RF direct sampling method in the SKA mid-band from SKA-JP Industry Forum

[Workshop on East-Asian Collaboration for SKA]

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www.skatelescope.org

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EMC Microwave Systems
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Square Kilometer Array Industry of Japan

Range of Activities

- Proposing hardware, software, and subsystem integration, focusing on Mid-/High-band Dish antenna systems for SKA
  - 2 – 14GHz(20GHz) / Wide Band Single Pixel Feed(WBSPF)
- Developing and verifying subsystems and parts
- Exchanging information
  - SKA Industry Group
  - Overseas enterprises
  - Other organizations owning a radio telescope
- Japan's technical advantages
  - Technologies for achieving high quality, low cost, and a large production volume at the same time
  - Leading-edge technologies and production technologies
  - Power to unite a wide range of industries
- Applying developed innovative technologies to a variety of industry fields

Industry Group in Japan

Specific Activities

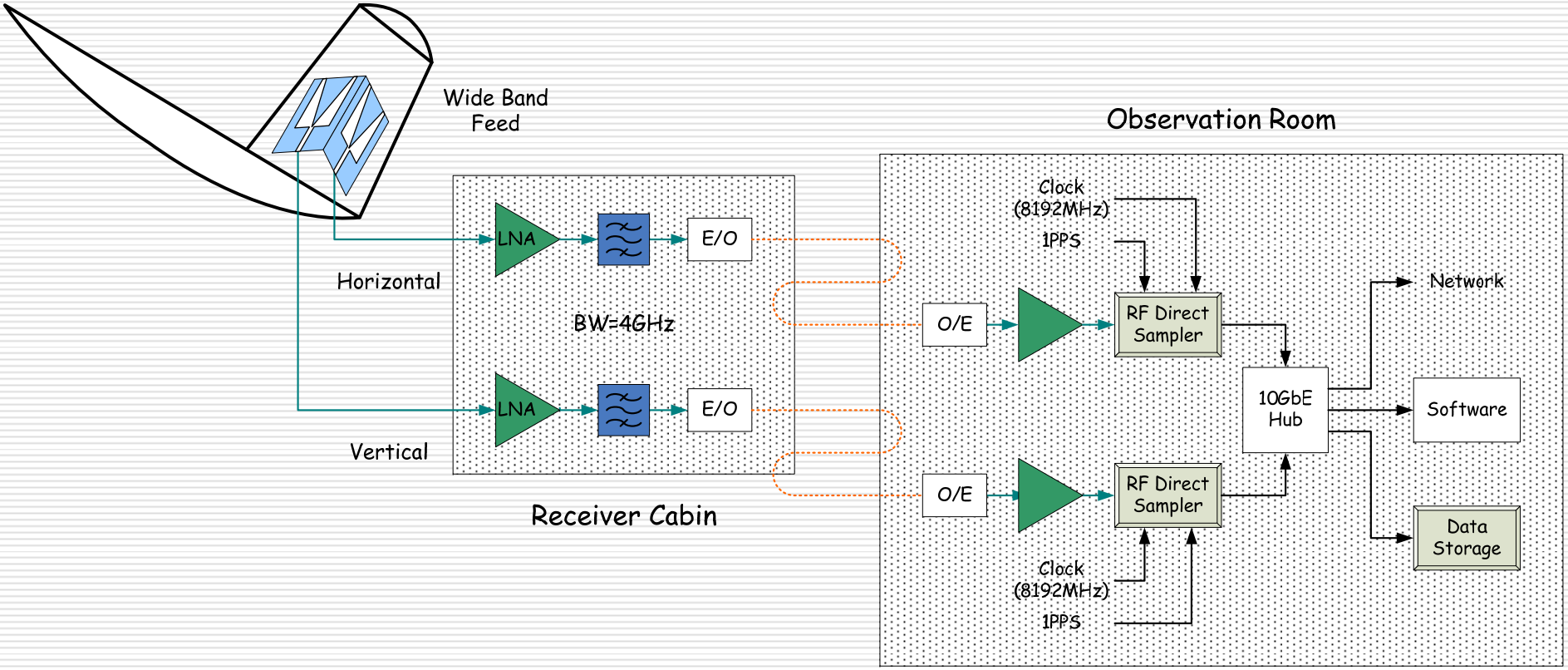
Information exchange and activity update

