

# Transmission Analysis of Digital TV Signals over a Radio-on-FSO Channel

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# Outline

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- ❑ Introduction
- ❑ Overview of Radio over FSO Technology
- ❑ Experimental Evaluation of ISDB-T based Wireless Services Transmission over RoFSO Channel
- ❑ Conclusion

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# Introduction

- The need to **communicate**, **exchange** and **share** information prompted the deployment of devices and applications such as:
- These applications and the emerging ones all have one "**common effect**" on the end users/businesses...



**MOBILE PHONES, HOME PHONES, BROADBAND, OFFICE PHONES, DIGITAL TV, VIDEO CONFERENCING, TELEMEDICINE, TELE-TEACHING AND MANY OTHERS ARE EMERGING BY THE DAY**

**→ ...increased **Bandwidth** requirement!**

**How can users have access to the required high bandwidth? **Optical fiber****

- Deployment of optical fiber in the backbone and metro networks have made huge bandwidth available to within one mile of businesses/homes in most places.

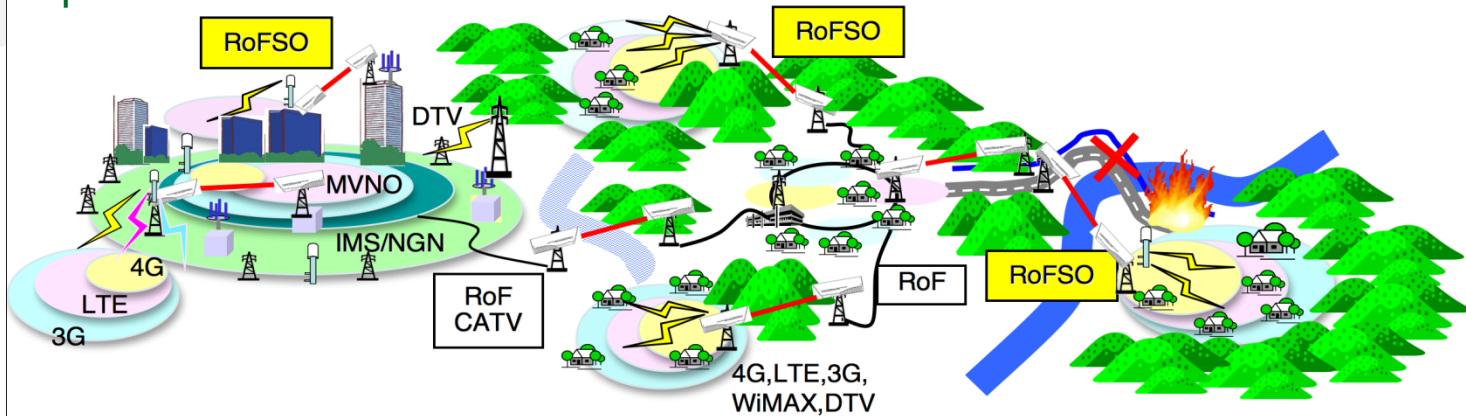


**But... time consuming, digging, need for permission...**

# Overview of RoFSO systems

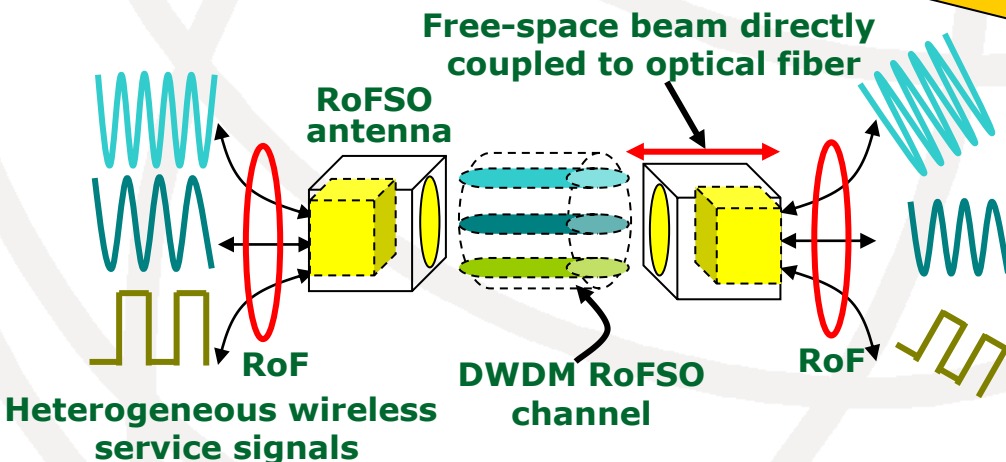
## Free Space Optics (FSO)...

refers to the transmission of visible and infrared (IR) beams through the atmosphere to obtain optical communications.



