

Report on the Second Field Test of 80 GHz Digital Fixed Link

Purpose

To evaluate the possible usage of the E-band at 71-76 GHz / 81-86 GHz (“80 GHz”) for digital fixed links in Hong Kong. The Force obtained temporary frequency assignment from the Office of the Communications Authority (“OFCA”) to conduct the field tests on 80GHz fixed link. This second report summarizes the latest field test results with focuses on the usage of 80 GHz fixed link in Hong Kong urban areas during the rainy season.

Field Trial Setup

2. The field test was tested at two different modulation schemes, namely 4QAM between 27th July and 10th September 2015 and at 16QAM between 10th September and 12th October 2015 respectively. Fixed transmitted power and modulation was configured based on the planning tool provided by equipment vendor with the aim to study the received power variation due to rain fading (attenuation).
3. The setup contained one 80 GHz fixed link. The fixed link was established between two government buildings at Central and Sheung Wan. The distance of the link was approximate 0.68 kilometers. The technical characteristics of this link have been described in Annex 1.

Methodology and Findings

First test – 0.68 kilometers line-of-sight at 4QAM modulation mode

4. One laptop was set up to conduct G.826 test from both microwave equipment nodes. The laptop logged G.826 performance data and received RF power levels for every 15-minute interval for both uplink and downlink.
5. For transmission throughput, the calculated maximum capacity of this 80 GHz fixed link with 250MHz channel spacing and using 4QAM modulation is 343 Mbps. RFC 2544 sweep test was performed at 340Mbps without error and no packets lost in non-rainy weather condition.

6. During the field test period (i.e. between 27th July 2015 and 10th September 2015), the link performed stably with no outage. The Received Signal Level (“RSL”) at both nodes maintain steadily at the level of around -28dBm under non-rainy weather condition. Although few rainstorms took place resulting with downgraded RSL, no outage was recorded from the link as the node RSL at 4QAM was still far above the threshold RSL of -69dBm. Nevertheless, the node RSL dropped significantly under moderate to heavy rainfall and some link performance data under 4QAM modulation are listed as follows:

Event Logged	Average rainfall ¹	Recorded RSL²	Performance
14:30 on 29 th July 2015	20mm	-66.3dBm	No error
20:45 on 9 th August 2015	14mm	-55.6dBm	No error
01:30 on 10 th August 2015	35mm	-54.9dBm	No error
08:15 on 13 th August 2015	8mm	-57.6dBm	No error
08:45 on 15 th August 2015	5mm	-50.9dBm	No error

Second test – 0.68 kilometers line-of-sight at 16QAM modulation mode

7. After the first test, the equipment at both nodes was reconfigured from 4QAM to 16QAM. The calculated maximum capacity of this 80 GHz fixed link with 250MHz channel spacing and using 16QAM modulation is 685 Mbps. RFC 2544 sweep test was also performed at 675 Mbps without errors and no packets lost in non-rainy weather condition.

8. During the second field test period (i.e. between September 10th 2015 and October 12th 2015), the link performed stably but a few intervals with outage were logged. The RSL at both nodes maintain steadily at the level of around -32dBm under non-rainy weather condition. However, few rainstorms took place resulting in the RSL levels dropped below the threshold RSL level of -69dBm at 16QAM. Some link performance data under 16QAM modulation are listed as follows:

Event Logged	Average rainfall ¹	Recorded RSL²	Performance
20:30 on 3 rd October 2015	7mm	-69.5dBm	22s outage
23:00 on 3 rd October 2015	25mm	-87.5dBm	220s outage
08:15 on 4 th October 2015	13mm	-73.1dBm	34s outage
06:15 on 6 th October 2015	15mm	-65.7dBm	11s outage
09:30 on 6 th October 2015	5mm	-87.4dBm	60s outage

¹ The average rainfall logged by the Hong Kong Observatory in Central during the same hour of the event logged.

² The RSL is logged in every 15-minute interval and only one of the figures is presented.

Observations

9. The test results shown that 80 GHz band is feasible for fixed link application in Hong Kong under normal rainfall weather condition and a short transmission distance, say few hundred meters. During typhoons and rainstorms seasons with extreme rain intensity, the link with longer distance and higher modulation rate are likely to be affected. Though the average rainfall figures quoted in this report only represent the weather near the field trial area at that particular moment and it may not proportionally related to the recorded RSL, it still form a good reference on how 80GHz link perform under rainy weather. In general, it is observed that 80GHz is far more sensitive to rain attenuation as documented. Even in such a short link distance, it is difficult to guarantee 99.999% link availability under the sub-tropical climate in Hong Kong.

10. In order to maintain higher availability during high rain intensity, it is recommended to increase fade margin by activating Adaptive Transmission Power Control (ATPC) and/or using bigger antenna to offset rain fading.

11. To further increase the margin, adaptive modulation may be used to allow the system to automatically lower the modulation when the link is affected by high rain intensity. ATPC, antenna size and adaptive modulation should be considered during the link design in order to maximize fading margin for the link.

Annex 1

Technical Characteristics of the 80 GHz Fixed link at 4QAM

Frequency Band 71-76GHz / 81-86 GHz

Duplex Mode FDD

Channel Space 250MHz

Operating Frequency 73.25 GHz and 83.25 GHz

Modulation Scheme 4QAM

Transmit Power 4dBm was used (Max output 14dBm)

Receiver sensitivity -69dBm

Antenna Polarization Vertical

Antenna Size 0.3m diameter

Antenna Gain 46.5dBi at 78.5GHz

Power Supply POE (Power over Ethernet)

Technical Characteristics of the 80 GHz Fixed link at 16QAM

Frequency Band 71-76GHz / 81-86 GHz

Duplex Mode FDD

Channel Space 250MHz

Operating Frequency 73.25 GHz and 83.25 GHz

Modulation Scheme 16QAM

Transmit Power 2dBm was used (Max output 14dBm)

Receiver sensitivity -62dBm

Antenna Polarization Vertical

Antenna Size 0.3m diameter

Antenna Gain 46.5dBi at 78.5GHz

Power Supply POE (Power over Ethernet)