ETRI

For next generation mobile communication base station

RoF (Radio over Fiber) based mobile fronthaul system

Contact: Heejin Choi
Email: hjchoi2@etri.re.kr
Phone: +82. 42. 860. 4946

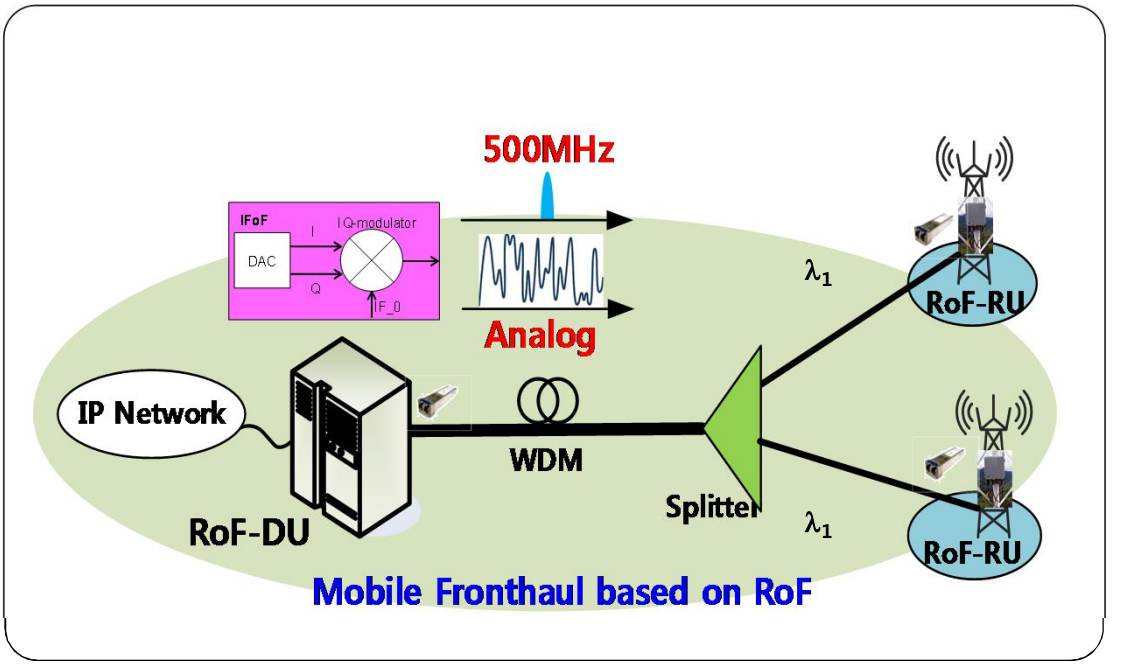
TECHNOLOGY BRIEF

RoF based mobile fronthaul system

▣ Technology Overview

RoF (Radio over Fiber) technology transmits using optical fiber by directly converting mobile signal to analog optical signal. This technology can solve problems of mobile fronthaul such as energy (E), area (S), cost (Co), resources (R), and traffic (T).

▣ Technology Structure



☐ **Keywords** | RoF, Analog optical transceiver, C-RAN, LTE, DU, RU

☐ **TRL** 5

Technology Classification Code		
Sector	Sub Sector	Industry
Network	System	Wired/wireless fused network