- Face-to-face regular meeting (approx. once a month)
- Participation in SKA-JP regular meeting (approx. once a month)
- Information provision to and information exchange with SKA Industry Group（at non-regular intervals）
- Information exchange with overseas companies and organizations (when necessary)

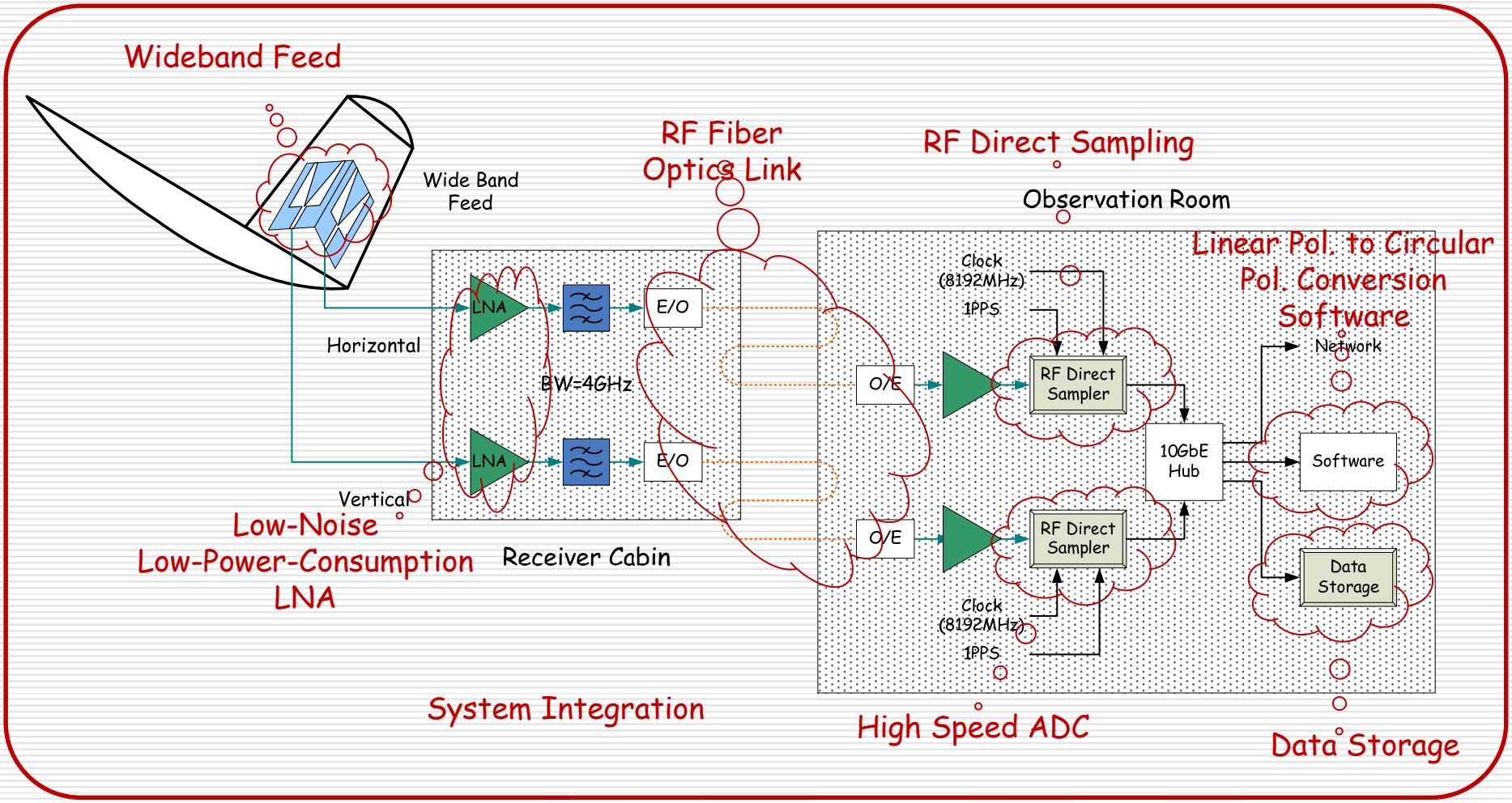
Presentations and Workshops

- Presentation at SKA Japan Workshop（2010-11）
- Poster exhibition at PrepSKA WP2（2011-10）
- Presentation at FY2011 VLBI Symposium（2011-11）
- Presentation at WS on East-Asian Collaboration for SKA（2011-11）