## Radio over FSO (RoFSO)... $\text{RoFSO} = \text{FSO} + \text{RoF}$

**Next Generation FSO system** = Direct coupling between optical fiber and free-space



## Proposed DWDM RoFSO system

- Uses 1550nm wavelength
- Transport multiple RF signals using DWDM FSO channels
- Realize heterogeneous wireless services e.g. WLAN, Cellular, terrestrial digital TV broadcasting etc

# Free Space Optics Standards Start!

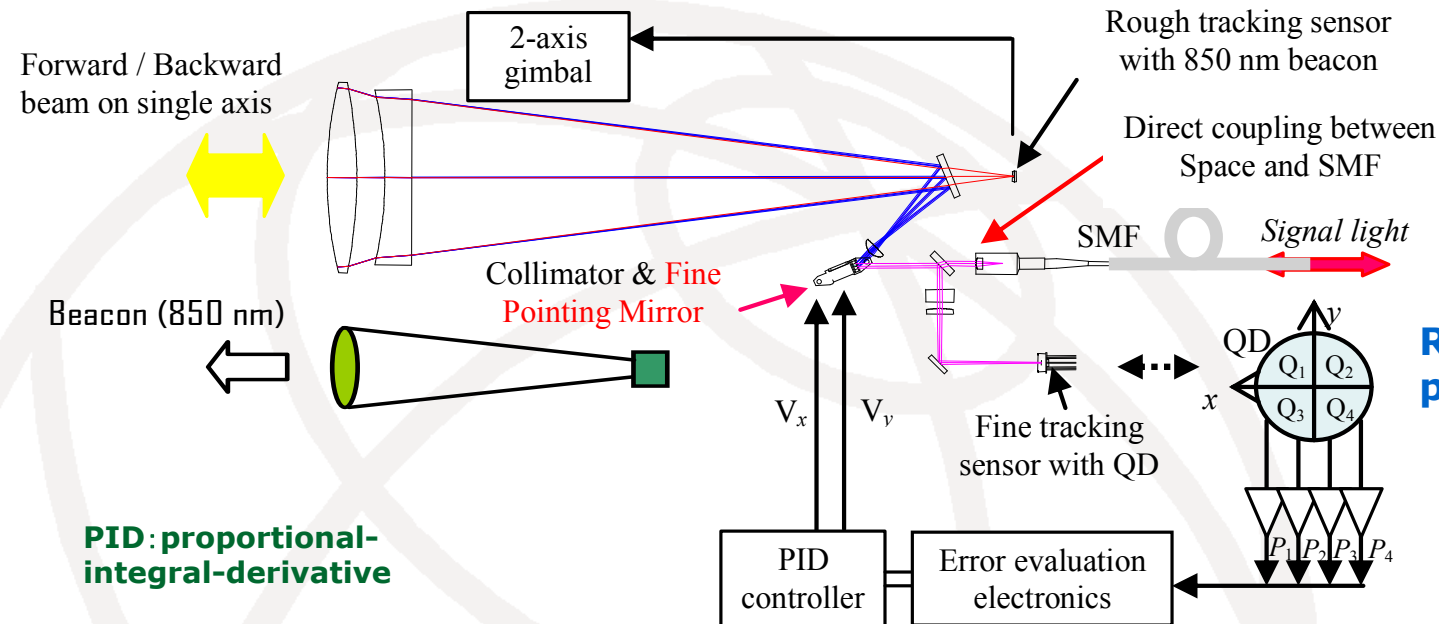
- In March 2006, the **first ITU-T Recommendation** has been published:  
Entitled “Co-location longitudinally compatible interfaces for free space optical systems”, **ITU-T Recommendation G.640** (ex G.fso) means that users of FSO systems will be able to co-locate FSO solutions provided by different manufacturers for the first time.
- Calculations of the conditions required to be met to prevent interference in some examples of co-located FSO systems are also included.
- ➔ Need for a ITU-T standardization study for maturity and rapid adaptation of the newly developed RoFSO technology.

