National Centre for Radio Astrophysics

Internal Technical Report
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Optical Receiver for GMRT Upgrade

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Acknowledgement

We thank the Center Director and Dean GMRT for giving us an opportunity to work on the design for upgrade and valuable suggestion and motivation during the work. We thank our colleges of fiber optics lab GMRT for their help in carrying out this work at lab and during installation and testing at field.

Revision	Date	Modification/Changes
Ver. 1.0	27th January 2014	Initial version R-261

1.0 Introduction

The GMRT receiver system is being upgraded to achieve seamless coverage from 50 to 1600 MHz. The upgraded broadband analog fiber optic link to bring in the RF signals directly from the frontend system to central electronics building without down converting it to IF signals. With the new advancement in DWDM technologies, we could combine signals from four LASER transmitters operating at different wavelength on to one single mode fiber using optical multiplexer at antenna base and it is separated into individual channels using optical de-multiplexer at central electronics building. Two optical transmitters are used to carry two polarizations of frontend signal and the third one is used for supporting the existing GMRT fiber optic system to carry the two IF signals, return LO and telemetry signals. The block diagram below explains the detail channel allocation in DWDM multiplexed system.

The forward link between CEB and antenna operates at 1310 nm and it is travelling in the opposite direction to the DWDM link from antenna to the central electronics building. This is done using bi-directional communication scheme by using WDM couplers with DWDM optical multiplexed system. The new upgraded system co-exists with the old fiber optic system of GMRT on one single fiber. A variable attenuator is placed in the RF gain block unit which is the interface unit between the frontend and optical fiber system. The attenuator is adjusted to ensure linear operation of the new broadband analog fiber optic like at all RF bands. The total power received from the frontend system vary with frequency band and to provide constant input power to the fiber optic system a variable attenuator is included in the RF gain block unit. The RF PIU at remote antenna base has two independent receiver chain carrying both the polarizations from frontend system. The signal from RF PIU is fed to laser transmitter which converts RF signal into optical signal and the optical signal is multiplexed and transmitted on to the single mode fiber from antenna base to CEB.

2.0 Fiber Optics Receiver System:

Photo detection is the processes to convert the received optical signal to RF for further signal processing. This is done using PIN photodiodes with built in Transimpedance amplifier for immediate amplification. The PIN diode detector is made of InGaAsP grown on InP a popular photo-detector having low dark current and high responsivity. The optical receiver is optimized to operate at -5 dBm optical input power for better optical and RF linearity. The electrical to optical and optical to electrical conversions will add 40 dB conversion which is compensated using the TIA with 20 dB and the first stage post amplifier. An additional 10 dB gain is provided to meet the output power requirements of backend at L-Band and during narrow bandwidth applications. Also a 10 dB fixed attenuator is placed in the receiver which can be varied to meet any other system requirements in future. A 20 dB directional coupler is also added to provide continuous monitoring of received frontend signals from antenna. Figure 2 shows the block diagram of the receiver system and figure 3 ,4 and 5 shows the PIU assembly with power supply card respectively. Table 1 shows the overall performance of broadband fiber optic system with optical receiver.