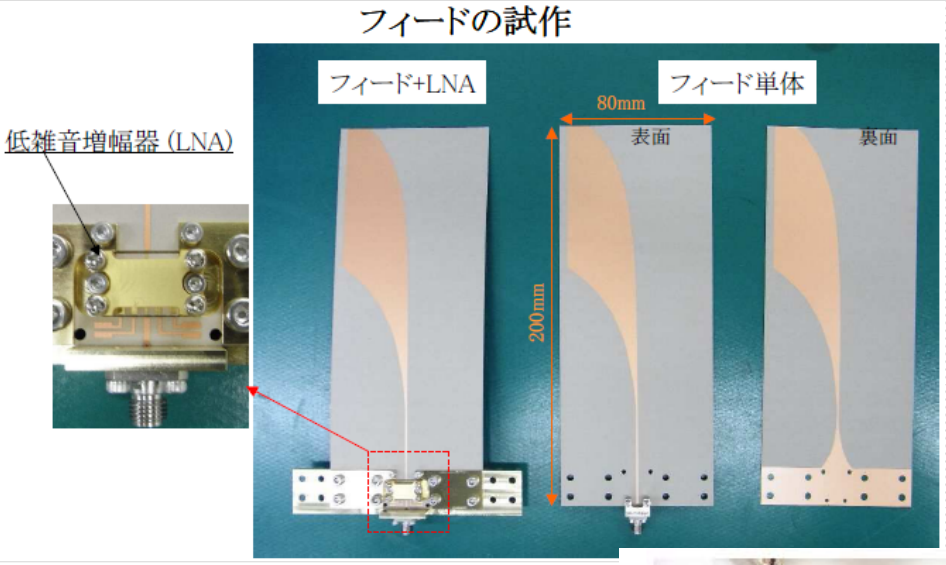
Advanced Wideband System



Under Discussion



Wideband Feed Test Model

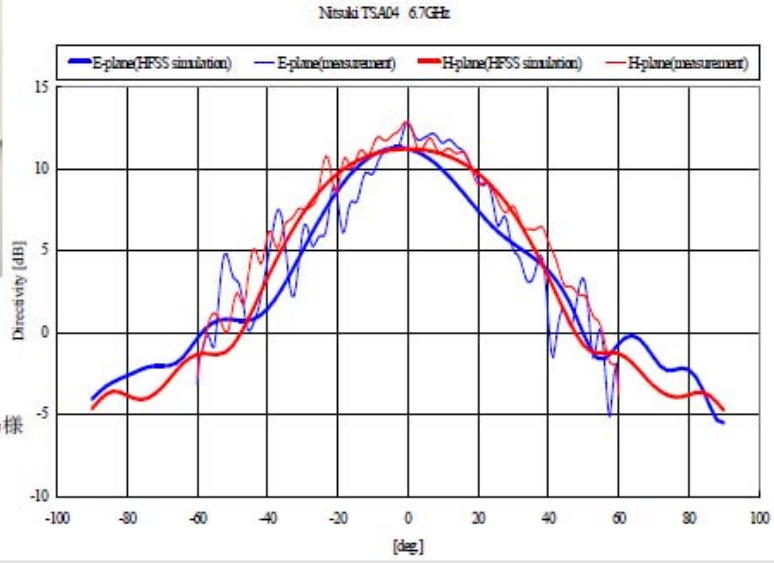


Electromagnetic Simulation

Prototype

Verification test

測定場所:京都大学宇治キャンパス
マイクロ波エネルギー伝送実験装置
測定装置:近傍界測定装置
測定周波数: 4～12GHz
作業期間:2011年2月24日～26日
作業者: NiCT 氏原様、総研大/水沢VLBI 貴島様
大阪府立大 木村様(2/24)
東陽テクニカ 熊澤様(2/25)
日通機 大野