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# Experimental Setup of RoFSO System



RoFSO antenna optical path and device layout

PID: proportional-integral-derivative

## DWDM RoFSO antenna specifications

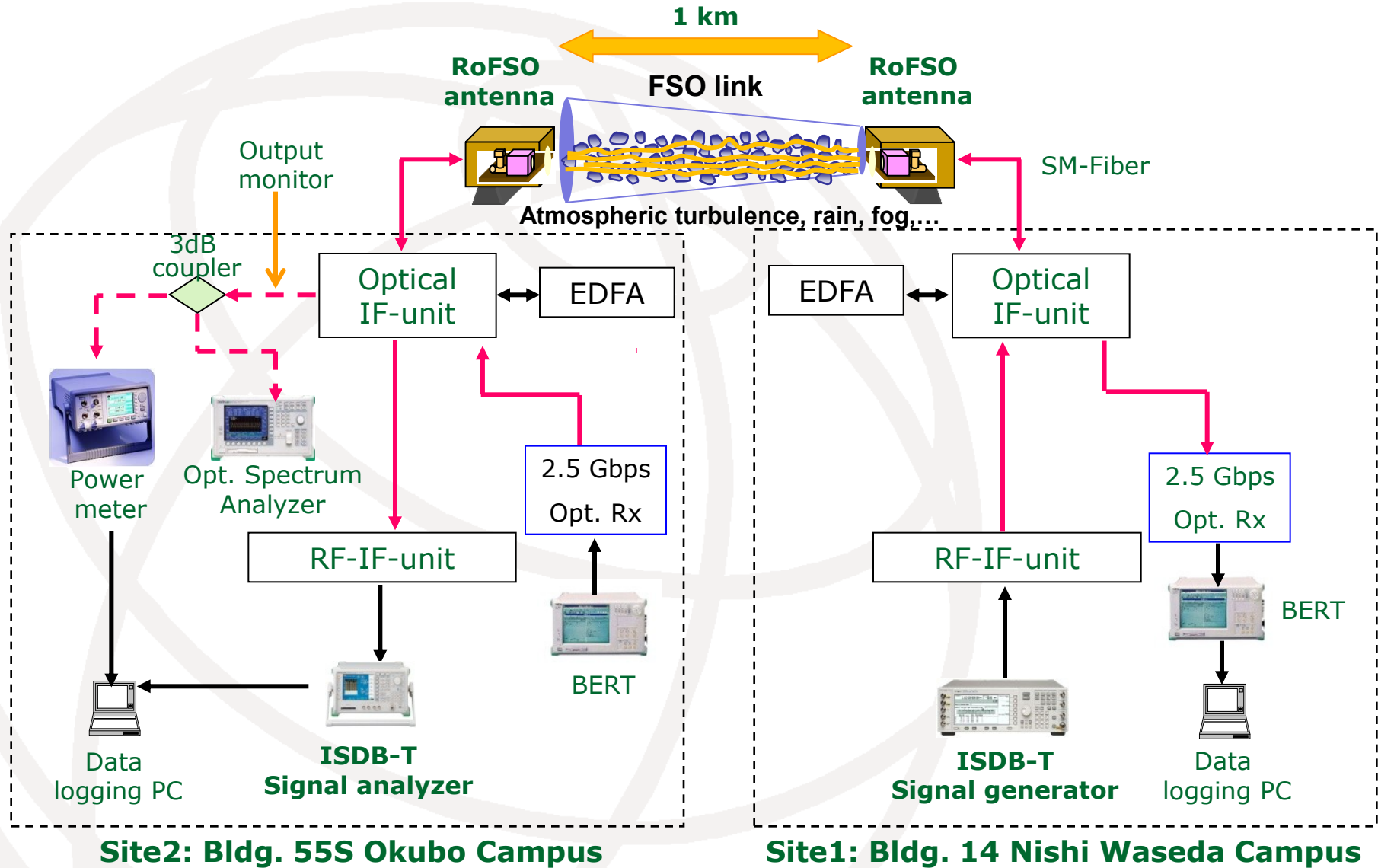
Parameter	Value
Communication wavelength	1550 nm
Beacon wavelength	850 nm
Antenna aperture	80 mm
Beam divergence	47.3 $\mu$ rad
Optical transmit power	20 dBm
Coupling losses	5 dB

## Key features:

- Optimized for transmission of RF signals.
- Can suppress most of effects induced from atmospheric turbulence like beam wander, AOA fluctuations.