TECHNOLOGY BRIEF

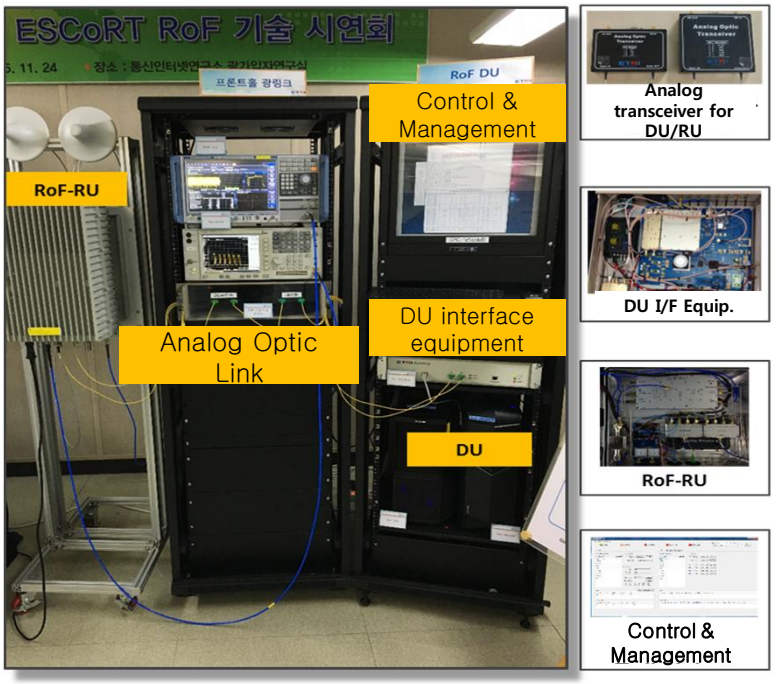
RoF based mobile fronthaul system

▣ Technology Description

▶ Detailed Structure of the technology

- Analog optical transceiver and optical link technology (world's best): at 12IF multiple transfer (~10Gbps), EVM of 6% or less is provided (world best IF 12EA transfer has achieved 12.5% EVM @OFC 2011)
- DU interface device and RoF RU technology (world's best, world's first implementation): 12IF generation / detection and frequency conversion (No other implementations of RoF based DU matching device and RoF RU in the world)
- Rof mobile fronthaul link management / control technology (world's best, world's first implementation): Implementation of DU-RU management control device using IF based 10 Mbps FSK method (No other implementations of RoF based mobile fronthaul link management in the world)

Mobile fronthaul demo system based on RoF tech.



▣ Application Fields

▶ Next generation mobile communication base station and wired/wireless fused network

- Applicable to C-RAN based next generation mobile communication base station
- Applicable to in-building DAS system
- Applicable to CATV and HFC

▣ Competitiveness of Technology

- **Requiring a broadband / ultra low delay characteristics that can be utilized in next generation mobile communication base station**
- **Can save OPEX/CAPEX investment for next generation mobile communication service**

▶ Advantages

- High linearity analog optical transceiver / optical link: RoF optical transceiver (>100 dB/Hz2/3) and optical link to accept LTE signal. Develop IF frequency layout optimization technology for minimized nonlinearity and has the world-leading 96IF.
- Support C-RAN based mobile communication base station that supports 3 Sectors, 2FA, 2X2 MIMI by developing 12IF DU matching device and RoF-RU.
- World's first management control device to monitor/control analog optical link and RoF-RU.

▶ Excellence compared to competitive technology

- High performance analog optical transceiver and optical link technology (<EVM: 6%, transmission range: 20km) (world's best)
- Multi-channel DU matching device and RoF RU (IF>13) (world's best, first implementation)
- RoF mobile fronthaul link management/control device (first implementation)

[CPRI vs. RoF]

Technology	Energy	Size	Cost	Resource	Traffic
CPRI	15W	30.94cm^3	$2500	5λ	10.3Gbps
RoF	1W	6.18cm^3	$300	1λ	500Mbps
Reduced cost	1/15	1/5	1/10	1/5	1/20

[Performance comparison of RoF technology]

Institution	Commercialized IF	Bandwidth	Modulation Method	Transfer Performance
Matsushita	7 EA	18 MHz	64 QAM	5% EVM
Technical University of Denmark	12 EA	20 MHz	16 QAM	12.5% EVM
Huawei	12 EA	20 MHz	64 QAM	10% EVM
ETRI	12 EA	20 MHz	64 QAM	6% EVM