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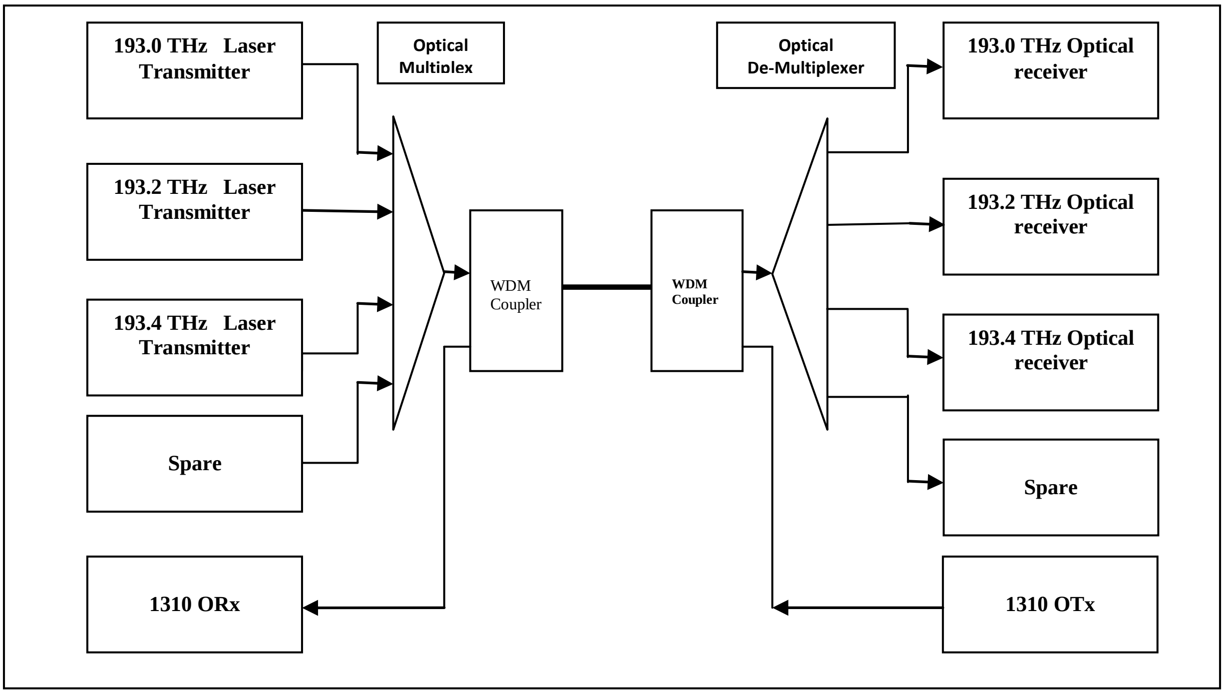