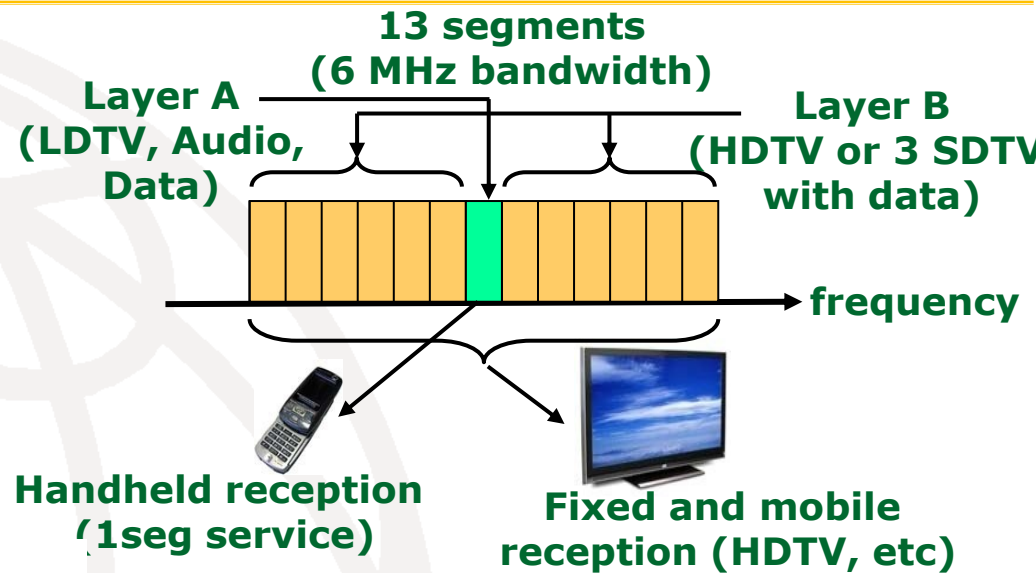


# Schematic Diagram of RoFSO system



# ISDB-T Signal Transmission: Introduction

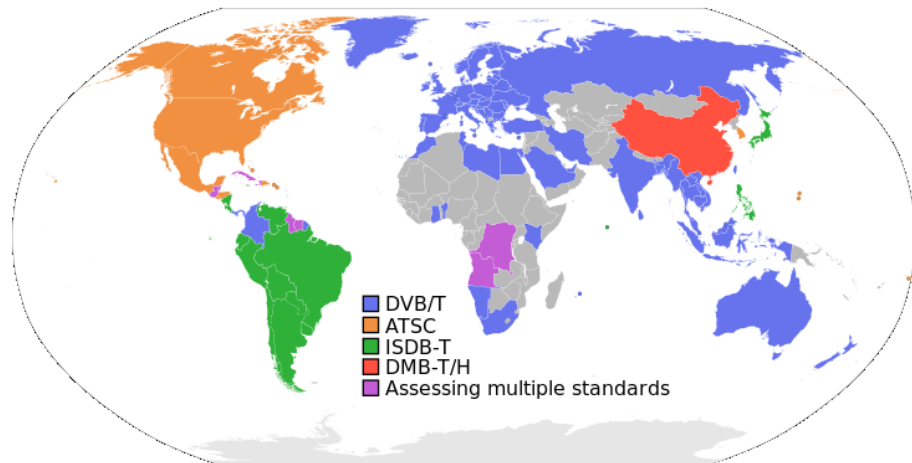
Integrated Service Digital Broadcasting - Terrestrial (ISDB-T) is one of **international standard format** developed and adopted in Japan and in almost all the South American countries.



## ISDB-T channel segments and services

The bandwidth is divided into **50 annels** numbered from 13 to 62.

Each channel is further divided into **13 DM** segments which includes a single segment, (**Layer\_A or 1seg**) for mobile receivers (LDTV, audio and data) and the remainder can be allocated as one 12-segments (**Layer\_B**) for high definition television (HDTV) programs.

