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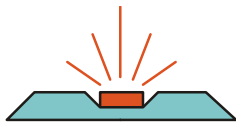
# **Optical freespace communication (OFC) with POF feeder lines**

Hans Kragl

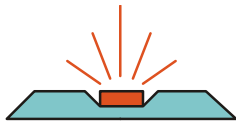
DieMount GmbH  
Giesserweg 3  
38855 Wernigerode

[www.diemount.com](http://www.diemount.com)

**FGT 5.4.1 Meeting, Oldenburg, May 12<sup>th</sup>, 2006**



- 1. Broadband data access for everybody?**
- 2. Optical freespace communication (OFC)**
- 3. Idea: from POF simplex to OFC simplex with POF feeder line**
- 4. Technical approaches**
  - simplex OFC systems
  - duplex OFC systems
- 5. Comparison: Simplex and duplex OFC systems**
- 6. Next steps**



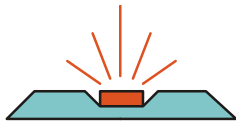
## **Telecom operators will introduce broadband access networks first:**

- for well funded customers,
- at places with a high customer density (large cities),
- a high number of customers per access line (multiple dwelling units).

## **I.e., customers:**

- outside economic centers (from rural regions in Europe to developing countries),
- living in small villages and
- living in single-family houses

**will be served with broadband access at last.**



## **Optical freespace communication systems allow**

- to bridge up to 8km transmission distance (@1.55 $\mu$ m wavelength),
- provide high bandwidth (2.5Gbit/s and more),
- don't require licences,
- offer easy installation,
- offer reliabilities of more than 99%, if system margin sufficiently high.

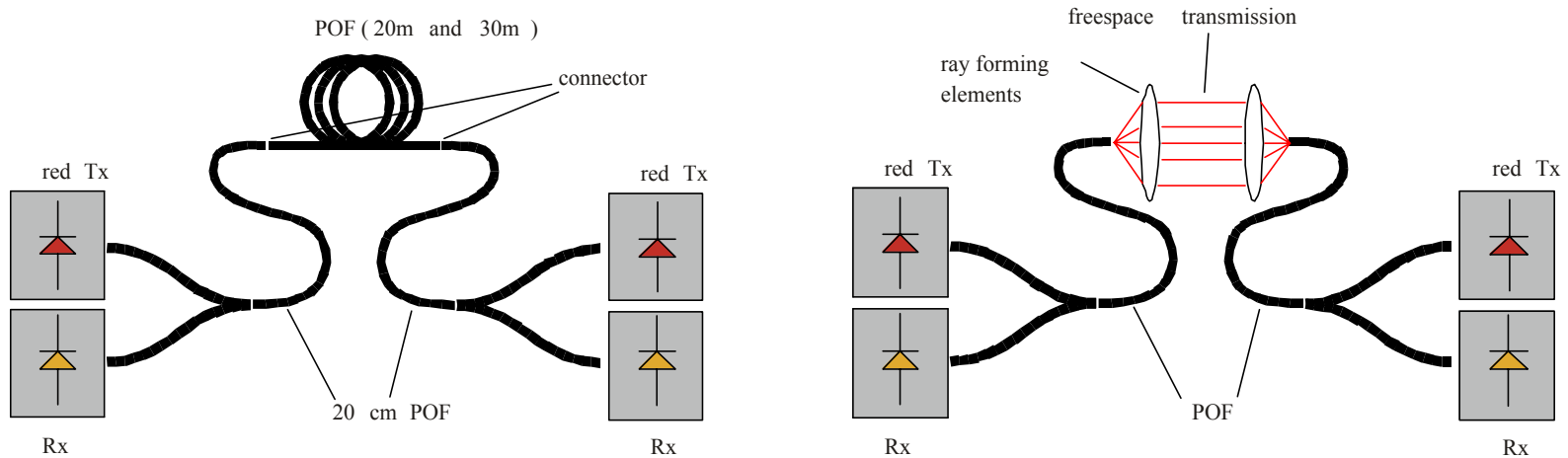
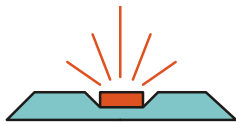
## **But:**

Commercially available systems today cost 4'000 to more than 25'000 Euro. This price is too high for:

- private persons, i.e. not professional applications and
- developing countries.

## **Idea:**

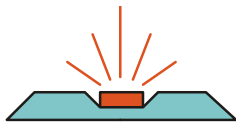
Is it possible to use low cost POF mediaconverters for optical freespace communication?



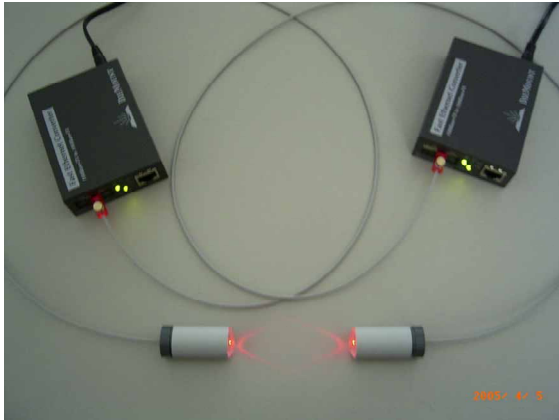
- optical header comprises passive optics,
- POF serves as feeder line to optical header,
- installation very easy, because one optical axis only,
- visible light (650nm) allows to find focus and install by „eye“,
- anti reflection at POF endface easily feasible.