▣ IPR Status

Korean Patent: 2 applicable

▣ Technology Trend

- In 2016, Huawei, Ericsson, Nokia, ETRI, and other companies are developing mobile fronthaul and in-building DAS technology using analog optical transmission technology.
- From 2014, ETRI has secured leadership in IFoF based mobile fronthaul related global technology (world's first proposal in 2014 OFC, holds 20 related research paper and IPR).
- Korean equipment companies, HFR and Solid Technologies, have available in-building DAS technology that supports 5~6 bands of LTE signal accepting digital and analog methods.
- Korea has secured the editorship and is leading the international standardization of ITU-T SG15/Q2 G.RoF (RoF systems) and IEC SC86C/WG4 61249-10 (RoF Transceiver Performance Standards).
- CPRI has established mobile fronthaul technology, but CPRI compression, Midhaul, RoF technology has been discussed to cope with the traffic spikes.
- Many ETRI research papers have been used for presentations in OFC 2015 and ECOC 2015 related sessions. Active OFC2015~2017 TPC committee.
- Global research leader of RoF fronthaul technology.

Institution (country)	Year	Annoucement	Commercialized IF	Transmission range	Used wavelength	Signal band width	Modulation method	Transfer performance	Application
Matsushita (Japan)	2006	IEEE MTT	7 EA	3 km	1 EA	18 MHz	64QAM	5% EVM	In-building WLAN
Georgia Tech. (US)	2010	OFC 2010	10 EA	10 km	1 EA	20 MHz	BPSK	7% EVM	In-building DAS
Technical University of Denmark (Denmark)	2011	OFC 2011	12EA	23 km	1 EA	20 MHz	16 QAM	11% EVM	Mobile Fronthaul
Superior Engineering Institute (Portugal)	2013	OFC 2013	5 EA	20 km	1 EA	20 MHz	QPSK	3% EVM	Mobile Fronthaul
Huawei (China)	2015	ECOC 2015	48 EA	5 km	1 EA	20 MHz	64 QAM	8% EVM	Mobile Fronthaul
ETRI (Korea)	2015	JLT 2016	96 EA	20 km	1 EA	20 MHz	64 QAM	8% EVM	Mobile Fronthaul

▣ Market Trend

- **Mobile communication base station related world market size was $5.9 billion (production value) in 2015.**
  Expected rise and a high 18.5% annual growth rate until 2019.

Base Station related Equipment Market Status and Outlook

2015	Production (Unit: thousand)	Revenue (Unit:$M)
BBU	82	2,579
RRH	1,079	2,153
Fronthaul	-	1,211

Domestic Base Station related Market Status

	Accumulation of built amount	
	2013	2015
BBU	62,924	93,848
RRH	373,212	556,269
Fronthaul*	373,212	556,269

* Fronthaul = one optical link + two optical module

☐ Market Leaders

▶ World leading vendor

- **Huawei, ZTE, ALU, Ericsson**

▶ Domestic leading vendor

- **HFR, Solid Technologies, Wurinet, COWEAVER, and etc.**

☐ Technology Demand

Application	Mobile network operators or equipment development companies
Industry	C-RAN based mobile communication base station, mobile backhaul/fronthaul

▣ Scope of Technology Transfer

- **Analog optical transceiver and optical link technology**
  - 6G analog optical transceiver design and implementation technology
  - Analog optical link design and implementation technology
  - Source code, detailed specification, and other technological documents
- **DU matching device and RoF-RU technology**
  - DU matching device design technology for LTE Rel.8 accepting 12 IF
  - RoF-RU design technology for LTE-band-7 accepting 12 IF
  - Source code, detailed specifications, and other technological documents.
- **RoF fronthaul management control device technology**
  - Commercialized FSK based management/control channel design and operation technology
  - RoF DU/RU management control device H/W (1 page)
  - RoF DU/RU management control device S/W (source code)
  - RoF Local Maintenance Terminal (LMT) Gui S/W (source code, GUI executing file)

▣ Applications and Effects

▶ Applications

- 4G/5G mobile fronthaul system for mobile communication base station
- 4G/5G in-building DAS system
- CATV and HFC network

▶ Effects

- Solve mobile traffic big bang using large capacity of mobile fronthaul link and digital processing.
- Build mobile fronthaul and lower operating cost by saving CAPEX/OPEX with downsized base station.
- Vitalize next generation mobile communication service with the characteristics of high-speed and low delay by simplification of mobile signal processor.