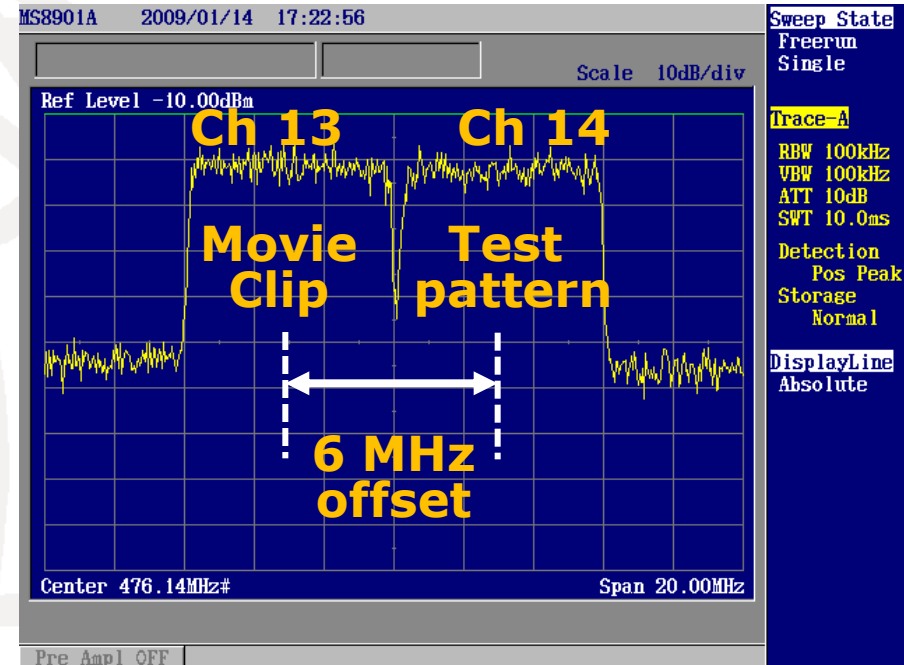


**Countries and territories using ISDB-T in green (Wikipedia)**

# ISDB-T Signal Transmission Characteristics

## ISDB-T Transmission parameters

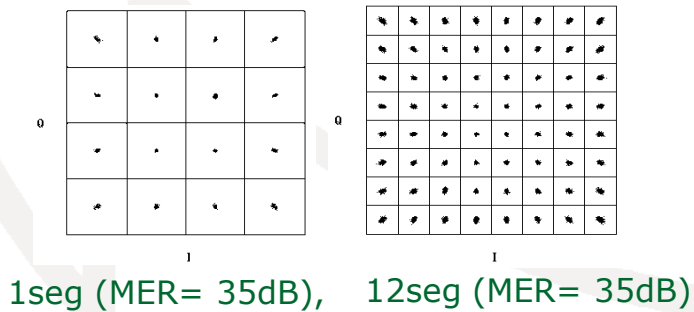
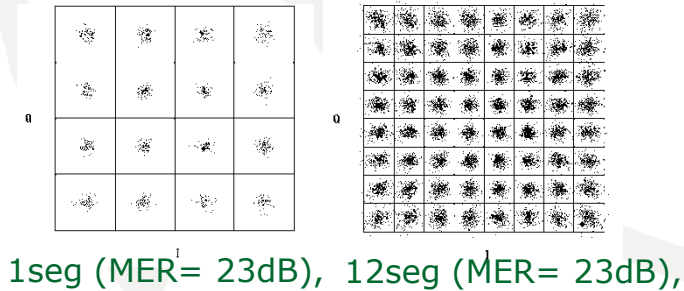
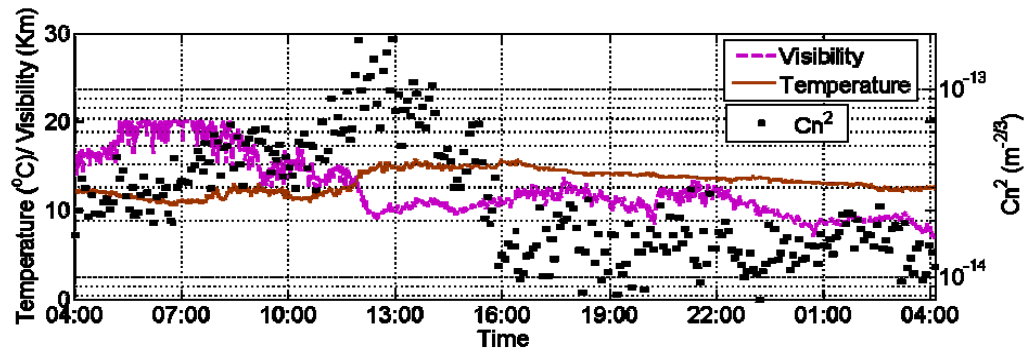
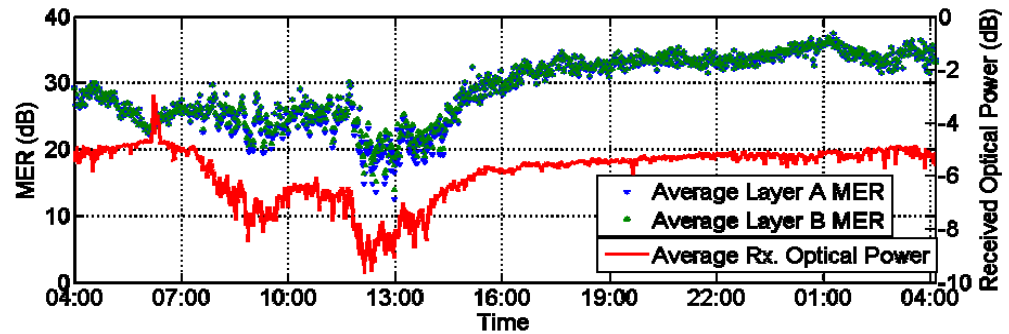
