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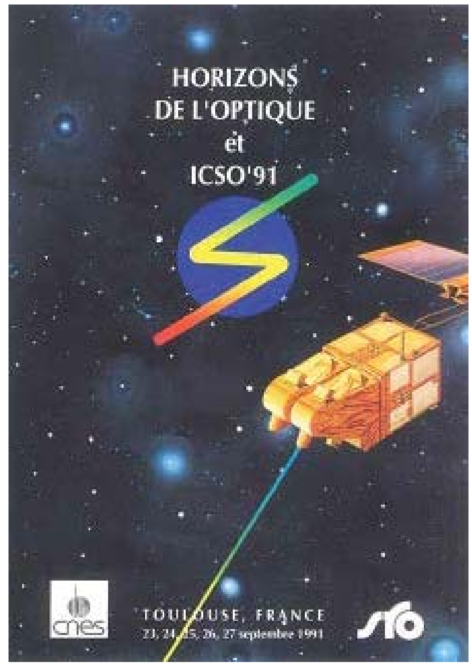

Posters: Optical Space Communications

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RESULTATS ET PERFORMANCES DE LA MAQUETTE DE POINTAGE OPTIQUE INTERSATELLITES ONERA

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-Présentation:

La maquette de pointage optique réalisée à l'ONERA simule toutes les conditions de la phase d'acquisition et de pointage fin d'un télescope pour les télécommunications intersatellites par laser. La très grande stabilité de pointage requise (<1µrd) et ses contraintes sont analysées sur cette maquette aussi bien sur le terminal embarqué sur le satellite géostatonnaire que celui sur le satellite en orbite basse.

-Description globale de la maquette.

-Définition des scénarios d'acquisition et de pointage en poursuite.

-Description, caractéristiques et qualification des composants:

- -Sources (balise, voie de contrôle, parasites ambiants).
- -Senseurs optiques (matrice CCD grand champ, minimatrice CCD, écartomètre CCD, écartomètre de contrôle).
- -Miroirs de pointage.
- -Miroir de dépointage (désaturation).
- -Miroir perturbateur (vibrations satellites).

-Résultats des essais systèmes et performances:

- -Acquisition -> pointage fin -> désaturation.
- -Tests de réjection à des bruits de structures et à des transitions du faisceau.
- -Tests avec des sources parasites.

-Conclusion

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TETE OPTIQUE D'EMISSION A DIODE LASER POUR TRANSMISSIONS PAR FIBRE OPTIQUE EN ENVIRONNEMENT SEVERE

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Les dispositifs optoélectroniques d'émission et réception sont généralement conçus pour les télécommunications : à titre d'exemple, les gammes de température de stockage ne dépassent guère -40/+70°C.

Les caractéristiques des fibres optiques (poids, taille, flexibilité,...) sont particulièrement intéressantes pour des transmissions sur satellites. Toutefois, des applications dans les domaines militaires et spa-tiaux ne pourront être envisagées de manière réaliste que si les dispositifs d'émission et réception sont rendus compatibles avec des environnements sévères.

Dans ce but, une nouvelle technologie a été mise au point afin de garantir, par exemple, la stabilité des caractéristiques d'une tête optique d'émission à diode laser après plusieurs dizaines de cycles entre -65°C et +150°C.

Par ailleurs, le dispositif ayant une bande passante supérieure à 7 GHz, permet le transport par fibre optique de signaux numériques à très haut débit et de signaux analogiques hyperfréquences.

Cette étude a été soutenue par le Service Technique de l'Electronique et de l'Informatique (STEI) de la Délégation Générale pour l'Armement (DGA).

OPTICAL FIBER MEDIUM FOR THE FUTURE EUROPEAN SPACE STATION LAN : CHARACTERISATION OF THE MAIN COMPONENTS

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SUMMARY

Optical networks are planned to be used within the European modules attached to the US space station. A study, performed in the frame of COLOMBUS in 1989 and sponsored by ESA (European Space Agency), has allowed to define the architecture of the medium adapted to the two envisaged standards (FDDI and 802.4) and to characterize the related optical components on a test bed. After a short recall of the main requirements, the optical medium optimized configuration is briefly presented with a summary of performed experiment.