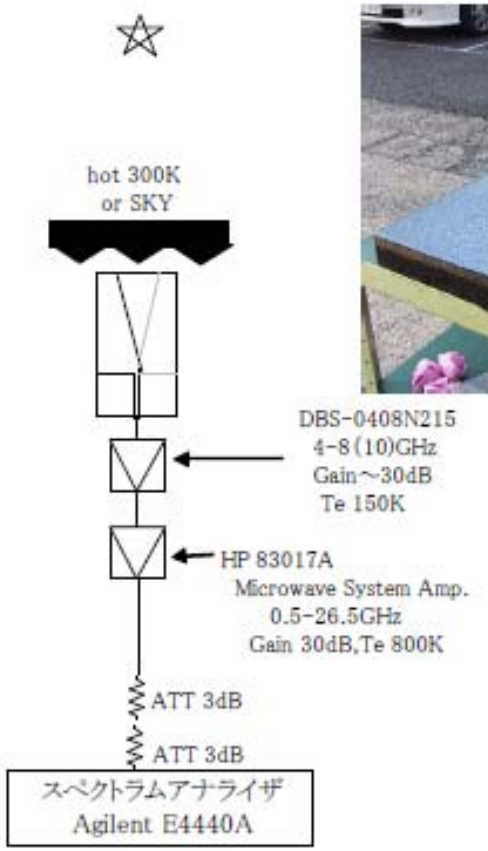


- Frequency Range = 1～15GHz
- Integrated with feed and LAN

Ref # TK0738A

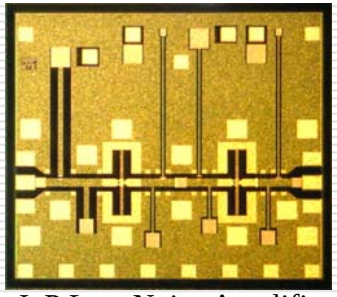
Square K

Verification Test of Noise Temperature



Development of Low-noise & Low-Power-Consumption Receiver

- We intend to realize low noise temperature/low power consumption by developing InP HEMT that replaces conventional GaAs HEMT.
  - InP HEMT requires about 1/5 as much power as GaAs HEMT requires for cooling down to 30K.
  - InP HEMT has a lower noise temperature in cooling down to 30K.