**Cost:**

A standard simplex media converter set + a fresnell lens in the optical header.



# OFC test systems with POF feeder line



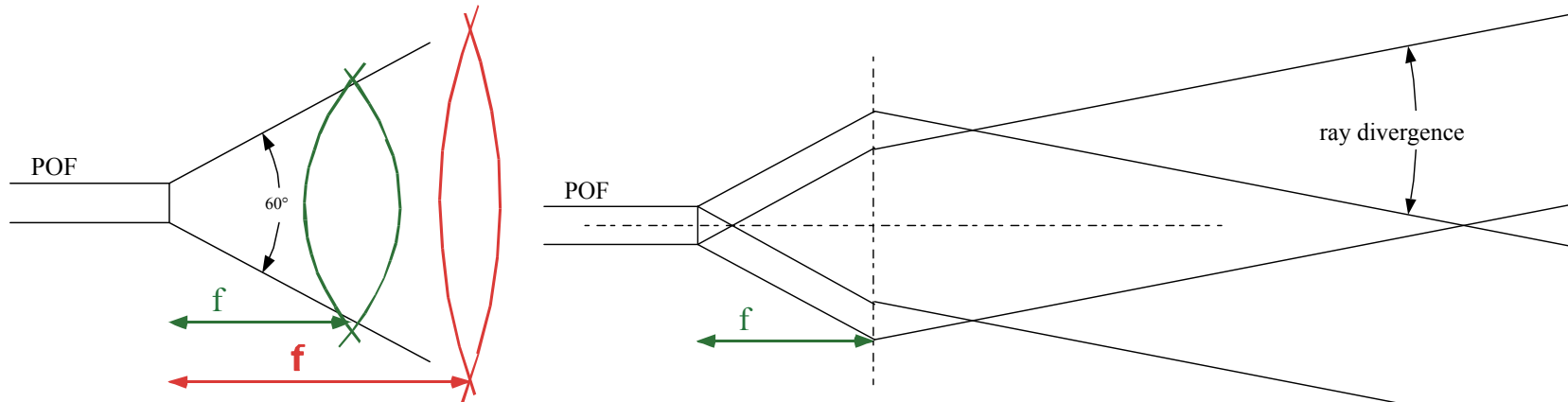
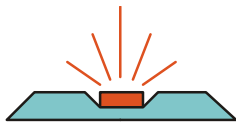
$d = 18\text{mm}\varnothing$ ,  $f = 30\text{mm}$ ,  $D = 1\text{m}$   
**App.: rotary data joints**



$d = 45\text{mm}\varnothing$ ,  $f = 150\text{mm}$ ,  $D = 6\text{m}$   
**App.: drag chain links**

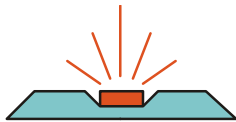


$d = 390\text{mm}\varnothing$ ,  $f = 270\text{mm}$ ,  $D = 100 - 150\text{m}$   
**App.: house to house link**



- The POF NA (0.5) fixes the relation of focal length and lens diameter to 1.15. Smaller lenses cause losses, larger lenses are useless.
- The lens focal length  $f$  and the large POF diameter of 1mm define ray divergence to:  $\arctan(1\text{mm}/ f [\text{mm}])$ .
- **Consequences:**
  - large lenses are necessary for long distances (small ray divergence)
  - large, but low cost lenses are fresnell lenses
  - fresnell have limited optical quality.

**With a power budget of 14dB (standard simplex POF system) simplex POF OFC systems allow to bridge up to 150m maximum only.**



$d = 260\text{mm} \times 260\text{mm}$ ,  $f = 200\text{mm}$ ,  
available low cost Fresnell lens

**Transmission distance: 50m (+x?)  
with a LED based 14dB power  
budget simplex system**

### Alignment procedure:

Starting point:

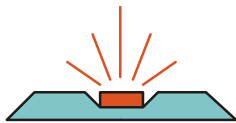


First step:



Second and final step:





**Duplex POF OFC systems overcome the problem of large, high quality lenses due to tiny laser radiation apertures.**

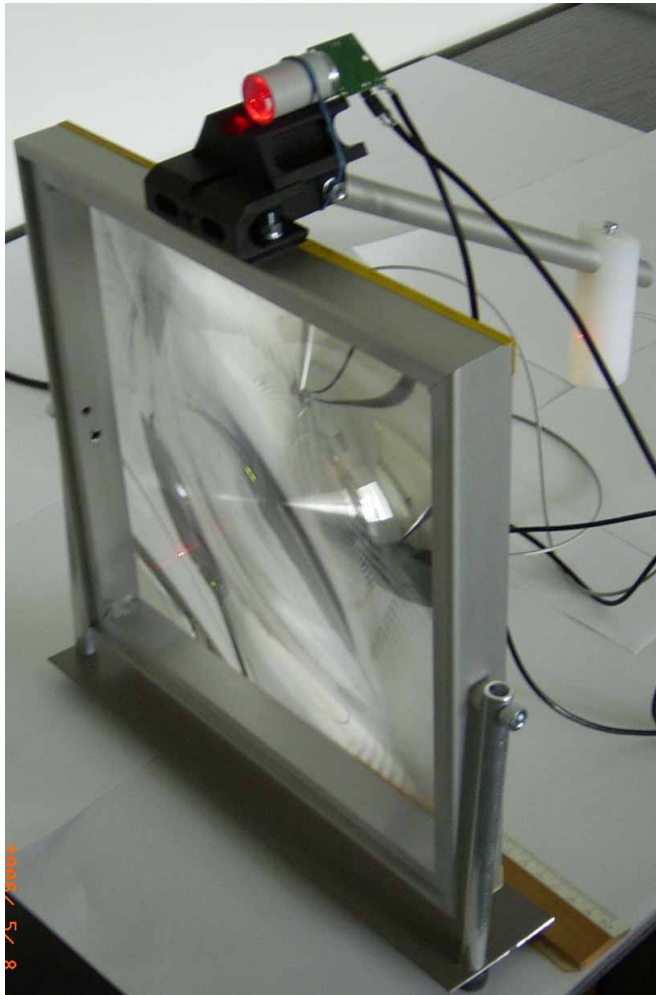
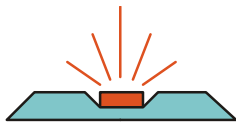
**But they require:**

- an active optical header comprising a laser diode,
- the alignment of two optical axis,
- 2 feeder cables: POF (receiver) and coax (data laser driver).

Long term stability aspect:

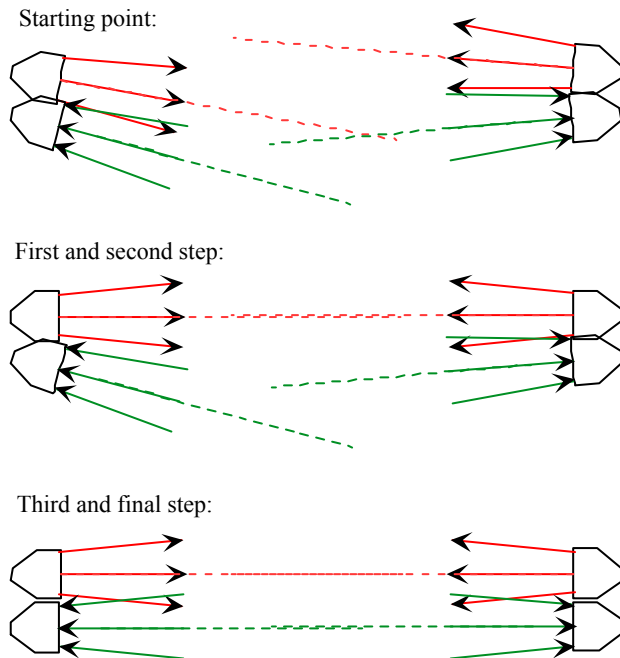
**Novel 650nm EELD promise a MTTF of 100'000 h (10 years).**

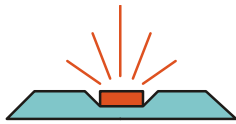
Failure:= 20% loss of optical power.



**Transmission distance: >300m  
with a 650nm EELD based 30dB  
power budget duplex system**

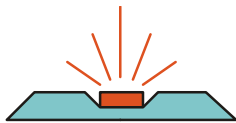
## Alignment procedure:



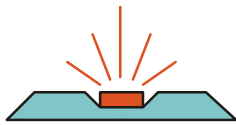


First OFC installation at asphericon GmbH, Jena.

The link is used to bridge an about 100m long public place between two company buildings.



<b><i>System:</i></b>	<b><i>Light source:</i></b>	<b><i>Relia- bility:</i></b>	<b><i>Installation:</i></b>	<b><i>Transmission distance:</i></b>
Simplex f=200mm	red 650nm LED	high	very easy	50m
Simplex f=200mm	780nm VCSEL	high	medium	100m
Duplex f=200mm	650nm EELD	? 100'000h MTTF (?)	medium to easy	>300m (up to 1km?)
Simplex f=200mm	650nm EELD	? 100'000h MTTF (?)	very easy	>150m (?)



**An EELD based simplex OFC system promises:**

- very easy installation,
- a completely passive optical header that allows to place, active electronics far away from the header,
- an estimated maximum transmission distance of >150m,
- a very affordable price due to POF media converter technology,
- upgrade from Fast Ethernet to Gb/s Ethernet no serious problem (first Gb/s POF transceivers?).

**Next steps:**

- Design an optical simplex transceiver comprising EELD.
  - Start of long term life tests.
  - Use demountable LD-modules to overcome the potential (!?) problem with limited EELD lifetime.
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