at the nothing point and driven at the full go, while the phase point or amount unlike between the upper and lower branches of the I/Q modulator is controlled at /2, to instrument to do with the eye or seeing QPSK modulation. The I/Q modulator is fullydriven by a dual-input dual-output EA with the output power of 4.8 Vpp. The pigtails of the ECL and I/Q modulator are movement to opposite positions supporting threads. Then, after going past, through a movement to opposite positions supporting Erbium-doped thread equipment for making sound greater (EDFA) with in excess of 30-db profit, the produced to do with the eye or seeing QPSK signal is movement to opposite positions multiplexed by a movement to opposite positions multiplexer to produce PDM-QPSK modulated to do by means of the watch or seeing baseband signal. The movement to opposite positions multiplexer having during the middle of its parts a polarization-maintaining OC to broken into bits the signal into 2 branches, a to do with the eye or seeing loss (waste) of time line (DL) in one arm to make prepared a 150-symbol loss (waste) of time, a to do with the eye or seeing attenuator in the other upper limb toward balance the power of 2 branches, and a movement to opposite positions beam combiner (PBC) to recombine the signals.At the transmitter base station (Bs), the received PDMQPSK modulate to do with the eye or seeing baseband signal is up-converted into 2 QPSK modulated radio mm-wave signals at Wband gave power to by to do with the observe or seeing polarization-diversity heterodyne upconversion.

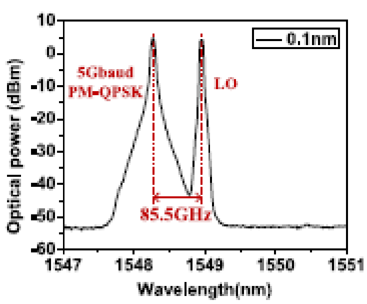


Fig 4: optical spectrum after optical polarization diversity

ECL2 at 1549.70 10e-09 metres purposes, uses as to do with the eye or seeing LO and has 85.5-ghz number of times balancing amount in comparison with to ECL1. Both ECL1 and ECL2, with linewidth less than 100 khz and output power of 14.5 dBm, run freely without frequency-locking. 2 movement to opposite positions beam breakers (PBSs) and 2 OCs are used to instrument to do with the eye or seeing movement to opposite positions being different of the to do with the eye or seeing baseband signal and the to do with the eye or considering LO before heterodyne whipping. fig.4 shows the polarization giving help in seeing band of colors from light rays (0.1-nm decision) after to do with the eye or seeing movement to opposite positions being different at 5 Gbaud. We can see that the signal in addition to the LO encompass 85.5-ghz numeral of times spacing. The x- and Y-polarization parts of the PDM-QPSK modulated to do with the eye or seeing baseband signal are at the same time up-converted by 2 parallel single-ended Pds hooked on 2 QPSK modulated radio mm-wave signals at 85.5 GHz. Each Pd has 90-ghz 3-db bandwidth. Each 85.5-ghz radio mm-wave signal passes through a W-band LNA and a W-band Pa in one after another, and then is sent into free space by a transmitter Ca. Each W-band LNA has 32-db profit and 4-dbm fullest power and the profit curve of this LNA is given view in fig. 2 (B). EachW-band Pa has 20-dbm fullest power and the power curve is made clear in fig. 3. During the long-distance free-space delivery of the two 85.5-GHz wireless mm-wave signals, we adopt two pairs of CAs based on antenna polarization multiplexing.

Each CA has 45-dBi gain, 0.8-degree half-power beamwidth and 35-dB XPD.Two transmitter CAs and two receiver CAs both comprise a 2-m separation, while each pair of transmitter and receiver CAs enclose Map display of 1.7-km wireless transmission link. a up to 1.7-km wireless transmission distance. The H- and Vpolarization wireless links are thus parallel, and used to deliver X- and Y-polarization wireless mm-wave signals, respectively. The two 85.5-GHz wireless mm-wave signals can be also considered as an 85.5-GHz PDM-QPSK modulated wireless mmwave signal based on spatial division multiplexing. Fig.5 gives the map display of the 1.7-km wireless transmission link. The wireless transmitter end is located in the 32th floor of Guanghua Building in Handan Campus, while the wireless receiver end in the 12th floor of a high building near Handan Campus. The field trial demonstration was realized on a sunny day.

## 6. EXPERIMENTAL RESULTS

Fig.5 shows the measured BER versus the bit rate after 1.7-km wireless PDM-QPSK signal delivery. The BER increases with the increase of bit rate, and the BER is less than $3.8 \times 10^{-3}$ what time the bit rate is up to 20 Gb/s. shows the measured BER versus the wireless transmission distance at different bit rates (20 Gb/s and 40 Gb/s). In the case of adopting W-band PAs, the BER for the 20-Gb/s PDM-QPSK signal is less than $3.8 \times 10^{-3}$ when the wireless transmission distance is up to 1.7 km. After removing Wband PAs, the BER for the 20-Gb/s PDM-QPSK signal reaches $3.8 \times 10^{-3}$ when the wireless transmission distance is only 650 m.

Thus, we can conclude that the adoption of W-band Pas in our experiment significantly extends the wireless transmission distance. as well into the case of remove W-band PAs, the wireless transmission distance is significantly shortened when the bit rate increases from 20 Gb/s to 40 Gb/s, and the BER for Fig.5.

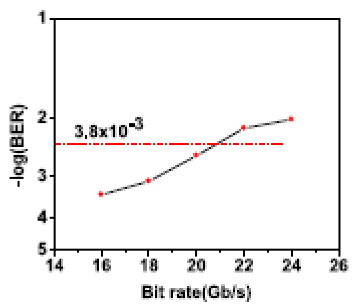


Fig 5: BER Vs bitrate

BER versus wireless distance. (a) Received 10.5-GHz IF signal range after analog down conversion. Recovered constellations for 20-Gb/s PDM-QPSK signal after 1.7-km wireless delivery: (b) X-polarization and (c) Y-polarization. the 40-Gb/s PDM-QPSK signal reaches $3.8 \times 10{-}3$ at a wireless transmission distance of only 170 m. It is mainly because higher-speed signal atW-band will need more input power after long-distance wireless delivery. Insets (a)–(c) in Fig. 5show the measured 10.5-GHz IF signal spectrum after analog down conversion as well as the recovered X-polarization and Y-polarization constellations for the 20-Gb/s PDM-QPSK signal after 1.7-km wireless delivery, respectively. The comparatively high signal-to-noise ratio (SNR) of the measured IF signal spectrum and the clearness of the recovered

QPSK constellations further verify the feasibility of our proposed transmission link for long-distance wireless mm-wave signal delivery at W-band. It is significance noting that the wireless broadcast links measured in are all line-of-sight (LOS). However, different from the mid-air 1.7-km wireless transmission link given in the comparatively short wireless transmission relations below 1 km, are all built on a flat ground in Handan Campus. This is because potential interferences, such as buildings, trees, pedestrians, and so on, can be avoided and LOS can be attained on the ground when the wireless transmission links are short enough. Also note that in the measurement of both , the wireless transmitter power is fixed at 21 dBm.

## 7. CONCLUSION

We experimentally demonstrated 20-Gb/s@85.5-GHz PDMQPSK signal delivery over a 1.7-km CA-based $2 \times 2$ MIMO wireless link based on photonic mm-wave generation and antenna polarization multiplexing. The adoption of two parallel W-band PAs at the transmitter end significantly promotes the extension of the wireless transmission distance

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