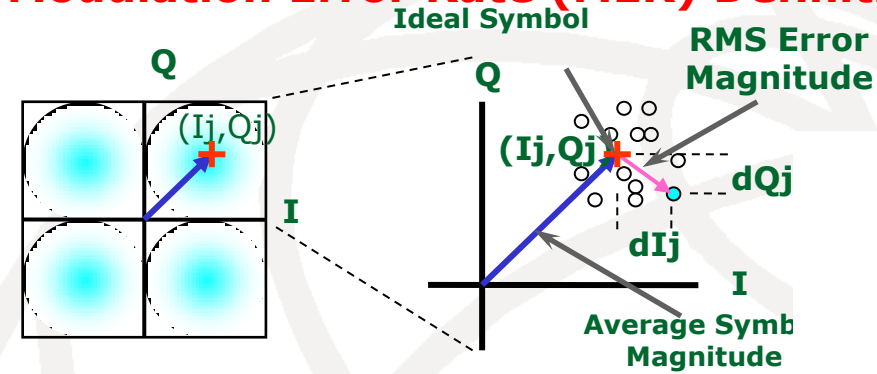
Parameter	Value	
Mode	3	
Layer	A	B
Number of segments	1	12
Modulation scheme	16 QAM	64 QAM
Information bit rate	624.13	19660
Required CNR/MER (dB)	11.5	22.2



Received ISDB-T signal spectrum

# ISDB-T Signal Transmission: MER Evaluation (1/2)

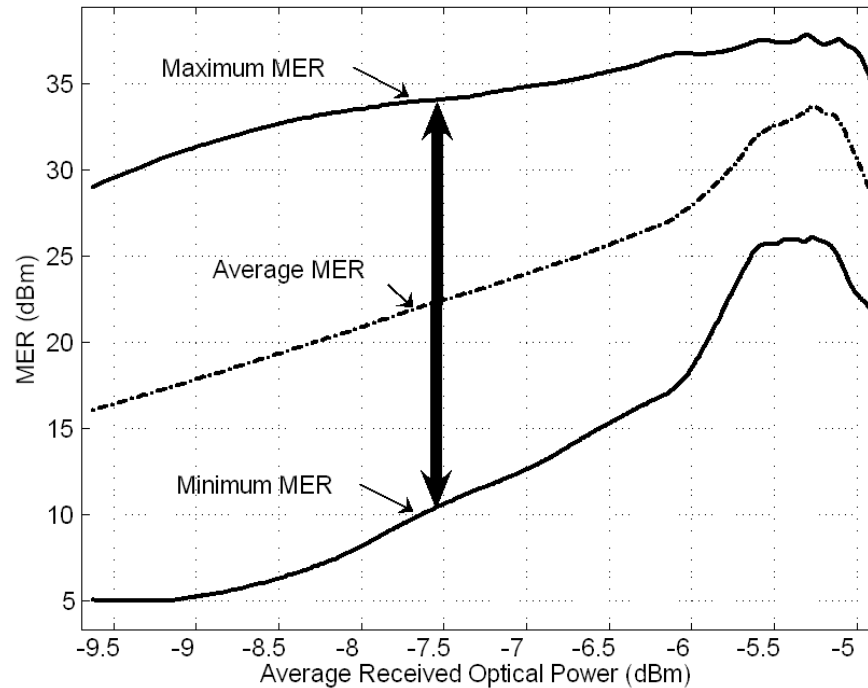
## Modulation Error Rate (MER) Definition:



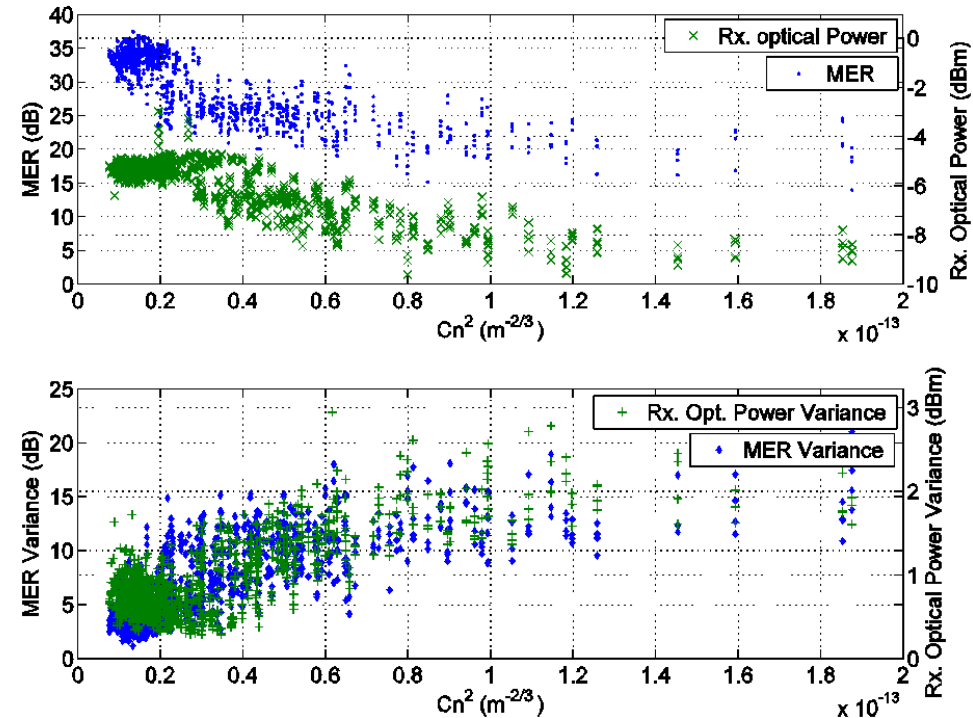
## ISDB-T Modulation analysis and Received Optical Power Characteristics