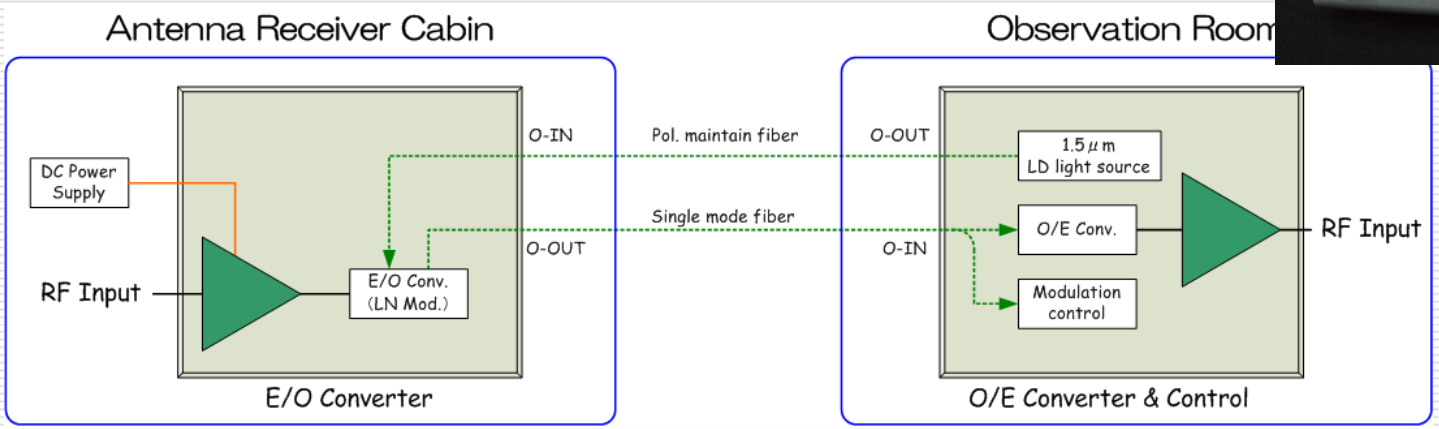


InP Low Noise Amplifier MMIC
Size: 1.4 x1.7 mm

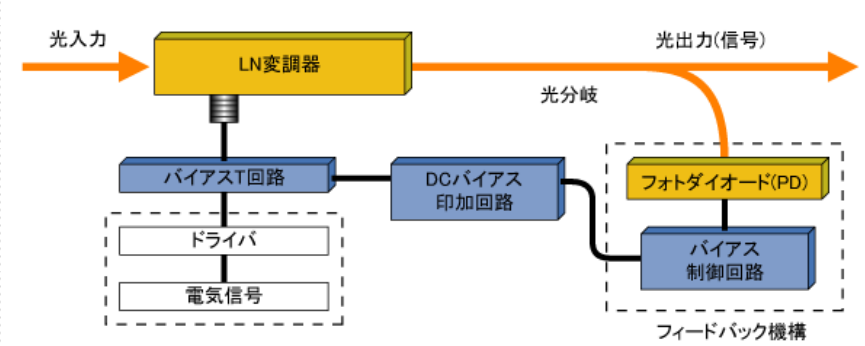
Sample of 40GHz-band InP HEMT LNA MMIC

At 30K cooling
- ✓ Low noise : 25K @ 43GHz
- ✓ Power save : 2.5mW (Gain = 14dB)

RF Fiber Optics Link



Items	Specifications	Notes
Frequency Range	1 ～ 18GHz	
Max. Cable Length	100m	
Gain	30dB Min.	
Gain Flatness	10dBp-p Max.	Freq.:1～18GHz
RF Output Stability	0.2dBp-p Max.	30min
RF Impedance	50Ω	
1dB Compression Level	-40dBm Min.	
Power Requirements	100V～240V	50～60Hz



RF Direct Sampling

Sampling at 8Gsps-3bits
4GHz bandwidth

VDIF output from
3 - 10GbitEthernet ports

Capability to directly sample RF signals of up to 10GHz

8Gsps X 3bits X 1 input or
4Gsps X 3bits X 2 inputs

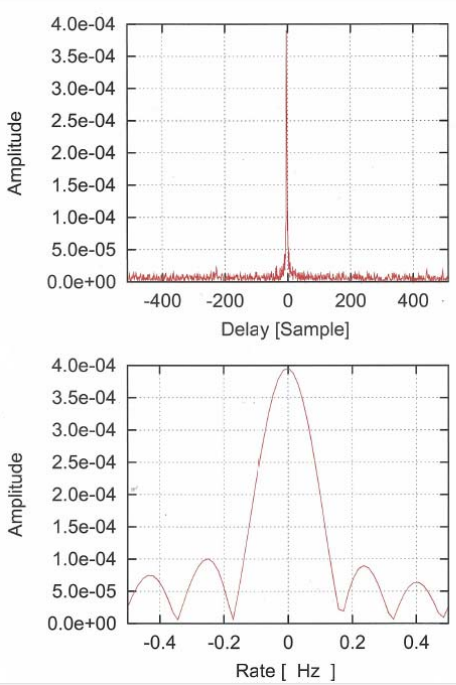
Down-sampling function

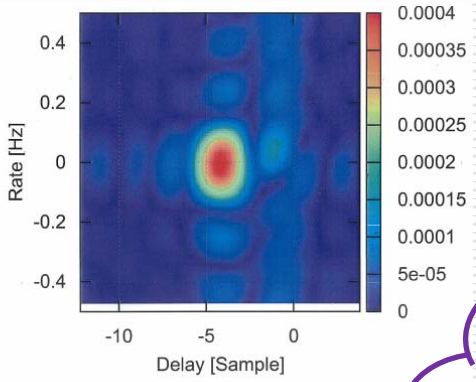
- Front-end can be made of fewer hardware items
  - No need for a frequency converter, local oscillator, or peripheral instruments
- Simple system configuration as a result of eliminating analog circuits
- Higher network compatibility

Lower cost
Higher stability

First Fringe (RF Direct Sampling)

First Fringe at 8192MHz






```
Epoch     : 2011/132 07:58:00
Station-1:                  Ef32
Station-2:                  Mh
Source    :                 3C84
Length    :     8.000000[sec]
Sampling  :  1024000000[sps]
Frequency: +8192.000000[MHz]
Peak Amp  :     0.039585[ % ]
Peak Phs  :  -133.810336[deg]
Delay     :    -4.195374[spl]
Rate      :    -3.059387[mHz]
SNR       :    59.974707
```