1 - INTRODUCTION

Both low (10 Mb/s) and high (100 Mb/s) data rate local Area Networks (LAN) have been envisaged to be used within the European modules contributing to the space station infrastructure. The high data rate implementation requires the use of an optical medium derived from the FDDI standard and adapted to the space related constraints. On the contrary, the low data rate LANs, designed to comply with the 802.4 standard, were until recently based on a medium constitued of coaxial cables. Nevertheless, due to some constraints related to the interoperability with the American equipment which is based on optical transmission, an optical version of the 802.4 was also studied as an option. It is likely that this will now become the baseline. Thus, the optimum architecture for each case has been defined and tested on a test bed for verifying the expected performances. In addition, partial environmental tests (temperature) have been performed on the various optical components required for this application.

2 - REQUIREMENTS AND HYPOTHESES

The main system constraints, which are relevant for the two types of network are summarized in figure 2/1. Some general design choices were the result of a trade-off with respect to the space related constraints. The use of low power laser diodes (a few mW operating point) was considered in order to improve the link budget. Lastly, short wavelength technology (780-870 nm) was the baseline in the frame of the study, for interoperability constraints with the American side.

3 - OPTICAL MEDIUM CONFIGURATION

Concerning the token bus topology (802.4 standard), various alternatives have been compared on the basis of several criteria including at least link-budget, overall cable length, reliability and failure tolerance, modularity and potential cost.
They included both passive and active (with regeneration) media on the basis of usual principles, i.e. central star, distributed stars, bus.
Finally, it appeared that the most interesting topology was based on distributed passive stars, possibly interconnected by one active central star as illustrated in figure 3/1.
The token ring topology (FDDI standard) was imposed by the standard and is based on two counter-rotating rings (primary and secondary) with optical by-pass switches at each connection port. The expected transmitter and receiver performances are summarized in figure 3/2.

4 - FIBER OPTIC TEST BED

A test bed has been installed in order to characterize the optical medium suited for each application. For the FDDI type network, a breadboard of TX and RX modules was manufactured and integrated in a rack including a representative medium with several optical switches, thus allowing system tests.
For the 802.4 standard, one star coupler and 2 sets of bus coupler were implemented and tested up to a system level.
3 types of transmitter were used, built around LED, multimode and monomode lasers, in order to identify any modal noise limitation.
Lastly, some of the previous components and several types of optical switches and connectors were intensively tested within the overall temperature range. Concerning system tests, Bit Error Rates as low as 10^{-11} have been measured and it was not possible to identify any significant degradation linked to modal noise problems.

5 - CONCLUSIONS AND RECOMMENDATIONS

The main conclusions of this study are related to optical switches and the use of a laser transmitter. The first item seems to require a significant improvement before being used in space environment (temperature, vibrations). Nevertheless, last results seem to show that the solutions are not so far, assuming realistic specifications would be issued.
The use of laser transmitters did not lead to any problem. This should have to be confirmed by more tests but this is still encouraging looking at the possible link-budget improvement. For reasons (not technical) linked to the interoperability with American and Japanese parts of the space station, or to the commonality with FDDI standard, the final choice could become long wavelength (1300 nm) LED or LD transmitters.

Number of users (capacity)	:	100
(expected)	:	40
Module dimensions, length	:	12 m
diameter	:	4 m
Drop length (user to medium)	:	10 m
Data rate (effective)	:	10 Mb/s (802.4), 125 Mb/s (FDDI)
Bit error rate	:	10^{-12}
Link margin objective	:	6 dB
Operating Temperature Range	:	
(rack level)	:	-20°/+50°C
(component unit level)	:	-20°/+70°C
Radiations (cumulated dose, Si, over 10 years)	:	10 Krad
Lifetime (replaceable units)	:	10 years
(non replaceable units)	:	30 years