Figure 1. Upgraded DWDM based fiber optics system

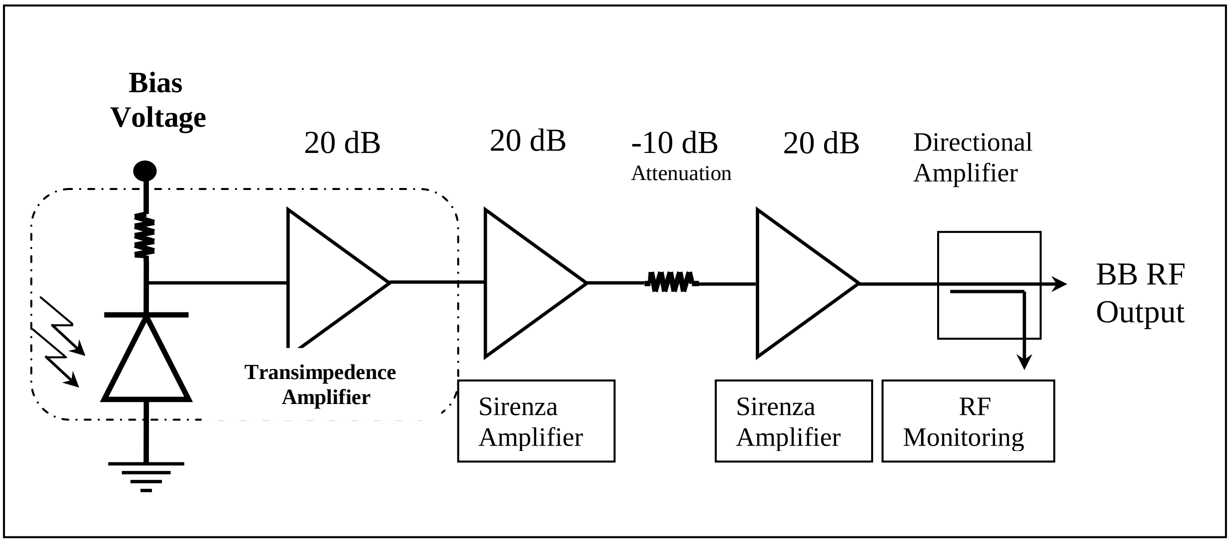

Figure 2: Optical Receiver PIU block diagram

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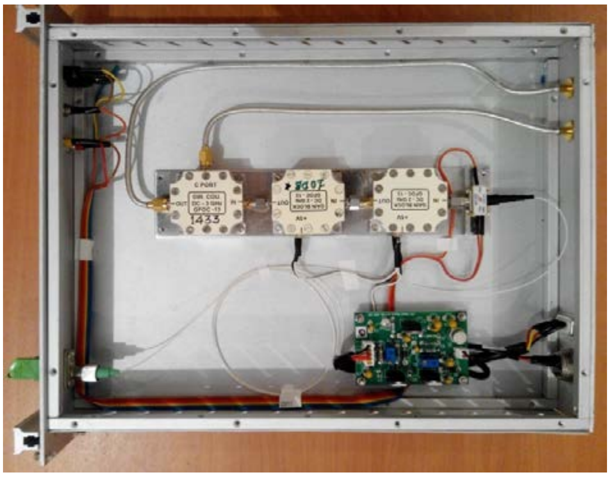

Figure 3 Optical Receiver Layout

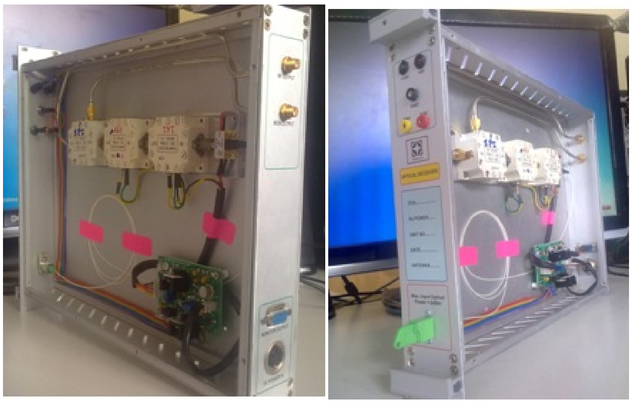

Figure 4. Optical Receiver PIU Interface

Figure 4. Power supply (15V Input DC and 12V, 9V and 5V Output DC with 1 A capacity).

Table 1. Performance of fiber optics system cascaded with RFI interface plug-in unit at antenna base

Parameters	Calculated	Measured
Input optical power to ORx	-5 dBm	-5 dBm
Responsivity (ORx)	0.8 mA/mW	0.8 mA/mW
Gain Of RF PIU	12 dB	12 dB
Gain of OFC Broadband system	38 dB	38 dB
I/P 1-dB compression point	-20.24 dBm	-21 dBm
I/P TOI (IP3)	-6.48 dbm	-6 dBm
Compression Dynamic Range	60.85	58 dB for 400 MHz BW
Spurious free Dynamic range	107.10 dB/Hz 2/3	105 dB/Hz 2/3

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3.0 **Protection and Precaution for Photodiode assembly.**

1) Required Slow start power supply for pin Vbd (10V) and pin Vbb (8V).
2) Proper Heat sink arrangement for Photodiode is necessary.
3) Antistatic workstation is needed while mounting the device.
4) The receiver should be powered up first before giving optical input.
5) The maximum optical input power should not exceed + 3 dBm.
6) The optical connector should be protected from scratches and damage to the polished tip any damage will have increased optical loss and reflection at the connector.

4.0 **Conclusion:**

The optical receiver uses PIN photodiode with TIA and it has ultra low reflection and highly linear suitable for analog application. The system works for 3 GHz bandwidth and the PIU is equipped with 50 dB gain. The post amplifiers, directional couplers, power supply are modules common to the optical transmitters and RF PIU. Design re-use scheme and modular design is adopted in building the optical receiver unit for GMRT upgrade.

References

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3. (Preliminary report) Signal flow analysis of broadband analog fiber optic system with 10 dB fixed attenuator and post amplifier, Ankur, S.Sureshkumar, Nov 2014.

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