First Fringe in RF direct sampling two stations

Experimental Setup (RF Direct Sampling)

RF Direct Sampling Unit

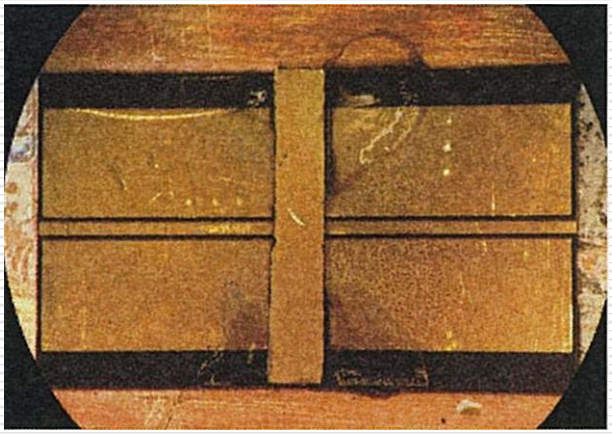
- The Ultra High-Speed A/D Converter unit is the key component in the DIGITAL BACKEND SUB-SYSTEM for the SKA and VLIB observation.
  - The unit samples analog signals of up to 10GHz at a sampling speed as high as 8Gsps X 1 input or 4Gsps X 2 inputs.
  - Digital data sampled by this model are converted into the VDIF (VLBI Data Interface Format) and then transferred to the data center from 3 X 10GbE outputs via optical cables.

Specification of RF direct sampling unit

Items	Specification
Analog Input Frequency Range	0.1 - 10GHz (26GHz Goal for the future)
Number of analog input ports	1 port (8192Msps) or 2 ports (4096Msps)
Sampling bandwidth	4GHz or 2GHz
Sampling frequency (Clock)	8192Msps or 4096Msps
Quantifying bit number	3bits
10GbE Protocol type	VDIF / UDP / IP
10GbE Optical connector	10GBASE-SR, 10GBASE-LR or 10GBASE-ER

Development of High Speed ADC with Package

Trial model

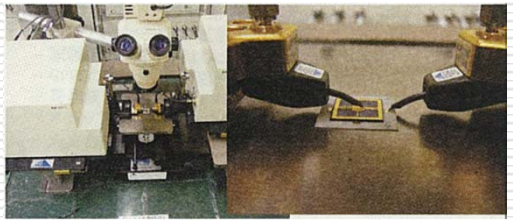


[Frequency Goal]

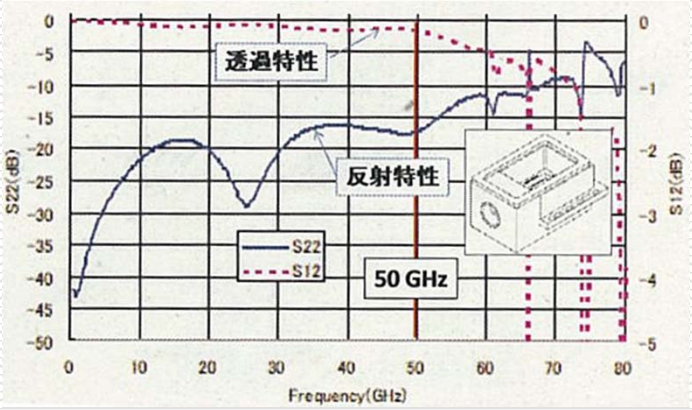
Analog Input Frequency = 50GHz

Sampling Frequency = 20GHz

Test probe

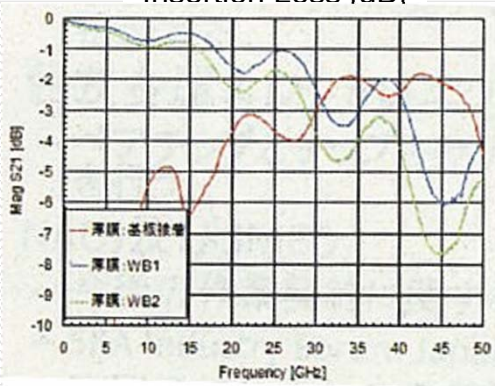


RF characteristics

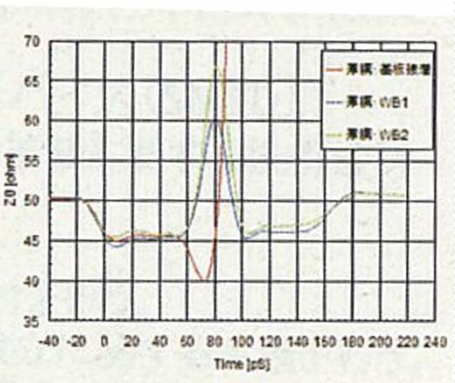


Compare new package with wire bonding

Insertion Loss [dB]