Figure 2/1 : Main requirements

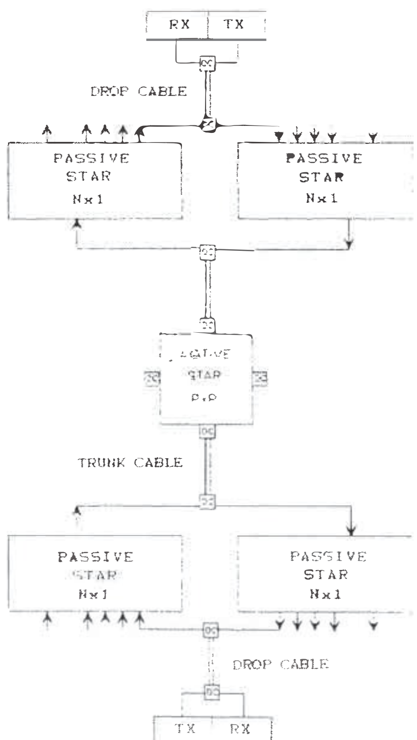

Figure 3/1 : Distributed stars with active central star

- TX output power (average, pigtail)	LD	>	0 dBm
	LED	>	-7.5 dBm
- Extinction ratio		>	20
- RX sensitivity (BER = 10^{-12})	10 Mb/s		-45 to -38 dBm
	125 Mb/s		-30 dBm
- RX dynamic range		>	20 dB

Figure 3/2 : Expected TX/RX performances

MONOLITHICALLY INTEGRATED SEMI CONDUCTOR LASER/AMPLIFIER FOR COHERENT COMMUNICATION LINKS

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A high power source is needed for coherent optical communication links in space. Frequency shift key (FSK) modulation offers substantial increase in detection sensitivity, compared with direct modulation and detection. The target performance for a coherent source is power output of the order 400 mW and a linewidth of less than 1.5 MHz. A study(1) of semi conductor techniques and technologies to achieve this performance lead to the conclusion that monolithic integration of a single frequency laser with a power amplifier is a good solution (figure 1). The critical factors relating to the laser are grating design to maximise power output and minimise linewidth. Power output is limited by longitudinal spatial hole burning and thermal effects. Longitudinal spatial hole burning and linewidth can be minimised by using multi quantum well (MQW) active regions and proper grating design. The critical factors relating to the amplifier are unwanted reflection from the output facet and gain saturation. Unwanted reflection can be minimised by anti reflection coating and gain saturation can be minimised by use of MQW active region. The critical factor for integration is linewidth broadening caused by spontaneous emission (noise) generated in the amplifier. Detailed modelling(2) of a laser-amp using bulk active regions has shown that sufficiently narrow linewidths for FSK links can be achieved. Narrower linewidths are expected using laser-amps with MQW active regions. To test this concept experimental MQW laser-amps have been realised(3) and the first results are reported here.

A multi quantum well distributed feedback ridge waveguide laser monolithically integrated with a booster amplifier has been fabricated and evaluated. Light current characteristics and spectral performance are shown in figures 2 and 3. Single frequency output power in excess of 45 mW was achieved at 360 mA, limited by the wire bonds used. Linewidth values of less than 5 MHz were obtained at power output values above 8 mW. The minimum linewidth was 2.3 MHz at 35 mW. This design is not optimum. The results demonstrate that the monolithic laser-amp concept has good prospects for development. Improved designs are now being fabricated and will be reported.

Acknowledgements

The authors acknowledge constructive discussion with P. Roussel of ESTEC and financial support from the European Space Agency.

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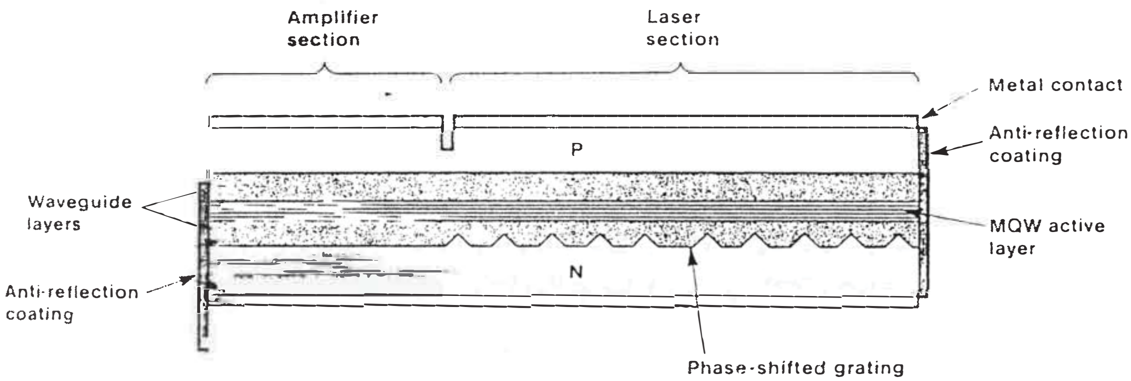

Fig 1 Schematic of monolithic multi-section grating laser/booster amplifier combination.