### ISDB-T Constellation Map

# ISDB-T Signal Transmission: MER Evaluation (2/2)

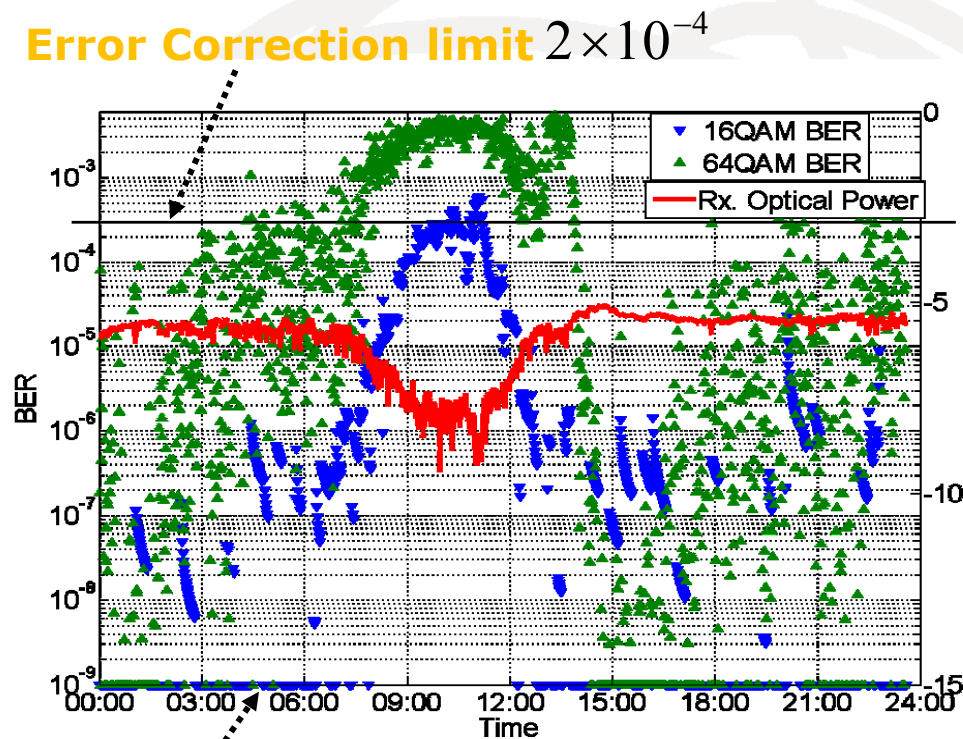


**Variation of the MER versus  
the received optical power**



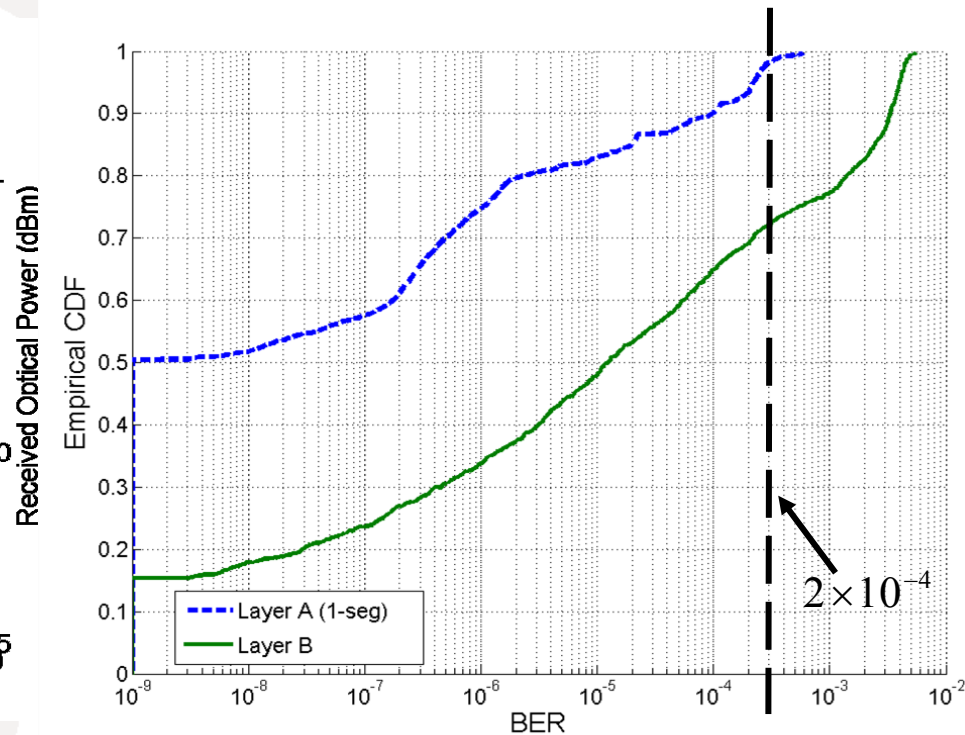
**Variation of Average and  
Variance of ISDB-T MER with the  
refractive index  $C_n^2$**

# ISDB-T Signal Transmission: BER Evaluation



**Error Free**

**ISDB-T BER and Rx. optical power characteristics**



**The CDF Layer A and Layer B BER**

Test Signal : ISDB-T\_16QAM\_1\_2 (Layer A 1seg 16QAM, Layer B 12seg 64QAM)

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# Conclusion

- An experimental evaluation on **transmission of ISDB-T service signals** using a newly developed advanced DWDM RoFSO system under real operational environment has been presented.
- Transmission performance evaluation of the proposed RoFSO system has **demonstrated consistent performance** in terms of specified quality metric parameters for the OFDM based digital TV signals in the **absence of severe weather conditions** and using **properly design interface units**.
- The obtained results confirm the technical feasibility and practicality of utilizing the RoFSO system as a universal platform for providing ubiquitous wireless services.
- The presented work on the newly developed RoFSO system can offer guidelines for an ITU-T standardization study for rapid adaptation of such technology.



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# Thank you for your attention!

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