Time domain reflection



Data Storage

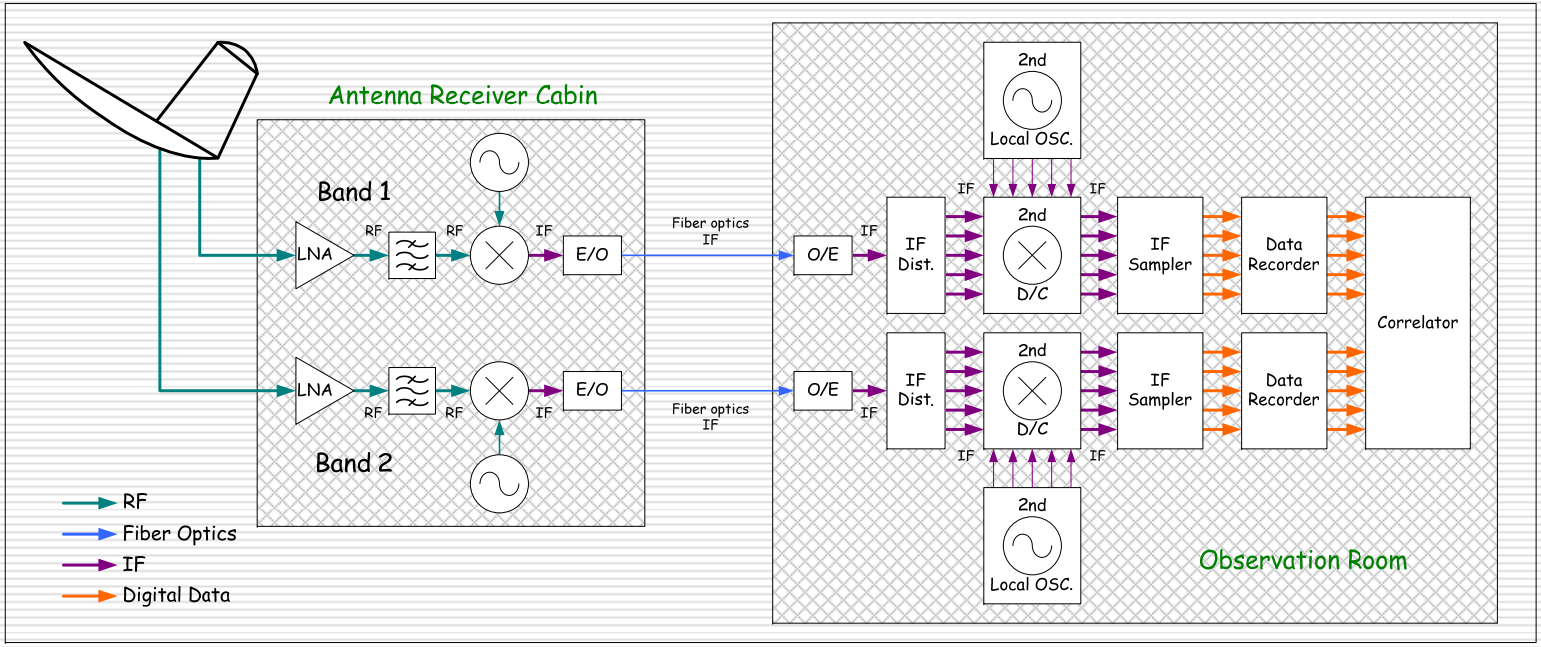
- The Removable Storage unit is a state-of-the-art data recording device.
  - Records, Saves, and Replays wideband data streams through 10GbE from the digital sampling unit.
- The Removable Storage unit records wideband data streams of up to 2Gbps X 2 lines.
  - Input through its 10GbE ports on a detachable large-capacity storage module (hard disk array)
  - Outputs data saved in the storage module from its 10GbE ports as data streams of up to 2Gbps X 2 lines