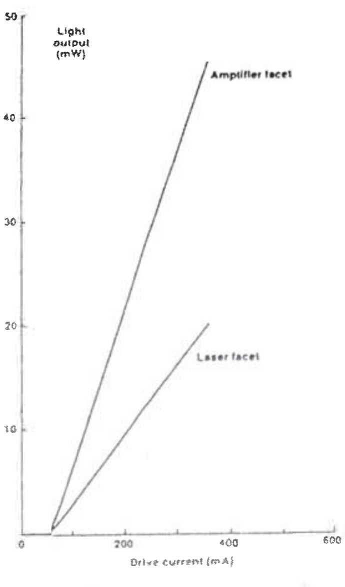

Fig 2 Light-current characteristic of a monolithic amplifier + λ/4 DFB laser with a single p-side contact.

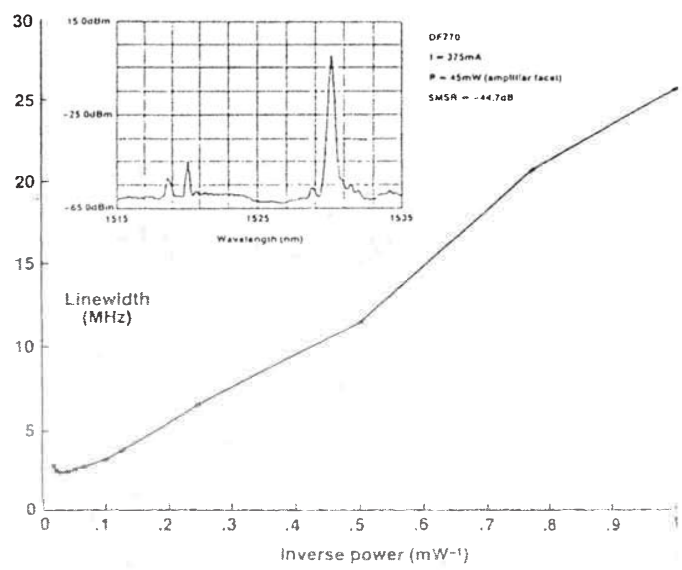

Fig 3 Plot of spectral linewidth versus inverse output power (from the amplifier facet) for a monolithic amplifier + λ/4 DFB laser.

FURTHER WORK ON STABILITY ASPECTS OF OPTICAL RELAYS FOR OPTICAL INTER-SATELLITE LINKS

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Within the field of optical relays for optical Inter-Satellite Links (ISL's) a number of risk areas have been identified which will effect the performance of the system in space. Two of these risk areas are:-

i) Optical Element Mounting
ii) Beam Combiner Stability

The unavailability (at the time of writing) of space qualified optical cements has necessitated the optical design to include a number of 'separated doublets', the stability of each element within these doublets being of paramount importance for maintenance of system wavefront performance. Stabilities of the order of 0.005mm in the plane of the element are element are envisaged: this parameter is to be examined.

The second risk area to be analysed is the 'Beam Combiner Stability': a paper entitled 'Stability Considerations in Relay Lens Design for Optical Communications' presented at 'Free Space Laser Communication Technologies III' (in Los Angeles) identified the 'Beam Combiner Module' to be the key sub-assembly within the ISL in terms of transmit/receive paths co-alignment. A co-axial stability of the order of 2.5 urads is to be examined.

Technology experiments are to be set up to analyse the two parameters described above with the objective of qualifying a design construction for optical element mounting and beam combiner module which will be carried forward to the full design phase of the ISL optical relays. This paper will describe the technology experiments, report on the results obtained and make recommendations to be incorporated into the final design phase.