Specification of Data Storage unit

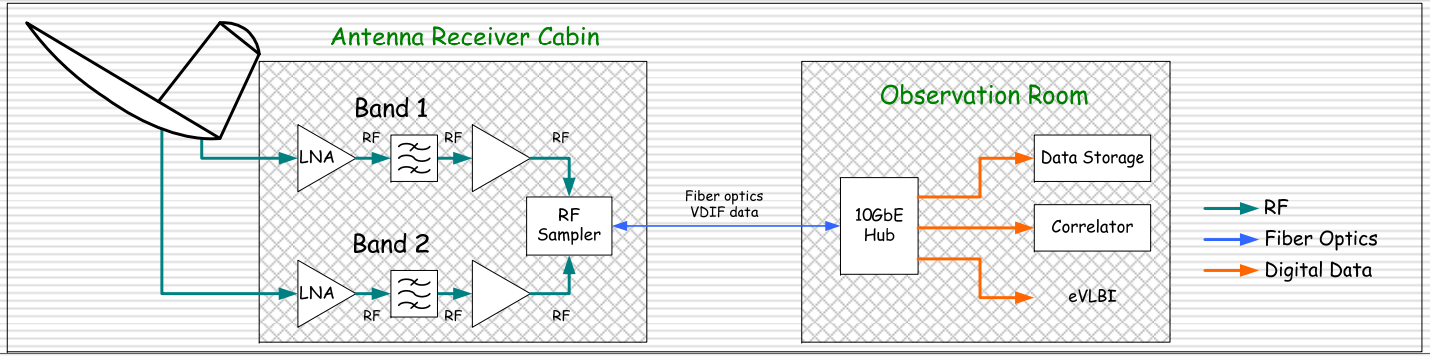
Items	Specification
Max. record and playback speed	8192Mbps max.
Stream	8 streams max.
Number of storage modules	2 module max.
Max. recording time	19 hours max. (4Gbps) / 1 module
File system	LINUX file system
10GbE Transmission protocol format	VDIF / UDP / IP
10GbE Ethernet type	10GBase-SR / 10GBase-LR / 10GBase-ER

Summary (Comparison of system)

Established

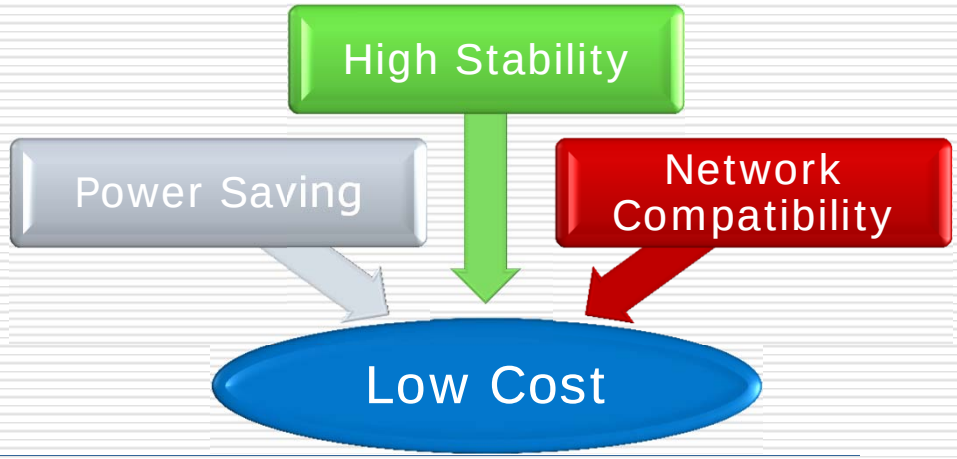


Proposed



Summary (Key Words)

- Wider bandwidth : 2～10GHz (20GHz)
  - Feed, Receiver (LNA), Direct sampler's input
- Front-end with minimal hardware items
  - No need for a frequency converter, local oscillator, or peripheral instruments
- Power saving
  - Adoption of power-saving components and reduction in the number of hardware items
- Higher stability
  - Only the analog circuits being in the receiver and the input of the RF Direct sampler
- Higher network compatibility
  - More flexible operation
- Lower costs
  - Not only the system price but also the operation cost



Thank you !

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